Infant milks in the UK

A practical guide for health professionals

July 2018

FIRST STEPS NUTRITION TRUST

Infant Milks in the UK: A Practical Guide for Health Professionals – July 2018

Authors: Dr Helen Crawley and Susan Westland

This report is provided for information only and individual advice on diet and health should always be sought from appropriate health professionals.

We have attempted to provide accurate information on the current composition of infant milks sold in the UK in this report, and do so in good faith. However, composition may change so please refer to the specific manufacturers for up-to-date information. This report is updated regularly and the date of this publication appears as a footer on each page. Always check you are consulting the latest version of this report by checking the website.

Acknowledgements

The first iteration of this report, written by the same authors, was for The Caroline Walker Trust in 2011 and we would like to thank the A Team Foundation (registered charity number 1077094) for funding the publication of the original report. We would like to thank Public Health Wales, The Scottish Government and The Public Health Agency Northern Ireland for contributions to the continual updating of this resource.

Thanks are also due to Professor Elizabeth Opara of Kingston University, Shel Banks at the Local Infant Feeding Information Board, Unicef UK Baby Friendly Initiative, Mike Brady at Baby Milk Action, Rachel Elsom at Public Health England, and all the scientific staff at the breastmilk substitute manufacturers who provided information on infant milk composition for this report.

First Steps Nutrition Trust

www.firststepsnutrition.org
E: helen@firststepsnutrition.org
T: 07590 289182
Registered charity number 1146408

First Steps Nutrition Trust is a charity that provides objective, evidence-based information and resources about the importance of good nutrition from pre-conception to 5 years. For more information about our range of resources on infant milks, see our website **www.firststepsnutrition.org**

Contents

List of Tables

Acronyms

AD	Atopic dermatitis
ALA	α-linolenic acid
ARA	Arachidonic acid
CMPA	Cows’ milk protein allergy
COMA	Committee on Medical Aspects of Food and Nutrition Policy
COT	Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment
DHA	Docosahexaenoic acid
EAR	Estimated average requirement
EC	European Commission
EFSA	European Food Safety Authority
EPA	Eicosapentaenoic acid
ESPGHAN	European Society of Paediatric Gastroenterology, Hepatology and Nutrition
EU	European Union
EAACI	European Academy of Allergology and Clinical Immunology
FAs	Fatty acids
FDA	Food and Drug Administration
FOF	Follow-on formula
FOS	Fructo-oligosaccharides
FSA	Food Standards Agency
FSG	Foods for specific groups
FSMP	Foods for special medical purposes
GIT	Gastrointestinal infections
GOS	Galacto-oligosaccharides
GUL	Guidance upper level
HMO	Human milk oligosaccharide
IBFAN	International Baby Food Action Network
IF	Infant formula
LA	Linoleic acid
LBW	Low-birthweight
LCPUFA	Long chain polyunsaturated fatty acids
PC	Phosphatidyl choline
PUFAs	Polyunsaturated fatty acids
RCN	Royal College of Nursing
RNI	Reference nutrient intake
RTF	Ready-to-feed
RTI	Respiratory tract infections
SACN	Scientific Advisory Committee on Nutrition
SCF	Scientific Committee on Food
TDI	Tolerable dietary intake
TPAN	Total potentially available nucleotide
WHO	World Health Organization

Glossary

Allergy – Adverse reaction to foods, caused by the production of antibodies.

Amino acids – The base units from which proteins are made.

Anhydrous fat – Milk fat with water removed

Atopic – Pertaining to clinical manifestations of type 1 (IgE-mediated) hypersensitivity, including allergic rhinitis (hay fever), eczema, asthma and various food allergies.

Atopy – Allergic hypersensitivity affecting parts of the body not in direct contact with the allergen, eg. eczema, asthmas and allergic rhinitis.

α-lactalbumin – Predominant whey protein of human milk.

Bifidogenic – Promoting the growth of (beneficial) bifidobacteria in the intestinal tract.

β-lactoglobulin – Predominant whey protein of cows' milk.

Casein – Globular protein that can be precipitated from milk, commonly during the cheese-making process. It consists of a group of 12-15 different proteins which make up about 75% of the proteins of milk.

Complementary feeding – The process of expanding the infant diet to include foods other than breastmilk or infant formula. (Sometimes also known as weaning.)

Dextrins – A mixture of soluble compounds formed by the partial breakdown of starch by heat, acid or amylases.

Elemental formula – Infant formula based on synthetic free amino acids.

Fluorosis – Damage to teeth (white to brown mottling of the enamel) and bones caused by an excessive intake of fluoride.

Follow-on formula – The term often used to describe milks suitable for infants over the age of 6 months who are also receiving some solid food.

Foods for special medical purposes – Infant milks that are covered by foods for special medical purposes legislation, not by infant formula and follow-on formula regulations.

Fortification – The deliberate addition of specific nutrients to foods as a means of providing the population with an increased level of intake.

Fructo-oligosaccharides – Oligosaccharides consisting of fructose.

Fructose – Also known as a fruit sugar, a six carbon monosaccharide sugar.

Galacto-oligosaccharides – Oligosaccharides consisting of galactose.

Galactose – A six carbon monosaccharide, differing from glucose only in the position of the hydroxyl group on carbon-4.

Gastroenteritis – Inflammation of the mucosal lining of the stomach and/or small or large intestine, normally resulting from infection.

Glucose – A six carbon monosaccharide sugar occurring free in plant and animal tissues and formed by the hydrolysis of starch and glycogen. It may also be known as dextrose, grape sugar and blood sugar.

Glucose polymers – Oligosaccharides of glucose linked with alpha 1, 4 and alpha 1, 6 glycosidic links.

Glucose syrup – A kind of glucose polymer.

Glycerol – A trihydric alcohol also known as glycerine. Simple or neutral fats are esters of glycerol with three molecules of fatty acids (triglycerides sometimes known as triacylglycerols).

Hydrolysed – When a compound (complex) is split into its constituent parts by the action of water or an enzyme or catalysed by the addition of acid or alkali.

Hypernatraemia – The presence of an abnormal concentration of sodium in the blood. Hypernatraemia is generally not caused by an excess of sodium, but rather by a relative deficit of free water in the body. For this reason, hypernatraemia is often synonymous with the less precise term, dehydration. Hypernatraemia most often occurs in people such as infants, those with impaired mental status, or elderly people, who may have an intact thirst mechanism but are unable to ask for or obtain water.

Hypersensitivity – Heightened responsiveness induced by allergic sensitisation. There are several types of response including that associated with allergy.

Hypoallergenic – A term first used by advertisers to describe items that cause or are claimed to cause fewer allergic reactions.

Ig – See *Immunoglobulins (Ig).*

Immunoglobulins (Ig) – The five distinct antibodies present in the serum and external secretions of the body: IgA, IgD, IgE, IgG and IgM.

Lactase – The enzyme that breaks down lactose. Sometimes called milk sugar, a disaccharide of glucose and galactose.

Lactose intolerance – The inability to metabolise lactose due to the absence of the enzyme lactase in the intestinal system or due to a low availability of lactase.

Low birthweight – Weight at birth below 2,500g.

Luminal – Pertaining to the lumen, the interior of a hollow structure.

Maltodextrin – A polysaccharide produced from the partial hydrolysis of starch.

Maltose – Malt sugar or maltobiose, a disaccharide consisting of two glucose units.

Mature breastmilk – Milk produced from about 14 days post partum.

Methionine – An essential sulphur-containing amino acid. It can be used by the body to make the non-essential, sulphur-containing amino acid cysteine.

Neonate – A human infant less than 28 days old. The term includes premature infants, postmature infants and full-term newborns.

Nucleotide – Compounds of purine or pyrimidine base with a sugar phosphate.

Palmitic acid – A saturated fatty acid (C16:0).

Pathogen – Disease-causing bacteria, as distinct from those that are harmless.

Peptide – Compound formed when amino acids are linked together through the peptide (-CO-NH-) linkage. Two amino acids linked in this way form a dipeptide, three a tripeptide, etc.

Phospholipids – Lipids found in cell membranes that have fat and water attracting properties.

Phyto-oestrogens – Compounds in plant foods, especially soya bean, that have both oestrogenic and anti-oestrogenic action.

Postbiotics - Metabolites and/or cell-wall components released by probiotics.

Prebiotics – Non-digestible oligosaccharides that support the growth of colonies of potentially beneficial bacteria in the colon.

Pre-term – A term used to describe infants born at less than 37 weeks' gestation.

Probiotics – Live micro-organisms that, when consumed, may have beneficial health effects on the host.

Single cell oils – Oils produced from biomass of bacteria, algae and yeast, of potential use as animal or human food.

Structured triglycerides – Triglycerides that have been chemically, enzymatically or genetically modified to change their nutritional and/or functional properties. They are also referred to as structured lipids.

Sucrose – Cane or beet sugar. A disaccharide composed of glucose and fructose.

Synbiotics – A mixture of pre- and probiotics.

Tryptophan – An essential amino acid, the precursor of serotonin (a neurotransmitter) and of niacin.

Visual acuity – The acuteness or clearness of vision, especially form vision, which is dependent on the sharpness of retinal focus and the sensitivity of the interpretative faculty of the brain. It is the most common measurement of visual function.

Whey – The liquid component of milk, which remains after the insoluble curds have been coagulated and removed.

Whey protein – The name for a collection of globular proteins that can be isolated from whey.

1 Introduction

The World Health Organisation (WHO, 2003) and health departments across the developed world recommend that the best way to feed an infant is exclusive breastfeeding for the first six months of life, and breastfeeding alongside complementary foods after 6 months and for as long as the mother wishes to do so. Where mothers cannot, or choose not to, breastfeed, breastmilk substitutes are available. Breastmilk substitutes include infant formula, follow on formula, milks marketed as foods for special medical purposes and milks marketed for children up to three years of age. All breastmilk substitutes are an imperfect approximation of breastmilk and there are inherent differences between breastmilk and breastmilk substitutes. (Renfrew et al, 2012).

- The exact chemical properties of breastmilk are still unknown and cannot be reproduced.
- A mother's breastmilk changes in response to the feeding habits of her baby and over time, thus adjusting to the infant's individual growth and development needs.
- Infant formula does not promote neurological development as breastmilk does.
- Infant formula has no positive impact on maternal health.
- Breastmilk includes a mother's antibodies and many other defensive factors that help the baby avoid or fight off infections, and gives the baby's immature immune system the benefit of the mother's mature immune system.
- Infant formula requires manufacturing, storage and delivery systems with inherent quality control problems.

It is essential that alternatives to breastmilk are available and that these are well regulated as food products. Infant milk is unique among foods as it is the sole source of nutrition for infants. It is vital that all those who give advice to parents and carers about infant feeding have access to clear and objective information about the different types of infant formula and other infant milks currently available. (For definitions of the terms infant formula and infant milk, see the next page.)

Breastfeeding

This report is about infant milks, a variety of which are available to replace or complement breastfeeding during the first years of a child's life.

First Steps Nutrition Trust strongly believes that every infant in the UK should, wherever possible, be exclusively breastfed for the first six months of his or her life, and that breastfeeding should then continue alongside the introduction of complementary foods for the first year, and longer if the mother so chooses. We strongly support greater investment to support women to breastfeed their infants. For more information about the benefits of breastfeeding for infants and for mothers, and for details of organisations that support breastfeeding, see *Breastmilk and breastfeeding: A simple guide* at www.firststepsnutrition.org.

We fully support the WHO International Code of Marketing of Breast-milk Substitutes and subsequent World Health Assembly resolutions and urge all health professionals to consider their role in ensuring safe infant feeding following these recommendations.

Terminology

There are a number of names and terms used for infant milks. Whilst breastmilk substitutes is an umbrella term for all milks marketed to children under 3 years of age, the terms 'artificial milks' or 'formula milks' are frequenty used. The term 'breastmilk substitute' refers to all products that are marketed in a way which suggests they should replace breastfeeding, even if the product is not suitable for that purpose. This may include infant milks, baby foods, gruel, tea, juice, bottles, teats/nipples and related equipment.

For clarity we are using the following terms throughout this report:

What do we mean by infant milk?
We use the term infant milk as an umbrella term for all milk-based drinks provided commercially for infants and young children. This term is also used for milks for which there are currently no compositional regulations, such as toddler milks.

What do we mean by infant formula?
We use the term infant formula to mean a food that can meet all an infant's nutritional needs during the first six months of life and alongside complementary food for the second six months, and which complies with the regulations for infant formula.

What do we mean by follow-on formula?
We use the term follow-on formula for those milks that are marketed for infants from 6 months of age and which comply with the regulations for follow-on formula.

What do we mean by foods for special medical purposes?
These are milks which can be used from birth, but which are designed for infants with special medical needs, and which by their definition should be used under medical supervision. These milks do not have to comply with infant formula and follow-on formula regulations and are governed by a separate set of regulations on composition, labelling and marketing.

A glossary of terminology surrounding infant formula can be found on page 9.

1.1 What does this report contain?

This report provides information on infant milks currently available to buy over the counter in the UK. The information will help health professionals, and others who give information to families, to provide clear and accurate advice.

The report provides information on:

- what infant milks contain and what we know about the ingredients used and their composition
- what milks are currently available and key points about these, and
- how much milk is recommended and how to make up infant milk feeds safely.

Section 7 gives sources of further information. Appendix 1 gives background information about infant milks and the infant milk market, and Appendix 2 provides information about monitoring the composition and safety of infant milks.

Similar information on milks which come under the foods for special medical purposes regulations (which we call specialised infant milks) is available on our website, see *Specialised infant milks in the UK: Infants 0-6 months* at **www.firststepsnutrition.org.**

1.2 Format of the report

This report has been formatted so that each section can be printed out separately and kept in a binder. When we update certain sections these can be reprinted and substituted into the folder. On the website **www.firststepsnutrition.org** we show how you can use this resource in the folder format. We recommend that you print this version out as your master copy, and make additions to this in future.

Please note we do our best to keep this report up to date and review the evidence provided by the companies, but sometimes changes are made between report updates, or we have not been able to get information on specific components from the manufacturers. Information can also be checked on websites and through helplines and we welcome any new information from readers if they are given information which differs from what we have in the latest iteration of this report.

1.3 Working with the Unicef UK Baby Friendly Initiative

Healthcare professionals in more than 91% of maternity settings, 87% of health visiting services, 69% of university midwifery courses and 19% of health visiting courses are working in their local area within, or towards, Unicef UK Baby Friendly Initiative accreditation (July 2017). In addition 10 Children's Centres and 1 neonatal unit have received full independent accreditation. There is a clear pathway for offering support and advice to parents who choose to artificially feed their baby within this, and the key points are summarised here. For full details of the Unicef UK Baby Friendly Initiative and how health care professionals can support families with their infant feeding choices at all these stages, see http://www.unicef.org.uk/BabyFriendly/Health-Professionals/New-Baby-Friendly-Standards/

In pregnancy

- Health care staff should have an open discussion about breast and bottle-feeding so that parents can make an informed decision about how they might want to feed their baby.

- Parents-to-be should also have an opportunity to talk about things that can help them recognise their baby's needs for food and comfort. Health professionals should discuss the importance of spending time in skin-to-skin contact after birth and keeping baby close, to enable parents to look out for cues that tell if baby may want to feed or be cuddled, regardless of how they choose to feed their baby.

After birth

- The importance of skin-to-skin contact after birth is fully recognised in the Baby Friendly standards and is considered as a good way to calm a baby and let parents and baby get to know each other. It is likely that while baby is in skin contact he will start to show some signs of being ready to feed, such as rooting and moving his hand towards his mouth. Parents may wish to offer a breastfeed and some women do have a strong feeling to do this even if they had planned to bottle-feed.

- However, health professionals will ensure there is *no pressure* on parents to do this and if they decide that they want to bottle-feed it can be lovely for parents to offer the first bottle whilst they are in skin-to-skin contact.

In the first two days

- Parents should be given independent information about infant milks so they can choose the one most suited to all their needs. Parents should also be given all the information they need to make up bottles safely, and on how to sterilise feeding equipment.

At home

- Parents should be supported so that they know their baby is feeding effectively, and growing well, regardless of how their baby is being fed. Healthcare professionals should support the maintenance of a close and responsive relationship with the baby when they are being fed.

How to bottle-feed

To encourage responsiveness and discourage overfeeding:

- Hold the baby close and look into their eyes during feeds.
- Respond to cues that baby is hungry.
- Invite the baby to draw in the teat rather than forcing the teat into the mouth.
- Pace the feed so that the baby is not forced to feed more than they want to.
- Recognise the baby's cues that they have had enough milk.

At about 6 months

Babies who are either breastfed, mixed fed or formula-fed should be introduced to complementary foods at about 6 months of age. Advice on this and on how to manage milk feeding alongside complementary feeding can be found at

http://www.nhs.uk/start4life/Pages/healthy-pregnancy-baby-advice.aspx

The report *Eating well: the first year* can be accessed at www.firststepsnutrition.org

In children's centres

- Parents should be supported with appropriate infant feeding choices and in building a close and loving relationship with their baby.
- Pregnant women should be supported to recognise the importance of early relationships to the health and well-being of their baby.

The Unicef UK Baby Friendly Initiative supports all families however they feed their babies, and a report explaining *'**How the Baby Friendly Initiative supports formula feeding parents'*** can be downloaded at
http://www.unicef.org.uk/Documents/Baby_Friendly/Leaflets/guide_infant_formula.pdf

First Steps Nutrition Trust and Unicef UK Baby Friendly Initiative have also produced a one page leaflet on ***'What infant formula to choose'***
https://www.unicef.org.uk/babyfriendly/wp-content/uploads/sites/2/2018/02/Infant-formula-and-responsive-bottle-feeding.pdf

Unicef UK Baby Friendly Initiative and Start4life produce a booklet **'*A guide to bottle feeding'***
https://www.unicef.org.uk/babyfriendly/wp-content/uploads/sites/2/2008/02/start4life_guide_to_bottle_-feeding.pdf

Unicef UK Baby Friendly Initiative also produce a report '***Working within the International Code of Breastmilk Substitutes: A guide for health workers***'
https://www.unicef.org.uk/babyfriendly/baby-friendly-resources/guidance-for-health-professionals/the-code/a-guide-for-health-workers-to-working-within-the-international-code-of-marketing-of-breastmilk-substitutes/

2 A simple guide to choosing milks for infants and toddlers

Table 1 provides a simple guide to choosing milks for infants and toddlers up to 2 years of age, who do not have any special medical needs. The rationale for the information given in this table can be found in section 5 of this report.

TABLE 1
A simple guide to choosing milks for infants and toddlers up to 2 years of age

✓ =	Safe to give
Seek advice =	Ask a health professional as these milks may not be recommended for use or may be for specific conditions only, or there may be little evidence that they offer any benefit.
x =	Do not give this milk.

Milks suitable for use	Infants 0-6 months	Infants 6 months - 1 year	Toddlers 1 year - 2 years
Breastmilk	✓	✓	✓
Whole cows' milk as main milk drink	x	x	✓
Infant formula suitable from birth (cows' or goats' milk protein based)	✓	✓	Seek advice
Infant formula marketed for hungrier babies, suitable from birth (cows' milk based)	Seek advice	Seek advice	Seek advice
Thickened (anti-reflux) infant formula suitable from birth, made up at 70°C	Seek advice	Seek advice	Seek advice
Thickened (anti-reflux) infant formula suitable from birth, made up at less than 70°C without medical advice	x	x	x
Soya protein based infant formula suitable from birth	Seek advice	Seek advice	Seek advice
Lactose-free infant formula suitable from birth	Seek advice	Seek advice	Seek advice
Partially hydrolysed infant formula suitable from birth	Seek advice	Seek advice	Seek advice
Follow-on formula suitable from 6 months of age (cows' milk or goats' milk based)	x	Seek advice	Seek advice

The rationale for the information given in this table can be found in the appropriate sections of this report.

TABLE 1 (continued)
A simple guide to choosing milks for infants and toddlers up to 2 years of age

✓ =	Safe to give
Seek advice =	Ask a health professional as these milks may not be recommended for use or may be for specific conditions only, or there may be little evidence that they offer any benefit.
x =	Do not give this milk.

Milks suitable for use	Infants 0-6 months	Infants 6 months - 1 year	Toddlers 1 year - 2 years
Good night milk	x	Seek advice	Seek advice
Growing-up milks and toddler milks suitable from around 1 year of age (cows' milk or goats' milk based)	x	x	Seek advice
Growing-up milks and toddler milks suitable from around 1 year of age (soya protein based)	x	x	Seek advice
PaediaSure Shake for fussy eaters	x	x	x
Growing-up milks and toddler milks suitable from around 2 years of age	x	x	Not before 2 years. Seek advice for 2 years +
Whole goats' milk	x	x	✓
Whole sheeps' milk	x	x	✓
Unsweetened calcium-fortified soya milk alternative*, nut based milk alternatives, hemp milk alternative or oat milk alternative	x	x	✓ but seek advice to ensure the diet is sufficiently energy dense
Rice milk alternative– do not give this milk to children under the age of 5 years	x	x	x

The rationale for the information given in this table can be found in the appropriate sections of this report.

* Milk alternatives are also called soya drinks, rice drinks, oat drinks etc.

2.1 Frequently asked questions

The following questions are answered on the next few pages and may help health professionals when talking to families about infant feeding. *A simple guide to infant formula, follow-on formula and milks for special medical purposes* can be downloaded at www.firststepsnutrition.org/pdfs/Infant_milks_%20a%20simple%20guide.pdf

- **Where can parents get advice to help them continue breastfeeding if they are having difficulties, or are thinking about introducing formula milk?**
- **Is there a formula milk that is closest to breastmilk?**
- **Is there any evidence that a hungry baby formula will help babies to sleep better?**
- **Is formula based on goats' milk less allergenic than formula made from cows' milk?**
- **If a baby is bringing up milk after feeds, do they need a special formula to prevent reflux?**
- **My baby is unsettled in the evenings and cries a lot. Will a comfort milk help settle her stomach?**
- **My baby has diarrhoea and I think he may be in pain after feeds. Could he need a lactose-free formula?**
- **I am worried my baby might be allergic to cows' milk protein. Is there a milk I can buy which is suitable for babies with this allergy?**
- **Is soya-based formula a good option if there are allergies in the family?**
- **We are vegetarians. Which milk should we use if we want a vegetarian formula for our baby?**
- **We are vegans. Is there a suitable infant formula if we want to bring our baby up as a vegan?**
- **Are infant formula halal?**
- **Are ready-to-feed milks different to powdered milks?**
- **Can a partially hydrolysed formula prevent eczema in infants?**
- **Do babies need follow-on formula after 6 months of age?**
- **At what age can I use cows' milk as the main drink?**
- **What non-dairy alternatives to cows' milk are suitable from 1 year of age?**
- **How do toddler milks and growing-up milks differ from whole animal milk?**
- **Is an infant milk for 'fussy eaters' useful?**
- **Is home-made infant formula safe to use?**

Q. Where can parents get advice to help them continue breastfeeding if they are having difficulties, or are thinking about introducing formula milk?

A. There are a number of national helplines and organisations that can offer support to women who are breastfeeding. Many women regret giving up breastfeeding and really value the opportunity to get support to continue. Most health professionals and lactation consultants agree that, once formula milk is introduced, breastfeeding continuation is compromised. Every drop of breastmilk counts, however, so seek help to continue breastfeeding even if you plan to introduce formula as you can still give your baby some breastmilk. Never be afraid to ask for help at any stage of your breastfeeding journey. All the helpline volunteers know what you are going through.

Breastfeeding helplines

National Breastfeeding Helpline
0300 100 0212

The National Breastfeeding Helpline is staffed by volunteers from the Breastfeeding Network and the Association of Breastfeeding Mothers. The helpline can answer questions in English, Welsh and Polish.

La Leche League Helpline
0845 120 2918

NCT Helpline
0300 330 0771

Q. Is there a formula milk that is closest to breastmilk?

A. No. It is impossible to recreate breastmilk. Breastmilk is not only nutritionally uniquely suited to the human infant; it also contains hundreds of unique components and living cells to protect infants from infection and to aid development. These components cannot be made in a laboratory. All formula milks have to be of a similar composition to comply with EU compositional requirements and they are all nutritionally adequate for infants. If a substance was found that was definitely beneficial for infant health that could be added to formula milks, it would be in all formula by law.

Q. Is there any evidence that a hungry baby formula will help babies to sleep better?

A. No. There is no evidence that milks marketed for hungry babies offer any advantage, and it is recommended that first milks are used throughout the first year of life if babies are not being breastfed. Hungry baby milks have more ‘casein’ than ‘whey’ in the protein mix, and casein is harder for babies to digest. An infant has a tiny tummy and needs to eat little and often, day and night, in the first few weeks and months. First infant milk (whey-based) will provide the best alternative if babies are not being breastfed (or are not receiving milk from a milk bank). Whey-based infant formula is the only breastmilk substitute needed throughout the first year of life.

Q. Is formula based on goats' milk less allergenic than formula made from cows' milk?

A. No. Milk based infant formula can have cows' milk or goats' milk protein as the main protein source. They are equivalent in terms of allergenicity and safety.

Q. If a baby is bringing up milk after feeds, do they need a special formula to prevent reflux?

A. Many babies will bring up small amounts of milk after feeds or if they burp, and this causes them no distress. Crying, vomiting milk after feeds, and back-arching or being unsettled are not symptoms of reflux in most babies. Reflux is rare and should be properly diagnosed by a paediatrician. If your baby brings up milk after feeds, it may be that he needs smaller milk feeds more often, or may need more frequent winding during a feed. As long as your baby is growing adequately, many of these problems will disappear as he gets bigger. You can talk to your health visitor or GP for reassurance if you are worried. Thickened (anti-reflux) milks do not have to comply with infant formula regulations in the UK, and they should only be used under medical supervision. There are several reasons to be cautious about using these milks:

- These formula contain cereal-based thickeners, and infants do not need anything other than milk in the first few months of life.
- Manufacturers recommend that anti-reflux formula are made up at lower temperatures than the temperature currently recommended for safety, and it is important that this potential risk is considered by a medical practitioner. Powdered formula are not sterile, and making them up at lower temperatures will not kill any harmful bacteria that might be present.
- If your baby is taking certain medicines, it may not be advisable to give them an anti-reflux formula.

In 2015 NICE published guidelines to support health professionals, including GPs and hospital doctors, that will help everyone provide consistent, evidence-based support for anyone concerned about infant reflux and regurgitation. You can read the guidance at http://www.nice.org.uk/guidance/ng1/resources/gastrooesophageal-reflux-disease-recognition-diagnosis-and-management-in-children-and-young-people-51035086789. This guidance has also been reiterated in NICE Quality Standards published in 2016 available at www.nice.org.uk/guidance/qs112

Q. My baby is unsettled in the evenings and cries a lot. Will a comfort milk help settle her stomach?

A. It is not uncommon for young babies to be unsettled or fussy in the evenings and to cry more than they might at other times of the day. You may be surprised to know that the average amount a baby cries in the first six weeks of life is about 110 minutes a day, reducing to about 75 minutes a day at 10-12 weeks. All babies are different and many need more attention and soothing in the evenings, frequent small feeds and frequent winding (during and after feeds) in the first few months. There is no consistent evidence that comfort milks improve babies' wind, colic, constipation or fussiness, and these will pass as the baby gets older. Often small changes to the timing and quantity of feeds can be effective in managing periods of fussiness.

Q. My baby has diarrhoea and I think he may be in pain after feeds. Could he need a lactose-free formula?

A. Lactose intolerance is rare in babies and it is important not to self-diagnose lactose intolerance in case your baby has a cows' milk protein allergy, which is serious and needs to be treated very differently. Cows' milk protein allergy is also uncommon but, if your baby has sickness or diarrhoea and has signs of an immediate allergic reaction after a milk feed (a red itchy rash around his mouth, facial swelling, red lumps on the body, or a streaming nose), or symptoms of a delayed reaction such as eczema or poor growth, it is important to seek help as soon as you can for a proper diagnosis. If a baby ever has breathing problems or goes floppy after a feed, call an ambulance. Thankfully this is very rare. Diarrhoea may be a symptom of a gastro-intestinal infection rather than an intolerance, and some babies might have a temporary lactose intolerance after a bout of gastrointestinal illness. If you think this might be the case, you should talk to your GP or health visitor. It is important to use lactose-free milks under medical supervision, as the source of carbohydrate in these milks is more likely to damage teeth and the risks of using any specialist milk products should always be weighed up against any potential benefit.

Q. I am worried my baby might be allergic to cows' milk protein. Is there a milk I can buy which is suitable for babies with this allergy?

A. If you have allergies in your family, there is lots of evidence that breastfeeding is the best way to protect your baby from developing allergies. Some infant formula may claim to reduce the risk of a baby developing an allergy, but experts in the UK do not believe there is good enough evidence to make this claim. Cows' milk protein allergy is uncommon (it is thought that between 6% and 8% of children aged 0-3 years in the UK have food allergies). Cows' milk protein allergy can only be diagnosed and managed by your GP or a paediatrician, and they will follow specific clinical guidelines to do this. If you are breastfeeding, you can carry on doing so if you make some changes to your own diet. If a baby is on formula milk already, an extensively hydrolysed or elemental formula is suitable for managing cows' milk protein allergy, and these are only available on prescription. Don't try and self-diagnose your baby. Talk to your GP about your concerns, and avoid websites which may offer confusing information or suggest tests which are not recognised as helpful.

You can see the NICE guidance about what to do if cows' milk protein allergy is suspected, at http://cks.nice.org.uk/cows-milk-protein-allergy-in-children#!scenario
For NICE guidance about what to do if cows' milk protein allergy is diagnosed, see: http://cks.nice.org.uk/cows-milk-protein-allergy-in-children#!scenario:1

Q. Is soya-based formula a good option if there are allergies in the family?

A. No. Soya-based formula is not recommended for use in infants under 6 months of age unless recommended by a medical practitioner. These milks are not recommended for use without medical supervision for a number of reasons:

- Children are as likely to be allergic to soya as to cows' milk protein, and this needs to be investigated.
- Soya is a rich source of phyto-oestrogens and these mimic sex hormones in the body. For older children and adults, some soya is not a problem, but for babies under 6 months who have soya protein based formula as their sole source of nutrition, current guidance in the UK is that the phyto-oestrogens in soya-based formula should be carefully considered as a risk.

The carbohydrate source of soya protein based formula is glucose, which is more likely to damage teeth.
If infants are allergic to cows' milk, they will be prescribed a suitable formula by their GP, and it is recommended that parents and carers should not use soya formula without taking professional medical advice.

Q. We are vegetarians. Which milk should we use if we want a vegetarian formula for our baby?

A. Many of those who choose a vegetarian diet will breastfeed their babies and will not require an infant formula in the first year of life. Currently the only first animal milk based infant formula powders on the market suitable for vegetarians are Kendamil First Infant Milk, Kendamil Mehadrin First Infant Milk, Sainsbury's Little Ones First Infant Milk and Holle Organic Goats' Milk Formula 1. Other milks either contain fish oils and/or use the animal-derived enzyme rennet during the lactose production process. Rennet is used to separate curds from whey and, although vegetarian alternatives are available, they are not used by all manufacturers. Although soya protein based infant formula are vegetarian and are advertised as suitable for vegetarians by manufacturers, these are not recommended for use in the first 6 months of life without medical supervision.

Q. We are vegans. Is there a suitable infant formula if we want to bring our baby up as a vegan?

A. Currently there are no infant milks suitable for vegans on the UK market, since even those that do not contain a source of animal protein do all contain vitamin D sourced from sheep's wool. Those who choose a vegan diet for themselves and who breastfeed throughout the first year can move their child onto a non-animal milk at one year of age. It is recommended that parents who want to bring up their baby as a vegan seek expert advice to make sure that all their baby's nutritional needs are met. Guidance on how to ensure a breastfed baby with a vegan mum gets all the nutrients he or she needs, can also be found in the resource *Eating well: vegan infants and under-5s*, which can be downloaded from www.firststepsnutrition.org.

Q. Are infant formula halal?

A. Some, but not all infant milks, are halal approved, and it is important to check the label. Status may also vary by type of milk within the same brand. The powdered infant milks may be halal approved but the ready to feed versions of the same milks might not be for example. For an up-to-date list of information provided to us by manufacturers, see Table 8.

Q. Are ready-to-feed milks different to powdered milks?

A. There are some small compositional differences between powdered and ready-to-feed milks, but there is little information available as to whether these are of any significance. There can also be differences in composition between different sized cartons of the same brand of ready to feed milks as these can be made in different factories in different countries. Ready to feed milks are less likely to be halal approved than powdered formulations so always check the packaging. There may be some changes to the composition of the milk since it is ultra heat treated, but this is not known, and current evidence does not support anecdotal ideas that ready-to-feed milks are 'easier to digest'. Ready-to-feed milks are much more expensive than powdered milks, particularly when sold in 'starter kit' 70ml bottles. Ready to feed milks also require considerably more packaging, which has an impact on the environment.

Q. Can a partially hydrolysed infant formula prevent eczema in infants?

A. One of the partially hydrolysed infant formulas sold in the UK – SMA HA – made claims that, if used as the sole milk from birth, it could prevent eczema in babies from families at increased allergy risk, but this has been changed since there was no evidence to support this, and the milk now claims that it can reduce the risk of cows' milk protein allergy. These claims are not made for the other partially hydrolysed infant milks available, which are sold as comfort milks. Current UK policy says there is insufficient evidence that a partially hydrolysed formula can prevent allergies in infants, and this is supported by the European Food Safety Authority. A recent academic review also stated that insufficient is known about the long term effect of these milks on infants. Exclusive breastfeeding is strongly recommended for infants from families who may have allergies.

Q. Do babies need follow-on formula after 6 months of age?

A. No. The Department of Health does not recommend that babies move on to follow-on formula at 6 months of age and this is why it is not possible to buy these milks with Healthy Start vouchers. The World Health Organisation has made a clear statement that follow-on formula is not needed. Current advice suggests that parents and carers who use infant formula continue with a first whey-based infant formula throughout the first year, as this is closer in composition to breastmilk than follow-on formula.

Despite not being recommended, follow-on formula can be advertised to families in the UK whereas advertising for infant formula is not allowed in the UK. There is evidence that many parents are confused by the advertising of these products, and a third of parents have been found to use follow-on formula for children under 6 months of age. There is no advantage to moving on to follow-on formula, and the WHO suggests potential nutritional risk. In the second six months of life, if babies are not breastfed or receiving breastmilk, a first infant formula should be used as a breastmilk substitute alongside a good variety of foods.

Q. At what age can I use cows' milk as the main drink?

A. After 1 year of age, children should be consuming three meals and two 'mini-meals' a day, and be eating a wide variety of nutrient-dense foods and avoiding salty and sugary foods. (Nutrient-dense foods are foods that contain lots of vitamins and minerals in a relatively small amount of the food.) They are also recommended to drink about 350ml of whole animal milk, or a suitable alternative, a day. If there are concerns about the quantity and quality of food consumed, health professionals may recommend continued use of first infant milk into the second year, but this is rare, and food should be the main source of nutrients for toddlers.

Q. What non-dairy alternatives to cows' milk are suitable from 1 year of age?

A. Any whole animal milk is suitable as the main drink from 1 year of age – cows', goats' or sheep's milk, as long as these are pasteurised. Alternatively, an unsweetened calcium-fortified soya milk alternative, oat milk alternative, hemp milk alternative or nut based milk altenative can be given. These can also be called soya drink, oat drink etc. However care needs to be taken if milk alternatives are used for children under 5 that the diet is energy and nutrient dense as milk alternatives are lower in energy. Some milk alternatives do not provide important nutrients such as riboflavin and iodine that animal milks provide. Seek advice from a health professional if you want to use a milk alternative. Do not give rice milk alternative (also called rice milk drink) to infants or children under 5. For information on non-dairy sources of calcium and milks to choose for children who avoid dairy products, see *Eating well: vegan infants and under-5s*, available from www.firststepsnutrition.org

---

Q. How do toddler milks and growing-up milks differ from whole animal milk?

A. Toddler milks and growing-up milks contain more sugar than animal milk and less of some important nutrients such as riboflavin, calcium and iodine. Manufacturers add some nutrients to toddler milks – such as iron, vitamin D and omega 3 fatty acids – but they do not replace all the nutrients that may have been destroyed in processing. Experts across Europe have agreed that young children do not need fortified milks to obtain particular nutrients. Children who are eating well do not need additional nutrients from fortified milks in their second year and beyond, and there is some evidence that giving lots of extra nutrients in fortified drinks to children who don't need them may be bad for health in the longer term.

Offering sweetened drinks to young children may also contribute to development of a sweet tooth and to overweight in childhood.

Q. Is an infant milk for 'fussy eaters' useful?

A. Periods of fussy eating are common in young children and in most cases resolve themselves if families continue to offer a range of foods, eat with their children and act as a good role model for eating a range of foods. Occasionally a child will have a more serious case of food refusal, and advice should be sought on how to manage this most effectively. Giving a fussy child a sweet milkshake drink will not help them eat better in the long term, and we discourage the use of any fortified milks for this purpose. For information on managing fussy eating, see the factsheet *Sources of information on fussy eating* at www.firststepsnutrition.org

Q. Is home-made infant formula safe to use?

A. No. We do not recommend that anyone attempts to make home-made infant formula. Home-made infant formula may not have an appropriate nutritional composition and therefore may not support proper growth and development. The ingredients themselves, or the way in which they have been prepared, increases the the risk of severe bacterial infection in infants. Unlike commercially prepared infant formula, home-made infant formula are not subject to any compositional standards and their preparation, storage and handling have not been subject to risk assessment and subsequent recommendations for safe usage.

Whilst there is no national guidance in the UK on the use of home-made infant formula, international health authorities in other developed countries do not endorse the use of any home-made infant formula. Healthy infants who are not breastfed, or receiving breastmilk, should only be given commercially prepared first infant formula based on cows' or goats' milk protein. Infant formula based on soya protein or hydrolysed proteins should only be used under medical supervision.

Do you have any more questions? Email helen@firststepsnutrition.org

3 The composition of infant milks

3.1 What are the main differences between breastmilk and infant milks?

Breastmilk is a unique living substance and it is impossible for any manufacturer to recreate it.

Breastmilk is a complex fluid that contains all the nutrients needed by an infant, in forms that are easily absorbed, and contains a range of protective substances tailored to each infant and the environment he or she lives in. Breastmilk contains: substances such as lactoferrin, a protein component that helps babies absorb nutrients and which binds iron in the gut so that pathogenic bacteria are inhibited; immunoglobulins and macrophages which protect the infant from infections; specific fatty acids which promote development; growth factors, anti-viral factors, anti-bacterial substances and living white blood cells. It is estimated that there are more than 100 substances present in breastmilk that are not present in artificial infant milks. In addition the milk feed of each mother changes over time, both within the feed and between feeds, to provide the fluid and nutrients the baby needs. The protective effect of breastfeeding for infants and human populations is fully accepted by all scientific agencies and health departments worldwide.

Just because an ingredient can be isolated from breastmilk and recreated in a laboratory does not mean that that ingredient will have the same benefits, or properties, when put into infant milks. Manufacturers often make claims for ingredients that are similar to those isolated from breastmilk, but frequently these are found to have no benefit, and may potentially be a burden to a young infant's metabolic system.

The European Food Safety Authority *Scientific opinion on the essential composition of infant and follow-on formulae* (EFSA, 2014) made the following important statement:

"Nutrients and other substances should be added to formulae for infants only in amounts that serve a nutritional or other benefit. The addition in amounts higher than those serving a benefit, or the inclusion of unnecessary substances in formulae puts a burden on the infant's metabolism and/or physiological functions as substances which are not used or stored have to be excreted."

An overview of the nutritional composition of, and the bioactive factors in, human breastmilk can be found in the review by Ballard and Morrow (2013).

3.2 What ingredients are used to make infant milks?

The basic components of any infant milk, regardless of the format (powder or ready-to-feed), are proteins, fats, carbohydrates, vitamins and minerals. The major infant formula producers develop their own brands with a combination of each of these components. However, this must be achieved in accordance with the regulatory framework of the Infant Formula and Follow-on Formula Regulations 2007 and any subsequent changes to the directive (if milks fall into those categories), or to regulations related to foods for special medical purposes. The basic nutritional profile of the majority of infant milks is therefore very similar. All milks marketed in the UK must be notified to a Government competent authority (usually The Department of Health in England) before they are put on the market so that the composition (and labelling) can be checked against the regulatory framework.

The majority of infant milks start with a base of cows' milk or goats' milk (skimmed or full-fat, liquid or powder, or using whey protein concentrates) with added lactose or other carbohydrates, vegetable and other oils, vitamins and minerals. About 80% of the base powder for infant formula in Europe is made in Ireland and this base powder uses milk protein, demineralised whey and lactose with added vitamins and minerals and other ingredients from other sources. Other milks may be based on soya protein from soya beans, with added vegetable and other oils and maltose, maltodextrin or glucose polymers, or may be based on hydrolysed proteins. A third category of infant milks are those containing no milk components at all. These include elemental formulas that are based on synthetic free amino acids (the building blocks of proteins). More information about specialised infant milks can be found in *Specialised Milks in the UK: Infants 0-6 months* available at www.firststepsnutrition.org.

Is it important whether infant milks are made from whole or skimmed milk?

Some infant milk manufacturers have replaced some of the skimmed milk in their products with whole milk, and are making claims that this benefits infant health. Whole milk is higher in dairy fats than skimmed milk and one manufacturer has increased the proportion of dairy fat in some of their products by directly adding anhydrous milk fat rather than replacing some skimmed milk with whole milk. Increasing the amount of dairy fat in products - by whichever means - has the effect of reducing the amount of vegetable oil that is needed to achieve the required energy content for growth and development.

Most of the claims made for the use of whole milk and dairy fats in infant milks focus on the differences in fatty acid composition and structure between dairy fat and vegetable oils. Whilst there are more compositional similarities between dairy milk fat and breastmilk fat than vegetable oils and breastmilk fat, there is no evidence to suggest any health benefits for products using some dairy milk fat.

It is important to note that the fat content of breastmilk is highly variable: depending on stage of lactation, time of day and the mother's diet. The fat content is highly complex, providing the primary energy source and having a range of metabolic and physiological functions important for growth and development. It is not possible for infant formula manufacturers to recreate the fat profile of human milk, however, current UK compositional regulations ensure that all infant and follow-on formula provide sufficient amounts, and proportions, of fatty acids for the proper growth and development of infants regardless of the source of fats.

3.3 How are infant milks made?

The manufacturing processes for most powdered milks are very similar. Powdered infant formula is manufactured using two general types of processes: a dry blending process and a wet-mixing / spray-drying process. Some manufacturers use a combination of these processes, and each has different risks and benefits with respect to the potential for product contamination by harmful bacteria.

In the dry blending process, the ingredients are received from suppliers in a dehydrated powdered form and are mixed together to achieve a uniform blend of the macronutrients and micronutrients necessary for a complete infant formula product. Dry blending does not involve the use of water in the manufacturing process, reducing the chance that harmful bacteria will become established in the plant environment in sufficient numbers to cause product contamination. However, the microbiological quality of a dry-blended product is largely determined by the microbiological quality of the constituent dry ingredients. In a dry blending process there is no heat treatment to destroy bacteria in the final product. Thus, if one or more ingredients in a dry-blended product are contaminated by even low numbers of harmful bacteria, these bacteria are likely to be present in the finished product.

In the wet-mixing / spray-drying process, ingredients are blended with water in large batches. The wet product is then homogenised, pumped to a heat exchanger for pasteurisation, and then spray-dried to produce a powdered product. This process has the advantage of ensuring a uniform distribution of nutrients throughout the batch, but some nutrients are destroyed. The pasteurisation step destroys harmful bacteria that may be present in the ingredients, so this process is much less dependent on the microbiological quality of ingredients. However, the wet-mixing / spray-drying process requires that the processing equipment be regularly wet-cleaned. This frequent wet-cleaning provides the moisture needed by bacteria to grow and become established in the plant environment. If not controlled, these bacteria can be a source of product contamination. Some nutrients are added after pasteurisation and the microbiological quality of these nutrients is critical, since the product may not receive further heating sufficient to destroy harmful bacteria.

3.4 Results of surveys of the nutritional composition of infant milks

A survey of the nutrient levels in infant milks by a number of global manufacturers was published in 2009 to provide information on whether infant milks were meeting or exceeding proposed Codex Alimentarius recommendations for minimum values or guidance upper levels (GUL) for nutrients. A large quantity of milk was analysed, and formula met the minimum levels for all nutrients, but levels in some milks were found to exceed the proposed GUL for vitamins A and K, thiamin, riboflavin, niacin, vitamin B_6, folic acid, vitamin B_{12}, vitamin C, iron, copper, manganese, potassium and iodine (MacLean et al, 2009). Data for nutrients showed considerable variability between products, and this reflects the difficulty of manufacturing a product which has to contain suitable amounts of nutrients from time of manufacture to end of shelf-life.

There have been few academic publications which look at the nutritional composition of infant formula relevant to the UK market. A study of mineral elements in infant milks in the UK (Ikem et al, 2002) concluded that the nutritional content of some formula brands were lower than recommended in zinc, magnesium and iron. Ljung et al (2011) analysed formula milks in Poland and reported that concentrations of manganese varied from 10 to several hundred times the amount a breastfed infant would receive, and that this could potentially have adverse health consequences. Very high iron and molybdenum intakes from infant formula were also highlighted as a concern in this study. In contrast, analysis of the selenium content of formula milks available in Europe showed that values are generally lower than found in breastmilk and that soya protein based infant formula had the lowest content (Van Dael and Barclay, 2006).

Analysis of formula milks in Spain (Chávez-Servín et al, 2008) showed that milks had lower amounts of iron (65% of the amount reported on the label) and selenium (73%-80% of the amount on the label) than declared, but higher amounts of vitamins A, E and C (included to allow for losses of these vitamins on storage). Given the complex nature of degradation of some nutrients on storage, the interaction between components, and the availability of a significant number of brands and types of milk, it is surprising that there has been so little consideration of whether the nutritional composition of milks at point of sale is adequate. Levels of the fat soluble vitamins A and D, for example, are likely to be vulnerable to degradation, with limits on how much can be added in milks at point of manufacture.

A more recent study in Italy examined the concentrations of five essential (iron, manganese, zinc, copper and selenium) and four non-essentail elements (chromium, cadmium, nickel and lead) in 35 first infant milks (infant formula, milks marketed for children with allergies and milks marketed for gastrointestinal problems) for children aged 0-6 months (Bargellini et al, 2018). The authors expressed particular concern over the high amounts of iron and manganese present, with estimated daily intakes of iron 18 times higher than the adequate intake and estimated intakes of manganese 23-51 times higher than the recommended intake value. High manganese levels were particularly founds in milks marketed as foods for special medical purposes. The authors recommend an urgent review of the safe levels of fortification of infant milks, potential risks of high intakes and regular monitoring of products.

First Steps Nutrition Trust has asked the companies that market infant milks in the UK to disclose how they analyse infant milks for nutritional composition, what methods they use and how frequently they do this across a product’s shelf life, and to provide results of these anslyses, but we have not been provided with any information.

3.5 Foods for special medical purposes

The term foods for special medical purposes (FSMP) includes all foods which are formulated, processed and intended for the dietary management of diseases, disorders or medical conditions of individuals who are being treated under medical supervision. Some infant milks commonly available fall into this category, and therefore may be designed to meet the regulations related to these foods, rather than to meet the infant formula and follow-on formula regulations.

Specialised infant formula are currently regulated by the FSMP Directive (1999/21/EC) which requires products to be labelled as for use ‘under medical supervision’. These products fall outside the infant formula and follow-on formula regulations and therefore have historically not needed to take into account the importance of restricting advertising and marketing of breastmilk substitutes in line with the WHO *International code of marketing of breast-milk substitutes* (WHO, 1981).

New regulations on Foods for Specific Groups (FSG) (EU 609/2013) were adopted by the European Parliament, the European Council and the European Commission in June 2013 (EU, 2013) and came into force in the UK on July 20th 2016. This new directive outlines some principles on compositon, labelling and marketing of infant milks. The detail of new regulations is however given in the specific delegated act on foods for special medical purposes which companies have until February 2020 to implement. How the UK, and specific regions will work within the new regulations and delegated act over the next few years is unknown, and for this report we are comparing all products with the previous regulations.

A comparison of the current compositional regulations for FSMP compared to infant formula and follow-on formula regulations can be seen in Table 6.

One of the key issues relating to infant milks that fall into this category is that they do not currently have to comply with the national and international recommendations on making infant milks up safely, and may encourage families to use unsafe temperatures which may not kill any harmful bacteria present in the powder. This applies particularly to infant milks marketed as ‘anti-reflux’ milks. For more on this, see section 5.7.

3.6 Energy content of infant milks

The current regulations require infant formula and follow-on formula to have an energy content of between 60kcal and 70kcal per 100ml. These figures are based on the energy content of breastmilk, which has been shown to be in this energy range (Butte et al, 2001, Wojcik et al 2009; Public Health England, 2014). However, the energy content of human milk is only a guide, since the composition of breastmilk changes within each feed, and the fat content of milk varies as the breastfeed progresses. It is thought that this major difference between formula milk and breastmilk contributes to the differences in growth patterns of formula-fed and breastfed infants, with the former growing faster in the first year of life (Koletzko et al, 2009, Hörnell et al, 2013). Faster growth in the first year of life has been associated with a risk of later obesity (Baird et al, 2005; Monteiro and Victoria, 2005). In its recent opinion on the essential composition of infant and follow-on formulae, EFSA (2014) stated clearly that:

"Infant formula cannot imitate breastmilk with respect to its energy and protein content."

As both infant formula and follow-on formula are breastmilk substitutes in the first year of life, the energy content of both types of milk are recommended to be the same. New recommendations from EFSA (2014) suggest that the range should still be between 60kcal and 70kcal per 100ml, but that milk should be designed towards the lower end of this range provided infants are fed 'on demand'. The energy content for FSMP is also currently the same.

3.7 Protein content of infant milks

Key points

Proteins are composed of amino acids, some of which are essential (cannot be synthesised by the human body). The protein requirements of infants have been calculated based on the concentration of amino acids found in mature human milk.

The majority of infant milks available in the UK are based on cows' (bovine) milk protein. Infant milks can be made using soya protein but a higher minimum protein level is recommended, as the biological value is slightly lower than for animal milk. From March 2014, UK legislation on infant formula and follow-on formula milk regulations was amended to allow infant formula and follow on formula to be made from goats' milk protein and hydrolysed proteins. Cows' milk and goats' milk in their raw state contain more protein than human milk and the proteins present differ from human milk in both the ratio of the proteins whey and casein and in the amino acid profile of the proteins present.

There has been considerable discussion in the last few years about the role of lower protein formula in managing weight gain in formula-fed infants, and protein contents of many infant formula are now at the lower end of the EU regulations to reflect this. New claims are being made for particular combinations of amino acids related to weight gain, but little evidence is provided to support this. EFSA (2014) are clear that *'Infant formula cannot imitate breastmilk in respect to it's (energy and) protein content.'*

α-lactalbumin

Some infant formulas contain enhanced proportions of the whey protein α-lactalbumin, which is present in higher amounts in human milk compared to cows' or goats' milk. Insufficient evidence is yet available to support suggestions that lower protein infant formula with higher amounts of α-lactalbumin and some changes to amino-acid content offers the same protection against weight gain or other morbidities as breastfeeding.

Nucleotides

Nucleotides are metabolic regulators and are involved in energy transfer and breaking down large molecules. At times of rapid growth or in disease, the body may not be able to synthesise nucleotides at the rate they are required, and so must rely on dietary sources.

The concentration of nucleotides in cows' milk is considerably lower than in human milk and it is suggested that dietary nucleotides have a role to play in both the immune and gastrointestinal systems. Claims have been made that feeding infants formula supplemented with nucleotides leads to a lower incidence of episodes of diarrhoea and increased plasma antibody response to some immunisations.

The EFSA (2014) *Scientific opinion on the essential composition of infant and follow-on formulae* has made a clear statement that there is no need to add nucleotides to infant and follow-on milk.

Cows' and goats' milk protein and soya protein are the main protein sources of most infant milks, but hydrolysed proteins are also allowable. Proteins are composed of many amino acids, eight of which are essential (cannot be synthesised by the human body), and these must be provided in adequate proportions in the diet.

Goats' milk protein based infant formula

Goats' milk based infant milks were excluded from the European Commission Directive on Infant Formulae and Follow-on Formulae in 2006, on the basis of original recommendations made by the European Food Safety Authority (EFSA, 2006).

In 2012, EFSA revised their conclusion on the suitability of goats' milk as a protein source for infant and follow-on formula milks. Their revision was based on evidence from a new randomised control trial in 200 Australian infants. The new trial included a breastfed reference group and results from biochemical analysis of blood samples. EFSA concluded that there were no relevant statistical or clinical differences in babies fed formula made with either goats' or cows' milk protein, provided it was adapted to meet current compositional regulations. In this study infants were fed the formulas exclusively for 4 months and no differences were found by formula type in terms of adequate weight, length and head circumference. Infants fed on both formula types differed from the WHO growth standards, which are based on breastfed babies, particularly for weight-for length which is usually higher in formula fed babies.

EFSA concluded that protein from goats' milk can be suitable as a protein source for infant and follow-on formula provided the final product complies with the compositional criteria laid down in recommendations (EFSA, 2012). Details of how the formula made from the goats' milk protein used in the trial assessed by EFSA was made and differences between goats' and cows' milk in terms of protein composition are provided in that paper (EFSA, 2012).

EFSA based this conclusion solely on the fact that the composition of formula and follow on formula made from either goats' milk or cows' milk could be adequately adapted to meet the current compositional recommendations. They clearly state that there is no evidence of any difference in 'digestibility' between formula made from goat's milk or cows' milk protein, and that insufficient data to support the belief that the incidence of allergic reactions is lower when feeding goats' milk based infant milks compared with cows' milk based infant formula.

The protein in goats' milk is very similar to that found in cows' milk and most babies who react to cows' milk protein will also react to goats' milk protein. The Department of Health recommends that infants with proven cows' milk protein intolerance who require a formula, can be prescribed an extensively hydrolysed infant formula. Goats' milk based infant milk is also unsuitable for babies who are lactose-intolerant, as it contains similar levels of lactose to cows' milk based infant formulas (Department of Health, 2007).

The European Commission Directive on Infant Formulae and Follow-on Formulae and the Infant Formula and Follow-on Formula (England, Scotland, Wales, Northern Ireland) Regulations (2007) were changed to allow goats' milk protein in infant formula and follow-on formula from March 2014.

Protein requirements

Protein requirements for infants are based on the concentrations of amino acids in mature human milk. The majority of infant formulas are based on highly modified cows' (bovine) milk. Both the protein quantity and protein composition differ between cows' milk and mature human milk. The total protein content of cows' milk is higher than that of mature human milk (3.3g/100ml vs 1.3g/100ml respectively) (Poskitt and Morgan, 2005). Regulations require infant formula to contain an available quantity of each amino acid at least equal to that found in human breastmilk. Whey and casein are the two major proteins of human milk. Whey, the predominant protein source, contains many different proteins and non-protein nitrogen. Colostrum is predominantly whey, and early breastmilk is whey-dominant (60:40), but the proportions of casein and whey become approximately equal later in lactation (Jensen, 1995). Whey and casein are present in cows' milk and goats' milk in different proportions to those found in breastmilk, with casein the predominant protein source (whey:casein ratio typically 20:80). First cows' milk based infant formula generally has an altered whey:casein ratio (60:40) to bring it closer to that found in breastmilk which is whey-dominant. Aptamil First Infant Milk has a whey:casein ratio of 50:50. Formula aimed at 'hungrier babies' has a whey:casein ratio of 20:80.

The predominant whey protein in mature human milk is α-lactalbumin and in cows' milk β-lactoglobulin. α-lactalbumin accounts for 28% of the total protein in human milk and only 3% of the total protein in cows' milk. Infant formula based on cows' milk therefore generally have a lower concentration of α-lactalbumin than human milk. Goats' milk is similar to cows' milk in its composition with respect to whey protein fractions (Haenlein, 2004).

The concentrations of some essential amino acids in cows' or goats' milk are lower than in human milk, and the concentrations of tryptophan and cysteine in cows' milk are approximately half of those in mature human milk (Heine et al, 1991). Therefore, in order for formula milk based on cows' or goats' milk to meet the amino acid requirements of infants, the total protein content of most infant milks has historically been higher than that of breastmilk. A higher minimum protein level is recommended for infant formula using soya protein as this will have a lower biological value and may have lower digestibility (Koletzko et al, 2005). EFSA (2014) has recommended a higher protein content when protein hydrolysates are used in infant milks, but acknowledges that adequacy still needs to be established based on clinical evaluation. The individual amino acids that are required in infant and follow-on formula are based on reference values from human milk analysed by the Scientific Committee on Food in 2003 (SCF, 2003).

Lower protein content and weight gain in infants

It has been reported that a higher protein content in infant formula is associated with higher weight in the first two years of life, although there is no evidence that growth is affected in terms of length or height (Koletzko et al, 2009). The protein content of most formula is now at the lower end of EU regulations, with infant formula milks typically providing a protein content of 1.2g - 1.3g/100ml and follow-on formula providing on average slightly more at 1.4g/100ml across the 4 main cows' milk based brands. It is worth noting that at 1.6g/100ml Mamia infant formula milk has the highest protein content of all the cows' milk based infant milks and at

1.8g/100ml, Mamia follow-on formula has the highest protein content of all the cows' milk based follow-on milks.

Previously formula had protein contents closer to 2g/100ml. The suggested link between body weight and protein content is thought to be higher post-prandial and fasting circulations of branched chain amino-acids in formula-fed infants compared to breastfed infants. Concentrations of these amino-acids are linked to insulin release, which in turn is linked to metabolic alterations which might be mechanisms for weight gain (Trabulsi et al, 2011). Rapid weight gain, upward crossing of growth percentiles and a greater weight-for-length at 6 months have been identified as risk factors for overweight and obesity later in life (Taveras et al, 2009). These two factors are being linked to suggest that lower protein milks may therefore reduce weight gain in formula-fed infants, but whether protein plays a role in increased growth rate and higher BMI in childhood is still a matter of debate and requires more research (EFSA, 2014).

The EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* (2014) has recommended a reduction in the currently permitted maximum protein contents of infant and follow-on formula, from 3.0g/100kcal for infant formula and 3.5g/100kcal for follow-on formula to to 2.5g/100kcal when based on cows' and goats' milk protein, and 2.8g/100kcal when based on protein hydrolysates. Currently many infant formula and follow-on formula on the UK market are at the lower end of the minimum-maximum protein range.

In April 2017, the EFSA Panel on Dietetic Products, Nutrition and Allergies delivered a scientific opinion on *'The safety and suitability for use by infants of follow-on formulae with a protein content of at least 1.6 g/100 kcal'.* This level of protein represents a minimum protein content of around 1.1g/100ml, which is lower than the average for follow-on milk products currently on the market in the UK. The panel concluded that the use of follow-on formula with a protein content of at least 1.6 g/100 kcal (1.1g/100ml) from either cow's milk protein or goat's milk protein and otherwise complying with the requirements of relevant EU legislation is safe and suitable for infants living in Europe with access to complementary foods of a sufficient quality. This conclusion does not apply to infant formula. The safety and suitability of follow-on formula made from either protein hydrolysates or soya protein isolates could not be established with the available data (EFSA, 2017). This change has not passed into UK legislation and the Infant Formula and Follow-on Formula (England, Scotland, Wales, Northern Ireland) Regulations (2007) continue to stipulate a minimum protein requirement of 1.8g/100kcal for both infant and follow-on formula made from either cows' milk protein or goats' milk protein.

In January 2016 SMA launched their reformulated first infant milk as SMA Pro First Infant Milk. This milk claims it has an essential amino acid profile similar to that of breast milk and also that it has the lowest protein content of any infant milk on the market, (although all formula have similar low protein contents and all must contain sufficient of all the amino-acids to meet regulations) however the difference is not sufficiently significant to differentiate it from all other brands and the difference in protein content between it and the brand with the next lowest protein content is only 0.02g/100kcal.

SMA Pro First Infant Milk claims that it contains less of the amino acids that are linked to insulin release or 'insulinogenic amino acids' than Aptamil First Milk. It also states that insulinogenic amino acids are shown to contribute to obesity later in life. There are, however, no articles from peer-reviewed journals to support these claims, and all of the claims above are referenced only as *“on file at Nestlé”.*

SMA Pro First Infant Milk also claims that it promotes a pattern of growth comparable to that of breastfed infants. This claim is supported by reference to a meta-analysis of eleven Nestlé sponsored studies looking at the growth of infants fed with Nan milk with a protein content of 1.8g/100kcal (Alexander et al., 2016). It is not surprising that this study showed that for the breastfed group and for both formula fed groups, pooled group analysis for BMI, weight for age and length for age was within 0.5 standard deviations of the WHO Growth Standard, as the protein levels were within EU regulations for infant formula milks. What the study also showed, however, were statistically significant differences in both growth and rate of growth between the breastfed and formula fed groups. Formula fed infants in both formula groups had greater weight and BMI at age 4 months than the breastfed group. When rates of growth were categorised as slow, gradual and fast there were significantly more infants from the formula fed groups in the fast category and less in the slow category compared to the breastfed group. The number of infants in the gradual growth category was similar between groups. This study does not support the claim that this milk is clinically proven to achieve a growth rate comparable with a breastfed baby.

It is established internationally that infant formula-fed infants grow at a different pace to breastfed infants (Garza and de Onis, 2004). It is unclear whether SMA Pro First Infant Milk is the same milk as the one used in the studies which they say support this claim, currently SMA Pro First Infant Milk has a protein content of 1.87g/100kcal.

3.7.1 α-lactalbumin in infant milks

α-lactalbumin is the predominant protein fraction of human milk included in the whey fraction and is particularly high in tryptophan. The primary limiting factor in reducing the total protein concentration in infant formula is the ability to provide sufficient quantities of essential amino acids. Enriching whey protein fractions in formula with substantially higher concentrations of α-lactalbumin which contains the limiting amino acids tryptophan and cysteine in higher amounts has been one way in which formula manufacturers have achieved lower protein intakes in formula, and these have not shown any impact on normal growth and development (Lien et al, 2004; Trabulsi et al, 2011). The higher proportion of α-lactalbumin in infant milks may be achieved by a fractionation process that removes most of the casein glycomacropeptide from the whey protein thereby increasing the proportion of α-lactalbumin. The food company Arla Foods, which makes formula milk and formula milk ingredients for Denmark, Sweden, Argentina and Germany, launched a report *How infant formula with Lacprodan© Alpha proteins could provide the key to tackling the obesity crisis* (Kvistgaard, 2012), and it is likely that similar claims for ‘a new generation of low protein infant formulas’ that can tackle the obesity crisis will become more common in all markets.

SMA Pro First Infant Milk, Hipp Combiotic First Infant Milk, Kendamil First and Follow-on Milks and Sainsbury's Little Ones First and Follow-on Milks also contain α-lactalbumin enriched whey.

There are manufacturers selling bovine α-lactalbumin whey products making considerable claims about their efficacy that are yet to be substantiated and agreed by scientific committees.

3.7.2 Nucleotides in infant milks

Nucleotides are substances that can be synthesised in the body from amino acids and which form the basis of DNA and RNA. The nucleotides added to formula milk include cytidine-disodium uridine- adenosine-, disodium- inosine-, and disodium guanosine- 5'-monophosphate. These substances are important metabolic regulators, involved in energy transfer and breaking down large molecules for example, and are particularly important in tissues with rapid turnover. Nucleotides are not considered essential in the diet as they can be synthesised in the body, but it is thought that, at certain times (such as during periods of rapid growth or in disease), the process of synthesis of nucleotides may not be able to keep up with demand and that the body relies on dietary sources.

Breastmilk is a source of nucleotides although the amount present is variable and the analysis methods used to determine composition can also be variable. Colostrum has the highest concentration of free nucleotides and during the first four weeks of lactation the concentration falls by about half. Mature human milk contains at least 1.0mg/100ml of free nucleotides, but the total potentially available nucleotide (TPAN) content of breastmilk was determined by Leach et al (1995) to be 7.2mg/100ml. The presence of nucleotides in human milk does not necessarily indicate a specific benefit for infants, as they may also be by-products of milk formation reflecting metabolic activity in the breast, shedding of cells or the occurrence of micro-organisms, without having a specific function for the infant (Scientific Committee on Food, 2003).

Cows' milk contains considerably lower amounts of nucleotides, and the chemical composition of the nucleotides also differ from that of human milk. Heat treatment during infant milk production also degrades the nucleotides present. European regulations permit a maximum concentration of 5mg/100kcal (equivalent to about 3.4mg/100ml) of nucleotides to be added to infant formula on a voluntary basis (with variable amounts for each specific nucleotide).

In the UK, all non-organic standard cows' milk based infant formulas for healthy term infants, with the exception of SMA Pro First Infant Milk powder, are supplemented with nucleotides at around 3.0mg/100ml. Studies examining the clinical effects of nucleotides have used formula supplemented with nucleotides at concentrations ranging from just over 1.1mg/100ml to 7.2mg/100ml and have examined healthy full-term infants, premature infants, small for gestational age infants, and infants living in different environments, so it is not always easy to compare the data.

Studies in infants have suggested that dietary nucleotides may have a role to play in both the immune and gastrointestinal systems. The most frequently reported effects of feeding infants formula supplemented with nucleotides include a lower incidence of episodes of diarrhoea, and increased plasma antibody response to immunisation with *Haemophilus influenzae* type b polysaccharide (Hib) and diphtheria and tetanus toxoids.

Only the SMA Pro liquid formulation of standard infant formula is supplemented with nucleotides at 2.0mg/100ml. SMA no longer mention nucleotides on their website however on previous versions of the website SMA restricted their suggestions for the health benefits of nucleotide supplementation in their standard range of formula milks to a possible improvement in immune function. The clinical trial which SMA referred to on its website used a test formula supplemented with 3.3mg/100ml of nucleotides and was supported by Wyeth Nutrition. This relatively large trial, conducted in healthy term infants, showed a modest improvement in antibody response to tetanus toxoid at 7 months for infants fed the supplemented formula. There was no difference between groups for antibody response to diphtheria toxoid (Hawkes et al, 2006). Whilst an improvement in immune function can be observed, this does not necessarily alter the incidence and severity of infection between groups, and this is not always measured.

The Aptamil range of standard infant and follow-on formulas is supplemented with nucleotides at 3.2mg/100ml. Aptamil supports the use of their product by reference to research which has shown that babies fed formula containing nucleotides have improved growth and enhanced immune systems. In a large 12-month trial by Yau et al (2003), using a test formula supplemented with nucleotides at 7.2mg/100ml, the incidence of diarrhoea and respiratory tract infections and immune response were measured. At 8-28 weeks, infants fed the supplemented formula were shown to have a 25.4% lower risk of diarrhoea than infants fed the control formula. Infants fed the supplemented formula also had higher concentrations of serum IgA throughout the study. Both groups had a similar antibody response to hepatitis B immunisation. Whilst both groups also had a similar incidence of lower respiratory tract infections, the risk of upper respiratory tract infections was 1.13 times higher in the group fed supplemented formula. It is interesting to note that, although the protein and micronutrient profiles of the test and control formulas were very similar, the whey:casein ratios were quite different. The control formula had a whey:casein ratio of 18:82, and the test formula 48:52. Differences in the formula used in trials and between groups in trials make it difficult to interpret evidence related to claimed health benefits.

Cow & Gate supplement their range of standard infant and follow-on formulas with nucleotides at 3.2mg/100ml. However, they do not suggest specific health benefits for the inclusion of nucleotides in formulas for healthy term infants. Kendal Nutricare supplement Kendamil infant formula (3.1mg/100ml) and follow on formula (2.8mg/100ml) with nucleotides but make no claims for this addition.

The studies used to support the use of nucleotides in standard infant formula have shown conflicting results, particularly in respect of their effects on response to specific immunisations. The optimal level of supplementation is also unclear, as a wide range of nucleotide concentrations have been shown to have beneficial effects in term infants. The recent EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* has clearly stated that:

"Taking into account the lack of convincing evidence for a benefit of the addition of nucleotides to infant and/or follow-on formula, the Panel consider that the addition of nucleotides to infant or follow-on formulae is not necessary." (EFSA, 2014).

3.8 Fat content of infant milks

Key points

The fat component of human milk is highly variable and changes according to the duration of a feed, stage of lactation and the dietary habits of the mother. The main function of dietary fats is to supply the body with energy in the form of triglycerides. Fat supplies about 50% of the energy in infants who are exclusively breastfed and is added to infant milks to supply similar amounts. Most infant milks are based on skimmed milk with the fat component coming mainly from vegetable oils, although one brand of infant milk now also contains additional cows' milk fat. Other brands use whole milk rather than skimmed cows' or goats' milk.

The component fatty acids in human milk are different to those in either cows' milk fat or vegetable oils. Manufacturers usually blend a variety of different oils or fats and oils to achieve a fatty acid profile similar to that of human milk. The source of fats and oils used in manufacture must be disclosed and can often change dependent on cost and availability.

Humans can synthesise some long chain polyunsaturated fatty acids (LCPUFA) from simpler fatty acid precursors, but they cannot synthesise the essential polyunsaturated fatty acids linoleic (LA) and α-linolenic acid (ALA), which must be provided in the diet. LA and ALA are present in human milk fat and vegetable oils but not present in cows' milk fat. EU regulations stipulate minimum concentrations of LA and ALA in infant formula milks.

Long chain polyunsaturated fatty acids (LCPUFA)

Arachidonic acid (ARA) and docosahexaenoic acid (DHA) are LCPUFA, found in high concentrations in neural (brain) tissue and the retina of the eye. Mammals including humans can synthesise these ARA and DHA from LA and ALA respectively. Human milk contains small amounts of ARA and DHA but cows' milk, goats' milk and most commonly used vegetable oils do not. EU regulations permit the addition of ARA and DHA to formula milks. This is generally achieved by adding small amounts of fish or fungal and algal (single cell) oils.

Trials which have examined the potential beneficial effects of using formula supplemented with DHA and ARA on visual function and neurodevelopment have had mixed results, but despite this a claim for a beneficial effect of supplemented formula on visual development has been allowed by EFSA. In the recent EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* (2014), however, it is stated that there is currently no conclusive evidence for any effects of DHA on any health outcomes studied beyond infancy. Most infant formula in the UK are now supplemented with LCPUFA and DHA will be a mandatory ingredient in infant formula and follow-on formula when new legislation is introduced in 2016.

Structured triglycerides

The fatty acid palmitate in human milk and cows' milk is more easily absorbed than the palmitate found in the vegetable oils commonly used as a fat source in formula milks. Some formula milk manufacturers use vegetable oils with an altered structure in order to imitate human milk (palmitic acid predominantly esterified in the *sn-2* position), and it has been suggested that this may aid digestion, improve calcium absorption and bone mineral density, growth, stool consistency and blood lipid profiles, and reduce crying episodes in infants. The recent EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* (2014) concluded there was no convincing evidence for a beneficial effect of the use of palmitic acid predominantly esterified in the *sn-2* position in infant or follow-on formula.

Phospholipids

Phospholipids are thought to have an important role in breastmilk in the emulsification, digestion, absorption and transport of fat in the infant gut. However, there is no evidence that using phospholipids in infant formula or follow-on formula has any beneficial effects.

The fat component of human milk is highly variable and changes according to certain factors including the duration of feed, stage of lactation and the dietary habits of the mother (Agostoni et al, 1999). Where infants are exclusively fed on mature human milk, fats supply 50% of their energy. Fats are added to supply 50% of the energy in formula milks, and vegetable oils are typically used. Vegetable oils used include palm oil, rapeseed oil, coconut oil, sunflower oil or other individual oils or blended mixes. Oils from fish and algal/fungal sources and egg lipid are also used. Cows' milk fat is now being added to some infant milks and ithese milks derive a greater percentage of their fat content from milk fat than those based on skimmed milk.

The component fatty acids present in human milk differ to those of either vegetable oils or cows' milk fat. Cows' milk fat has higher quantities of the saturated fatty acids lauric acid and myristic acid, which may impact on serum cholesterol levels and lipoprotein concentrations, and the amount of these fatty acids in formula is restricted. Trans fatty acids are naturally present in cows' milk fat and may have negative health implications in high amounts, so there are recommendations that trans fatty acids should not exceed 3% of total fat content in formula (Koletzko et al, 2005).

Human milk and most vegetable oils are higher in unsaturated fats than cows' milk fat, particularly linoleic and α-linolenic acids. Human milk also contains the long chain polyunsaturated fatty acids (LCPUFAs) arachidonic acid, eicosapentaenoic acid and docosahexaenoic acid. Non-organic infant formula are fortified with LCPUFAs through the addition of small amounts of fish or single cell fungal and algal oils but there is no organic source of these oils available. Structured triglycerides where the palmitic acid has been restructured to imitate that in human milk (through esterification at the *sn-2* position) are also used in some infant formulas. Betapol is a patented synthetic structured triglyceride, which is used in some brands of infant milks.

Whilst most formula milks use a blend of vegetable oils, the specific oils used may vary as worldwide vegetable oil prices fluctuate. Canola oil (also known as food grade rapeseed oil, rapeseed 00 oil, low erucic acid rapeseed oil or LEAR) is a variety of rapeseed oil which has been bred to contain a much lower proportion of erucic acid than standard rapeseed oil. Erucic acid has no known nutritional benefit and observations in animals have indicated potential myocardial alterations. Erucic acid levels in formula should not exceed 1% of fat content (Koletzko et al, 2005).

Prior to 2012 canola oil was widely used as an ingredient in infant formula in Europe, but not in North America due to safety concerns (Rzehak et al, 2011). In 2012, Danone successfully applied to the U.S Food and Drugs Agency (FDA) for GRAS (generally recognised as safe) status for the use of canola oil in infant formula and since then canola oil has become widely used in infant milks in the U.S.

Evidence from a recent randomised control trial considering normal growth of infants fed formula with, and without, canola oil found no differences in weight or length gain between 4 weeks and 7 months of age (Rzehak et al, 2011). Kendamil infant milks and Sainsbury's infant milks are the only infant milks available in the UK that specify the use of canola oil on the ingredients lists of their products. The fat source declared in the ingredients list of infant milks currently sold in the UK are included in the composition tables in section 5.0.

Current regulations (2006/141/EC) for infant and follow-on formula suggest different amounts of fat as a percentage of energy are appropriate for infant and follow-on formula, but the EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* proposes that these should be equal, as both are breastmilk substitutes, and that the fat content should provide a minimum of 40% to a maximum of 55% energy in both infant and follow-on formulae (EFSA, 2014).

3.8.1 Long chain polyunsaturated fatty acids (LCPUFA) in infant milks

Humans have the capacity to synthesise long chain polyunsaturated fatty acids (LCPUFA), from simpler fatty acid precursors. However, they cannot synthesise fatty acids with a double bond at the n-3 or n-6 position and therefore rely on these fatty acids (FAs) to be supplied in the diet. Linoleic acid (LA, C18:2 n-6) and α-linolenic acid (ALA, C18: n-3 LCPUFA) are the most commonly occurring dietary sources of n-3 and n-6 PUFAs (polyunsaturated fatty acids). In mammals these FAs are further metabolised by enzyme systems to LCPUFAs. The most important metabolites of LA are dihomo-gamma-linolenic acid (DHGLA, C20:3 n-6) and arachidonic acid (ARA, C20:4n-6) and those of ALA are eicosapentaenoic acid (EPA, C20:5 n-3) and docosahexaenoic acid (DHA, C22:6n-3) (Lauritzen et al, 2001).

ARA and DHA are the main n-3 and n-6 FAs of neural (brain) tissues and DHA is a major fatty acid in phospholipids of the photoreceptor cells of the retina in the eye. There is evidence to suggest that pre-term infants may have a greater capacity to synthesise LCPUFAs than term infants, but this may still be insufficient to meet the needs of all pre-term infants. Human milk contains small concentrations of DHA and ARA, whereas some infant formulas contain only the precursors ALA and LA and some now have added LCPUFA.

Trials which have examined the potential beneficial effects of using formula supplemented with DHA and ARA on visual function and neurodevelopmental outcomes in either pre-term and/or term infants have had mixed results, and there is a lack of consistency between the recommendations of several expert panels and committees on whether or not infant formula for term infants should contain added DHA and ARA (Koletzko et al, 2001; LSRO, 1998; FAO/WHO, 1994). The report of the Scientific Committee on Food (Scientific Committee on Food, 2003) suggested that, whilst DHA may have a potentially beneficial effect on visual acuity, no consensus could be reached that DHA or ARA, or both, are indispensable nutrients for term infants, nor that a dietary supply is beneficial (Lauritzen et al, 2001; Jensen and Heird, 2002; Lucas et al, 1999). A Cochrane systematic review of the safety and benefits of adding LCPUFA to formula milk for term infants, completed in 1998 and reviewed in 2007, found that feeding term infants with formula milk enriched with LCPUFA had no proven benefit regarding vision, cognition or physical growth (Simmer et al, 2007). These findings have been given further support by the results of a more recent meta-analysis examining the effect of LCPUFA supplementation on infant cognition, which reported no significant effects (Qawasmi et al, 2012).

In 2010, the European Food Safety Authority (EFSA) approved the claim that *"DHA has a structural and functional role in the retina and DHA intake contributes to the visual development of infants up to 12 months of age".* The validity of this claim is still debated, however, as it is argued that visual acuity develops slowly during the early years of life and early observations of visual measurements in infants are not predictive of later visual functions. Studies would have to follow children for seven years or longer to see if small clinical changes observed in early life had any real impact (Chambers et al, 2013). In addition it is argued that, while DHA-supplemented formula may be slightly better than unsupplemented formula, both are likely to be far less beneficial on visual development than optimal breastfeeding and therefore any claims are misleading (Kent, 2012).

The EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* (EFSA, 2014) presents a useful summary of all the evidence relating to fatty acids in human and artificial milks, but concludes that, whilst they still believe that DHA should be added to infant and follow-on formulae in similar amounts as are present in breastmilk as a 'prudent measure':

"There is currently no conclusive evidence for any effects beyond infancy of DHA supplementation in any of the health outcomes studied." (EFSA, 2014)

Longer-term impacts of supplemented milks have not yet been established. PUFAs in infant milk can react with lysine (an amino acid) upon oxidation and this may lead to the production of undesirable compounds such as furfurals (which can modify the nutritional value of proteins and change the taste and smell of milk). There are at present no established limits for furfural concentrations in infant formula, and few studies look at the long-term implications of additions to infant formula. A recent 10-year follow-up of a randomised control trial of DHA-supplemented formula in pre-term infants also found that girls were heavier and had higher blood pressure than the breastfed group (Kennedy et al, 2010), suggesting that the long-term implications of formula additions may not always be known.

A number of infant milks available in the UK contain these long chain fatty acids. The sources of LCPUFAs in Cow & Gate and most Aptamil products are vegetable and fish oils, whilst the sources of LCPUFAs in SMA products are fish and fungal and algal oils. The use of fish oils means that many milks are not suitable for vegetarians. Kabrita goats' milk formula also includes fish oils in their milks. Aptamil Profutura 1 also contains egg lipid.

Hipp Organic has also added LCPUFAs to their products. The sources of LCPUFAs in Hipp powdered formula milk are fungal and algal oils and fish oils, whilst LCPUFAs in the ready-to-feed formula are algal. Supplementation of formula with LCPUFA can increase the retail price by 5%-25% and single cell oils produced by micro-organisms are likely to be the oils of choice commercially in future (Chávez-Servín et al, 2008). There are therefore considerable cost implications for welfare food schemes and families if these fats are considered essential ingredients in all infant formula.

A review by Kent considering how fatty acid use in infant formula has been regulated in the USA concluded that there is inadequate regulation of the use of fatty acid additives such as DHA and ARA (Kent, 2014). It is suggested that infants are exposed to potential risks as manufactured versions of fatty acids have been inadequately tested for safety and efficacy. The same system of allowing additives to be added to formula without systematic assessment by Government is also the case in the UK.

3.8.2 Structured triglycerides in infant milks

The function of fatty acids is impacted not only by their chain length, but also by the structure and position of the fatty acids in the triacylglycerol molecule. The fatty acid palmitate accounts for about 25% of the fatty acids in human milk and about 70% of this palmitate is attached in the middle (*sn-2*) position of the triacylglycerol molecule. The palmitate in cows' milk fat is also mainly attached in the middle (*sn-2*) position. The advantage of this position is that, when the enzyme pancreatic lipase cleaves the fatty acid molecules at the *sn-1* and *sn-3* positions, the palmitate is still attached to the glycerol backbone and, along with the freed fatty acids, can be easily absorbed through the intestine. In vegetable oils, which are the main source of fats in standard formula milks, the palmitate is predominantly in the *sn-1* and *sn-3* positions so that, when hydrolysed by lipase, it becomes free palmitate in the intestine. Free palmitate can form complexes with calcium and these complexes are poorly absorbed (Kennedy et al, 1999). Their formation may reduce the amount of energy available from fatty acids and reduce calcium absorption due to bound calcium being excreted from the intestine. This may also have the effect of hardening the stools, leading to constipation and colic.

Betapol is a structured vegetable oil manufactured by Loders Croklaan for use in infant formula, where 40%-70% of the palmitic acid is attached at the *sn-2* position. Cow & Gate was the first formula milk in the UK to introduce Betapol to their milks in the early 2000s and its use appears to have been confined to formula designed to relieve minor digestive problems. Evidence suggested as showing efficacy of Betapol in aiding constipation and improving calcium absorption was taken from a number of studies. In a double-blind, randomised clinical trial using formula milk supplied by Nutricia, 203 term infants were randomly assigned to receive one of two formula milks, each with a similar concentration of palmitate as a percentage of total fatty acids (Kennedy et al, 1999). The test formula contained synthetic triacylglycerol (Betapol) with 50% of the palmitate in the *sn-2* position. In the control formula 12% of the palmitate was in the *sn-2* position. A control group of 120 breastfed infants was included in the study. The study concluded that changing the stereoisomeric structure of the palmitate in infant formula resulted in higher whole body bone mineral content, reduced stool fatty acids and softer stools, more like those of breastfed infants. Improved fatty acid and calcium absorption were also recorded in similar studies by Carnielli et al (1996) and Lucas et al (1997) for term and pre-term infants respectively. However, EFSA (2014) reviewed all these studies in their expert review and reported that there was no benefit for infant health from the addition of palmitic acid predominantly esterified in the sn-2 position.

Other studies have provided no evidence of efficacy despite being cited by industry. A study by Bongers et al (2007) found no significant difference in defecation frequency or constipation, and in one study a number of parents reported concern about runny stools after feeding formula containing Betapol to their babies (Kennedy et al, 1999). SMA made claims about reductions in crying times related to the use of milks with structured triglycerides, but no published evidence supports this, and the recent EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* (EFSA, 2014) considering all the evidence available and claims made concluded that:

"There is no convincing evidence for beneficial effects of the use of structured triglycerides with palmitic acid in the predominantly sn-2 position in infant and/or follow-on formula."

Whilst Nutricia and, more recently, SMA have supported clinical trials examining the nutritional efficacy of products containing Betapol, they do not market their products as containing Betapol, and SMA tell us that this may not always be the source of the structured vegetable oils included. The structured vegetable oils are variously referred to in marketing literature as a '*special vegetable fat blend'*, a '*new fat blend'* or '*SN-2 enriched fat blend'*. There is, however, greater consistency in the ingredients lists and all products list structured vegetable oils or beta-palmitate in their ingredients lists.

It is interesting to note that some manufacturers are citing the same references as evidence for the benefit of cows' milk fat added to infant formula as they did previously for these structured synthetic vegetable oils.

3.8.3 Phospholipids

In breastmilk, phospholipids act as fat globule membranes and have a high content of long chain polyunsaturated fatty acids compared to the fats in the core of the milk globule (Abrahamse et al, 2012). Phospholipids in breastmilk play a role in the emulsification of fat in the infant gut, promoting digestion, absorption and transport, and so it has been suggested that infant formula could supply long chain polyunsaturated fatty acids in phospholipids, rather than as triacylglycerol (Abrahamse et al, 2012). However, the recent EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* (EFSA, 2014) reports that there is no convincing evidence for a beneficial effect of using long chain polyunsaturated acids supplied as phospholipids.

3.8.4 Anhydrous milk fat

Anhydrous milk fat is simply milk fat (butter fat) that has had all water removed. Aptamil Profutura 1 First Infant Milk makes claims that the use of anhydrous fat in this product aids fat and calcium absorption. These claims are supported by two references, firstly a study by Jensen et al (1978) which reports on the variable composition of human milk in relation to maternal diet, and highlights the lack of reliable data at that time on milk composition, but offers no support to the claims made. The manufacturers also reference the Carnielli et al

1996 study which is also used to support claims that the manipulation of fats (changing the stereoisomeric structure to increase the amount of palmitate in the *sn-2* position) improves fat and calcium absorption.

3.9 Carbohydrate content of infant milks

Key points

Lactose is the main source of carbohydrate in all animal milk and is present in most infant milks either from the milk base used, or because it has been added back to a milk made up from its constituent parts.

Most infant milks for sale in the UK have lactose as the main source of carbohydrate, but a number of other carbohydrates are permitted depending on the type of formula and the protein source, and pre-cooked starch and gelatinised starch free from gluten are also permitted in limited amounts.

Soya protein based formula have glucose syrups added, and some milks contain maltodextrins which can be used in all infant and follow-on formula within maximum amounts. Milks marketed as 'lactose-free' have the lactose replaced by glucose syrups and are considered foods for special medical purposes, which should be used under medical supervision.

Milks marketed for older infants and children generally have a higher carbohydrate content than whole animal milk, and are permitted to contain sucrose and fructose as well as other sugars. These sweetened milks should be avoided for normal healthy children over 1 year of age.

Prebiotics are non-digestible carbohydrates added to milk in an attempt to mimic the complex mixture of oligosaccahrides found in breastmilk. There is insufficient evidence for beneficial effects on infant health of the addition of oligosaccharides to infant milks. (oligosaccharides are often called FOS or GOS by companies.)

Lactose is the major carbohydrate of human milk and cows' milk and provides about 40% of the energy. It is also the main source of carbohydrate in the majority of infant milks. In order to achieve the desired level of carbohydrate in infant milks, lactose is usually added back to the skimmed milk powder base. Lactose has beneficial effects on gut physiology including prebiotic effects, softening of stools, and effective absorption of water, calcium and sodium (Koletzko et al, 2005). Human milk does not contain sucrose or fructose, but contains small amounts of sugar alcohols, including inositol (see section 3.11.2). It is interesting to note that under new definitions of 'free sugars' provided by Public Health England, if lactose is added to foods this is now considered a free sugar (Swan et al, 2018).

Fructose cannot be added to infant formula in the EU, and sucrose can only be added to infant formula made from protein hydrolysates if less than or equal to 20% of total carbohydrate. The use of fructose and sucrose are restricted as they could cause serious illness and death in young infants with hereditary fructose intolerance. Whilst hereditary fructose intolerance is rare, it could affect up to 1 in every 20,000 infants and as it can be fatal, fructose is not allowed in formula for infants under 6 months of age (Koletzko et al, 2005).

The consumption of sucrose and fructose by healthy infants does not have any advantage over the consumption of lactose and may, because of their greater sweetness, increase the preference for sweet tastes in infants (EFSA, 2014).

Glucose is generally not considered suitable for routine use in infant formula. However, some infant milks marketed for children with lactose intolerance, and soya protein based milks, may have added glucose or glucose syrups, to achieve the desired energy intake with an acceptable level of sweetness. Infant milk with glucose as the main carbohydrate is likely to contribute to higher levels of dental decay in infants (Grenby and Mistry, 2000).

Maltodextrin is frequently used in infant milks as a carbohydrate source and is mainly derived from maize (corn) or potatoes. Maltodextrin is produced from starch by breaking up the carbon chains to change its structure. Maltodextrin is easily digestible, being absorbed as rapidly as glucose in the body, and can be either moderately sweet or almost flavourless. It is commonly used as an ingredient in a wide variety of processed foods, particularly where bulk without sweetness is needed at low cost.

Starch is permitted in small amounts in infant formula and despite lower levels of pancreatic α-amylase in an infant's duodenum compared to an adult's, it is suggested that infants aged from 1 to 5 months are able to digest 10g-25g starch a day (EFSA, 2014). A study on infants 3-4 weeks of age given precooked corn starch showed that more undigested carbohydrate reached the colon compared to when glucose or glucose polymers were the source of carbohydrate (Shulman et al, 1983). The EFSA panel (2014) noted that there are considerable uncertainties about the amount of starch that can be tolerated by newborns.

A discussion of sugars in growing-up milks can be found in section 5.13.

The EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* recommends that a minimum carbohydrate content of 9g/100kcal, and a maximum content of 14mg/100kcal, should apply to all infant and follow-on formulae (EFSA, 2014).

3.9.1 Prebiotics in infant milks

Key points

Prebiotics are non-digestible carbohydrates that may stimulate the growth and/or activity of one or more of the bacteria in the colon. Bifidogenic prebiotics stimulate the growth and activity of beneficial bacteria. Human milk contains over 200 oligosaccharides, which are thought to have a bifidogenic effect on the colonic microflora of infants, protecting them from hazards in their specific environment.

A mixture of a small number of fructo-oligosaccharides (FOS) and galacto-oligosaccharides (GOS), which have been shown to have a bifidogenic effect in adults, have been added to infant formula in an attempt to reproduce the bifidogenic activity of breastmilk.

Some trials claim to have shown health benefits. However, the European Food Safety Authority has found that evidence linking consumption of formula milks containing added FOS and GOS with a strengthened immune system are insufficient to make a health claim. The recent EFSA (2014) *Scientific opinion on the essential composition of infant and follow-on formulae* clearly states that:

"There is insufficient evidence for beneficial effects on infant health of the oligosaccharides that have been tested to date in RCTs when added to infant or follow-on formula."

Prebiotics are non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth and/or activity of one or several bacteria in the colon and by so doing improve host health (Gibson and Roberfroid, 1995). Colonic bacteria produce a wide range of compounds which may have both positive and negative effects on the host. The bacterial genera *Bifidobacterium* and *Lactobacillus* are generally accepted as being among the beneficial species of gut bacteria. *Staphylococci* and *Clostridium* are considered pathogenic and *Enterococci, Bacteroides* and *Streptococci* are amongst the genera considered to have both beneficial and harmful effects (Gibson and Roberfroid, 1995). There is evidence to suggest that postnatal immune development may be altered by influencing the constitution of gastrointestinal bacterial flora (Moro et al, 2006).

Human breastmilk contains over 200 different oligosaccharides, which account for approximately 1% of its composition, and different mothers produce different sets of human milk oligosaccharides (Petherick, 2010). The complex mixture of oligosaccharides present in human milk is thought to have a bifidogenic effect on the colonic microflora of infants to protect them from the specific hazards in their environment. Infant formula made from cows' milk is virtually free of prebiotic oligosaccharides (Costalos et al, 2008). It has been shown that the colonic microflora of infants fed on human milk is dominated by *Bifidobacterium*, while that of formula-fed infants is more diverse with *Bifidobacterium*, *Bacteroides, Clostridium* and *Streptococci* all prevalent (Yoshiota et al, 1991).

Simple mixtures of long-chain fructo-oligosaccharides (FOS) and galacto-oligosaccharides (GOS) can be produced commercially from lactose and sucrose are added to in infant formula in an attempt to reproduce the bifidogenic activity of breastmilk (Moro and Arslanoglu, 2005). Whilst FOS and GOS cannot mimic the complex oligosaccharide content of breastmilk, they have a similar molecular weight and high galactose content to oligosaccahrides found in breastmilk.

Immunofortis is a patented mix of prebiotics that was used by Milupa in their Aptamil infant and follow-on formula, but which is no longer named as such on their products. The specific blend of oligosaccharides used was subject to a wide range of clinical trials carried out by or sponsored by the then parent company Numico. (Numico no longer exists; the parent company is now Danone.) Aptamil products now say that they contain a patented blend of GOS (90%) and FOS (10%).

A large number of pieces of research were compiled by companies promoting formula with added prebiotics to show health benefits. Research used to support the previous use of

Immunofortis came from a number of studies, including a study of healthy term infants who had a parental history of atopic eczema, allergic rhinitis or asthma (Arslanoglu et al, 2008). Mothers who started formula-feeding within the first two weeks of life (and had ceased to breastfeed by 6 weeks of age) were recruited, and 134 infants either in the test formula or placebo group were followed for two years. Those infants who were fed in the first six months of life with a formula containing extensively hydrolysed proteins and prebiotic oligosaccharides had significantly fewer infections (as diagnosed by a doctor), fewer episodes of fever (as recorded by parents), and fewer incidents of atopic dermatitis, allergic wheezing and urticaria. However, this research may not be generalisable to all infants and, although differences between the groups were significant, the actual reductions in episodes of illness in some cases was small (for example, a mean of 0.5 episodes of ear infection among the supplemented groups, compared with a mean of 0.7 among the placebo group). Cow & Gate products use the same prebiotic mixture as Aptamil products and also call it a blend of GOS and FOS.

In February 2010, the European Food Safety Authority (EFSA) refused to allow the health claim for prebiotics in infant formula put forward by Danone. EFSA found insufficient evidence linking consumption of Danone's Immunofortis prebiotic formula and a claim to *"naturally strengthen the baby's immune system".* This ruling applies to infant milk products for babies up to 12 months of age. EFSA also reported that they found Danone's 30-trial dossier "*wanting for containing limited, inconsistent and irrelevant trial data*".

Prebiotics have been added to Hipp Organic formula milks since January 2010. The prebiotic mixture used contains only galacto-oligosaccharides and no clinical trials using their reformulated product have been completed to date. Galacto-oligosaccharides have also been added to Kabrita goats' milk based formula milks.

The only SMA milks with oligosaccharides added are SMA Pro Infant and Follow-on milk powders. They have previously suggested on their website that enriching formula with α-lactalbumin has been shown to have a prebiotic effect by increasing the development of a *Bifidobacteria*-dominant flora. This suggestion was supported by a single journal abstract which described a prospective study carried out by Wyeth, USA, in which 154 healthy term infants were randomised to receive formula enriched with either α-lactalbumin or α-lactalbumin and fructo-oligosaccharide. After eight weeks the faecal flora of both groups were similar to that of infants fed human milk (Bettler and Kullen, 2007). In order for a foodstuff to qualify as a prebiotic, it must induce luminal or systemic effects that are beneficial to the host health (Gibson and Roberfroid, 1995). In this instance, a bifidogenic effect was observed, but no evidence of beneficial effects to host health were recorded and therefore it was incorrect to suggest that α-lactalbumin has a prebiotic effect.

The EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* (EFSA, 2014) notes that most of the studies which investigated the effect of non-digestible oligosaccharide addition to formula had considerable limitations, including a high drop-out rate, lack of consideration of missing values, unclear sequence generation, unclear achievement of allocation, concealment and/or blinding. EFSA (2014) has concluded, as have previous EFSA panels considering health claims, that there is no evidence for health benefits from the addition of prebiotic oligosaccharides to infant or follow-on formula. Despite this, many claims are still made on both family and health professional websites and in health professional literature about the benefits of adding prebiotics to infant milks. In the UK, Holle Organic Infant Formula 1, Kendamil Mehadrin First Infant Milk and Kendamil Organic First Infant Milk are the only cows' milk based powdered infant milks that do not contain added oligosaccharides.

3.9.2 Human Milk Oligosaccharides (HMO) in infant milks

Analogues of the oligosaccharide 2'-fucosyllactose (2'-FL) found in human milk have only become commercially available relatively recently. Whilst these analogues are referred to as Human Milk Oligosaccharides (HMO), they are not sourced from human milk but may be produced by microbial fermentation using genetically engineered micro-organisms including strains of E. coli and yeast. Currently, 2'FL-HMO is not added to any infant formula available in the UK, but it may be a potential new ingredient in the future. It has been added to Similac formula in the USA where it is marketed as supporting infant immune systems. Abbott reference their own clinical trial in healthy, term infants, to support their claims including that:

'2'-FL HMO circulates throughout baby's body.'

'supports the immune system in the gut.' and that

'Similac with 2'-FL HMO helps support baby's developing immune system by closing five gaps in immune function between formula-fed and breastfed infants.'

Whilst the clinical trial reported some similarities in rates of absorption of 2'FL-HMO at day 42 of the trial between breastfed infants and those fed supplemented test formula, these similarities were no longer apparent at day 119, and differences were reported in how 2'FL-HMO was absorbed and excreted between the groups but no clinical advantage was shown (Marriage et al 2015).

A smaller study reported that cytokine concentrations in plasma, for half of the cytokines measured, were similar between breastfed infants and infants fed test formulas but different to infants fed an unsupplemented control formula. When ex vivo cytokine production was tested, no differences were found between any of the groups for production of 5 cytokines, with the exception of the group fed formula supplemented with the lower level of 2'FL-HMO where production of 3 cytokines was lower than it was for the control formula group. Results from further biomarkers of immune function including circulating lymphocyte populations, immune cell proliferation, cell cycle analysis and respiratory syncytial virus (RSV) load did not suggest that infants consuming formula milk supplemented with 2'FL-HMO could develop immune function similar to that of infants fed human milk (Goehring et al., 2016).

We are concerned that the term human milk oligosaccharide is an extremely misleading term since the oligosaccharides are not derived from, or are in any way comparable, to the oligosaccharides found in human milk. We would encourage people not to use the term human milk oligosaccharides as this has now become a marketing term.

3.10 Vitamins and minerals in infant milks

Key points

Vitamins and minerals are micronutrients, the majority of which cannot by synthesised by the body and which must be provided in the diet regularly. Some vitamins and minerals are more easily absorbed from human milk than from formula milk and are added to formula milks in higher amounts to compensate for this.

European regulations currently set minimum and maximum levels of vitamins and minerals that must be present in infant formula and follow-on formula, but the recent EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* (2014) proposes only minimum values, which should be understood as target values. Both minimum and maximum figures will, however, be included in the new EU regulations.

Some vitamins and minerals deteriorate during storage, so the length of time milks are stored will impact on the amount of vitamins and minerals available. This highlights the need for regular monitoring of the composition of formula milks available to buy 'off the shelf' in the UK.

There is some concern that high iron intakes in infants may impact on growth and immune function, as high iron intakes can impact on zinc and copper absorption.

Claims are made that milks for older infants and toddlers are important for providing enough iron and vitamin D in the diet, but there are no recommendations in the UK for the use of either follow-on formula or growing-up milks in healthy children.

Vitamins and minerals are micronutrients – substances that are essential in the diet in minute quantities for growth, maintenance and functioning. Most vitamins cannot be produced by the body and must therefore be provided in food. Vitamins and minerals in breastmilk are generally considered to be absorbed more efficiently than those in infant milks, and therefore more has typically been added to infant milks than would be found in breastmilk, to allow for reduced absorption levels. The bioavailability of calcium and zinc are known to be significantly less in infant milk compared to breastmilk and some other micronutrients may also have lower bioavailability in formula milk, but data showing lower bioavailablity for some elements such as copper has been disputed (Koletzko et al, 2005). Low iron bioavailability from infant milks has long been assumed. It has been suggested that iron absorption from both breastmilk and infant formula is about 15%-20% (Koletzko et al, 2005), but other expert groups suggest that absorption from human milk is nearer to 50% and from formula 7%-14% (EFSA, 2014).

As some vitamins and minerals can be harmful if supplied in excess, the European Commission Directive on Infant Formulae and Follow-on Formulae currently specifies minimum and maximum levels of vitamins and minerals that must be present in infant and follow-on formula milks (see Table 2). However, the recent EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* suggests only minimum 'target' amounts (EFSA, 2014). Some minerals and trace elements are added to infant milks, but some micronutrients and other elements will be present within the raw ingredients used in the milks themselves. As some vitamins deteriorate during storage, infant milk has to allow for this in the amounts added at manufacture, or include additives that reduce the deterioration. There has been a suggestion by the FAO/WHO Codex Alimentarius Committee that:

"Whenever foods are given to infants under 12 weeks of age, they should be made up from fresh ingredients every day, as infants may not have developed to a point where they are able to cope with substances used to prolong shelf-life that present no problem to adults" (Codex Alimentarius Committee, 2006).

This is obviously not possible, but highlights the fact that additives used for preservation in infant formula are unregulated in relation to their effects on infants. It has also been suggested that babies given the freshest milks might get dangerously high doses of some vitamins, and those getting products stored for long periods might get dangerously low doses (Koletzko and Shamir, 2006). Requests to infant milk manufacturers in the UK to explain how they manage micronutrient contents of milk over time, and how frequently milks are analysed to ensure levels are always safe, have been made, but no manufacturer has as yet provided any information on this.

A summary of information relating to all micronutrients in human milk and the rationale for decisions made on the essential composition of infant and follow-on formula can be found in the recent EFSA scientific opinion (EFSA, 2014). Below we highlight a number of micronutrients where we feel there are specific interesting points to make.

3.10.1 Calcium in infant milks

Calcium is an integral part of the skeleton where it has a structural role, and calcium is needed for bone rigidity, strength and elasticity. Calcium deficiency in children leads to inadequate growth and bone deformity. Calcium is present in breastmilk at a level of about 20-30mg/100ml. Calcium absorption efficiency from breastmilk is suggested as about 58%, compared to about 38% from milk-based infant formula in the first four months of life, although other research has suggested breastmilk absorption as high as 76% and absorption from infant formula based on milk protein and hydrolysed protein of around 60% (EFSA, 2014). Absorption will vary depending on formula type and the infant's age. The new minimum (target value) for calcium in infant and follow-on formulae of 50mg/100kcal reflects the potential differences in calcium absorption between breastmilk and formula milk.

It is interesting to note that there are some anomalies between levels set by the European Commission Directive on Infant Formulae and Follow-on Formulae and the UK national dietary recommendations. All infant formulas available in the UK contain levels of calcium that are within the levels set by the Directive. However, the UK dietary reference values set the estimated average requirement (EAR) for calcium for formula fed infants aged 0-12 months at 400mg/day and the reference nutrient intake (RNI) (which meets the needs of 97.5% of the population) at 525mg/day (Department of Health, 1991). Based on a typical first infant milk containing about 50mg calcium/100ml, an infant would be required to consume about 800ml of formula milk a day to achieve the EAR calcium intake, or about 1050ml a day to meet the RNI. Based on Royal College of Nursing feeding guidelines for infants by age, the EAR could be achieved on average at 6-8 weeks and beyond, but the RNI not until 4-5 months and beyond.

3.10.2 Iron in infant milks

During the first six months of life, infants can obtain sufficient iron from breastmilk or from an appropriate infant formula. There has been considerable discussion about the optimum level of addition of iron to formula and follow-on formula milks, and about the absorption efficiency. The estimate for absorption efficiency of iron from formula currently used by EFSA (2014) is 7%-14%, with an average of around 10%, taken from Quinn (Quinn, 2014). EFSA (2014) also suggest that absorption of iron from human milk could be around 50%, but that this may be lower.

The current minimum and maximum standards for iron in formula milk are 0.3mg-1.3mg/100kcal. Average first milks in the UK contain about 0.6mg/100ml, which is almost 10 times higher than the amount found in mature breastmilk. The new EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* (EFSA, 2014) has set minimum (target) values for iron in infant formula at 0.3 mg/100kcal (0.2mg/100ml) and for follow-on formula at 0.6mg/100kcal (0.4mg/100ml). However, they suggest that, if the same formula is to be used from the first months of infancy and be suitable for the whole of the first year, the minimum iron content should be 0.6mg/100kcal for milk-based formula (with higher amounts suggested where milks are made from protein hydrolysates).

There is now much greater consideration of the potential risks associated with too much iron, which is a potent pro-oxidant and which, in contrast to other nutrients, cannot be actively excreted by humans. The regulation of iron absorption is immature in infants and does not reach adult status until after 9 months of age (Dömellof et al, 2002), which means that, whatever amounts of iron are given, they will be absorbed and accumulated, raising the risk of iron overload. The adverse affects on growth observed when high iron is given to infants may be due to interactions with zinc, and this could also impact on the immune system and be related to infection risk (Koletzko et al, 2005; Iannotti et al, 2006).

There is some evidence of lower copper status and copper absorption in infants fed formula with a higher level of iron (Lönnerdal and Hernell, 1994). There is also some evidence that excessive iron intakes may result in both a reduced uptake of trace metals including copper, and oxidation of lipids, due to the pro-oxidant effects of excess iron (Aggett et al, 2002a). There is evidence of an impact of high iron intakes in children aged 4-9 months who have adequate iron status on growth and on incidence of diarrhoea (Dewey et al, 2002), and a number of other studies have reported impacts of high iron intakes in iron-replete children on growth (Idjradinata et al, 1994; Majumdar et al, 2003; Lind et al, 2008).

EFSA (2014) suggests the following:

"Studies support that the absorption of iron cannot be down-regulated before the age of nine months with a risk for overload in those infants with sufficient iron stores but high iron

intakes. Iron replete infants might therefore be at risk of negative health consequences if given extra iron."

Follow-on formula are currently allowed to have iron contents of between 0.6mg/100kcal and 2.0mg/100kcal, with most brands having a content of about 1mg/100ml. A study in Chile among a sample of infants aged 6-12 months who received little additional iron from complementary foods given fortified formula with either 0.2mg iron/100ml or 1.3mg iron/100ml reported no significant difference in iron deficiency anaemia between the groups (Walter et al, 1998). This suggests that formula with a relatively small amount of iron appear to prevent iron deficiency anaemia. By 6 months of age in the UK, infants will also be receiving other foods, and many of these complementary foods will also be iron-fortified, so there is considerable potential for very high iron intakes. The new EFSA (2014) *Scientific opinion on the essential composition of infant and follow-on formulae* recommends a target (minimum) value of 0.6mg iron/100kcal for follow-on formula, which is equivalent to about 0.4mg iron/100ml (EFSA, 2014).

Follow-on formula have been vigorously marketed as a good source of iron for older infants, but it is agreed that there is no need, and potential risk, from the use of follow-on formula (WHO, 2013) and that it offers no advantage over standard infant formula after the age of 6 months (Moy, 2000). A recent large study from Chile, which looked at the impact of iron-fortified formula in infants aged 6-12 months on a range of cognitive and learning outcomes at 10 years of age, showed that iron-replete infants given iron-fortified formula did significantly less well in terms of long-term development than similar infants given low-iron formula, or iron-deficient infants given high-iron formula (Lözoff et al, 2011).

Current UK infant feeding guidelines recommend that complementary foods introduced alongside breastmilk in the second six months should include iron-rich foods and that the introduction of cows' milk, which has a lower iron content than breastmilk, should be postponed until 12 months of age. There is some evidence that high iron intakes among iron-replete toddlers may actually have an adverse effect on growth (Idjradinata et al, 1994) and a large trial of nearly 500 infants and toddlers given follow-on formula between 9 and 18 months of age in the UK found that there were no developmental or growth advantages in children given iron-supplemented follow-on formula (Morley et al, 1999). Whilst there may be nutritional and health advantages to continuing formula milk intake into the second year for those infants considered at high risk of iron deficiency because of poor diet or other difficulties, it is advised in the UK that first (whey-based) formula remain the milk of choice during the first year of life if babies are not breastfed. As shown in Table 2, all first infant formula currently provide adequate iron for the whole of the first year of life, based on new EFSA (2014) guidelines.

Infant formula based on soya protein will contain phytic acid and this may inhibit iron absorption (Hurrell et al, 1992). The minimum and maximum levels of iron in soya protein based formula must therefore be about 1.5 times higher than in those based on cows' or goats' milk protein.

TABLE 2
Iron content of major-brand first infant formulas suitable from birth and follow-on formulas marketed from 6 months of age, compared to the 'target' nutrient values proposed by EFSA (2014)

Nutrients per 100ml by milk type	**Energy** kcal	**Iron** mg	**EFSA target (2014)** mg/100ml	**EFSA target (2014) if milk used throughout first year** mg/100ml
Aptamil 1 First Milk	66	**0.6**	0.2	0.4
Aptamil 2 Follow-on Milk	68	**1.1**	0.4	0.4
Aptamil Profutura 1 First Infant Milk	66	**0.5**	0.2	0.4
Aptamil Profutura 2 Follow-on Milk	68	**1.0**	0.4	0.4
Cow & Gate 1 First Infant Milk	66	**0.5**	0.2	0.4
Cow & Gate 2 Follow-on Milk	68	**1.0**	0.4	0.4
Hipp Organic Combiotic First Infant Milk	66	**0.5**	0.2	0.4
Hipp Organic Combiotic Follow-on Milk	70	**1.0**	0.4	0.4
SMA Pro First Infant Milk	67	**0.7**	0.2	0.4
SMA Pro Follow On Milk	67	**1.0**	0.4	0.4

3.10.3 Vitamin D in infant milks

Vitamin D is essential for bone health in infancy. Current UK Government advice is that pregnant women in the UK take vitamin D supplements in pregnancy and when breastfeeding and that breastfed babies receive 8.5-10µg of vitamin D as a supplement from birth as a prudent measure. Vitamin D is added to infant milks in the form of vitamin D_3 (cholecalciferol), and infant formula provides enough vitamin D for the first year of life if infants are receiving 500ml or more per day. The proposed minimum (target) vitamin D content for infant and follow-on formula is 2µg/100kcal (EFSA, 2014).

Manufacturers of fortified milks for children over 1 year of age suggest in marketing material that these milks can protect children at risk of low vitamin D intakes, and correctly point out that vitamin D is likely to be available in limited quantities in many toddler diets. It is, however, recommended that all children aged 1-4 years in the UK have daily vitamin drops containing vitamins A, C and D and these are available through the Healthy Start scheme in many areas (www.healthystart.nhs.uk). In addition, it is recommended that babies and children spend some time safely outside in the summer sun (following guidance on sun safety) as they will make some vitamin D through the action of summer sunlight on the skin. The use of fortified milks for children over 1 year of age is not recommended in the UK, as these milks are high in sugar and can be low in some other nutrients that milk importantly provides (see section 5.13).

Koletzko and colleagues at the Early Years Nutrition Academy suggest that in many areas there are concerns over the vitamin D status of older children and that a higher maximum vitamin D content for follow-on formula may be useful (Koletzko et al, 2012). However, they make the point that, where there are vitamin D supplementation programmes in place, the vitamin D content of follow-on formula should be below maximum values. The new EFSA (2014) scientific opinion makes no differentiation between infant and follow-on formula in terms of vitamin D content recommendation. Most follow-on formula currently have two to three times the amount of iron compared to the EFSA minimum (target) value (EFSA, 2014).

3.11 Other ingredients in infant milks

3.11.1 Choline

Choline is found in a number of forms in human milk, and the choline content of human milk is influenced by maternal choline intake. It is synthesised in the body, and the extent to which it is a required dietary component under normal circumstances is unclear. Choline serves as the precursor for the synthesis of phosphatidyl choline (PC), the main phospholipid in brain, liver and other tissues. PC plays a role in normal membrane composition and signalling processes, lipid metabolism, and normal brain development. As it is essential, and the potential for impaired synthesis or increased needs are not clear, it remains an obligatory input to infant formula. EFSA (2014) recommends a minimum content of 25mg/100kcal in infant formula, but does not consider the addition to follow-on formula necessary.

3.11.2 Inositol

Inositol is an essential growth factor which is synthesised in the body but may need to be provided in the diet under certain conditions. Inositol is present in high concentration in human milk, and decreases over the course of lactation. Inositol levels in blood are high among neonates, leading to the suggestion that inositol plays an important role in early development (Scientific Committee on Food, 2003) and as the amount of endogenous synthesis in infants is unknown, legislation has previously given minimum and maximum levels for inositol in infant formula suitable from birth. EFSA (2014) agrees that inositol should still be added to infant formula at 4mg/100kcal, but that it is not a necessary component of follow-on formula.

3.11.3 L-carnitine

L-carnitine is the generic term used for a number of compounds that include L-carnitine, acetyl-L-carnitine, and propionyl-L-carnitine. L-carnitine plays a critical role in energy production and is concentrated in tissues like skeletal and cardiac muscle. The body makes sufficient L-carnitine to meet the needs of most people. However, some individuals, including pre-term infants, cannot make enough and L-carnitine must be supplied in the diet. Cows' milk contains more L-carnitine than human milk. Legislation sets minimum and maximum levels for L-carnitine in infant formula that have been manufactured from soya protein isolates or hydrolysed protein. EFSA (2014) recommends the continued addition of L-carnitine to infant formula at a minimum (target) content of 1.2mg/100kcal, but does not consider it a necessary addition to follow-on formula.

3.11.4 Lutein and zeaxanthin

Lutein and zeaxanthin are carotenoids found in common foods such as broccoli, peas and spinach, and are important antioxidants that might help to protect against oxidative damage to the eye. Although there are no data that suggest that lutein supplementation can influence visual acuity in infants, some studies have shown modest benefits to visual disorders in adults. Breastmilk contains lutein derived from the mother's diet and, whilst this carotenoid is not currently added to formula milk available in the UK, it may be a potential new ingredient in the future and has been trialled by Wyeth in the USA in a sample of infants to ensure that the addition of lutein does not impact on growth (Capeding et al, 2010).

3.11.5 Taurine

Taurine is a free amino acid found abundantly in human milk and in only small amounts in cows' milk. Most infant formulas are enriched with taurine, although it is an optional ingredient. Interestingly, taurine has been added to formula for many years because it was found in human milk, and the patent protection of the addition to formula made it economically beneficial to some companies, despite there being little scientific rationale for it. Many decades later it appears that taurine is a safe addition to formula milk, but there remains no clear clinical benefit for it (Koletzko et al, 2009). EFSA (2014) in their *Scientific opinion on the essential composition of infant and follow-on formulae* have recently stated that:

"The panel considers that the addition of taurine to infant formula or follow-on formula is not necessary."

3.12 Probiotics, postbiotics and synbiotics in infant milks

Key points

Probiotics are live micro-organisms that, when consumed, are suggested as having beneficial health effects on the host. Human breastmilk contains probiotics as well as hundreds of different types of prebiotic oligosaccharides. Infant formula based on cows' milk contains virtually no probiotics.

Postbiotics comprise of metabolites and/or cell-wall components released by the action of probiotics in the gut. These are sometimes also called paraprobiotics.

When probiotics are combined with prebiotics, this is known as 'synbiotics'.

The rationale given for the use of probiotics in infant milks is that they are capable of modifying the balance of intestinal microflora in favour of commensal (beneficial) bacteria over pathogenic bacteria, and this may have a protective effect against some common childhood infections including gastrointestinal infections (GIT) and respiratory tract infections (RTI).

The recent EFSA (2014) *Scientific opinion on the essential composition of infant and follow-on formulae* notes that the evidence for any benefit of probiotics or synbiotics on infant health comes from single studies and studies with methodological limitations, and concludes that there is no evidence for beneficial effects and that these are not necessary additions to infant and follow-on formula.

If families buy milks containing probiotics or synbiotics, it is important that they do not follow the manufacturer's instructions to use water at less than 70^{o}C when reconstituting powdered infant formula. Probiotics are not found in infant formula in the UK but may be present in foods for special medical purposes.

Probiotic supplements are sometimes given to premature infants in hospital settings and more information about this can be found in the report *Specialised infant milks in the UK: Infants 0-6 months.*

Probiotics are live micro-organisms that, when administered in adequate amounts, confer a health benefit on the host (FAO/WHO, 2001). The composition of the intestinal microflora is recognised as a major determinant of the well-being of the host (Vandenplas et al, 2011). Human breastmilk contains probiotics as well as hundreds of different types of prebiotic oligosaccharides. Cows' milk contains virtually none (Teitelbaum and Walker, 2002). In their efforts to provide formula milks that mimic the bifidogenic activity of breastmilk, many formula milk manufacturers have supplemented their infant milk products with prebiotics and/or probiotics. The rationale for their use in infant milks is that they may be capable of modifying the balance of intestinal microflora in favour of commensal (beneficial) bacteria over pathogenic bacteria, which it is suggested may offer a protective effect against some common childhood infections. Studies available to support the use of probiotics alone, or in combination with prebiotics (synbiotics) in formula milks, vary greatly in respect of quality, the bacterial strains used, dose and outcomes measured.

There has generally been considered to be insufficient evidence to recommend the addition of probiotics to infant feeds for prevention of allergic disease, food hypersensitivity or diarrhoea (Osborn and Sinn, 2007; Szajewska and Mrukowicz, 2001). The most recent research used to support the use of synbiotics in follow-on formula milks comes from a randomised control trial in healthy term infants aged 6 months to 1 year. This study reported that infants who consumed follow-on formula milk supplemented with prebiotic oligosaccharides and the probiotic bacteria *Lactobacillus fermentum* (CECT5716) had fewer incidences of gastrointestinal and upper respiratory tract infections and an overall reduction in incidences of infectious diseases compared to infants who consumed a formula milk containing only prebiotic oligosaccharides (Maldonado et al, 2012). A further study sponsored and co-written by Hipp Organic, designed to examine the safety and tolerance of this formula in infants from 1 to 6 months of age, found a reduction in incidence of gastrointestinal infections only (Gil-Campos et al, 2012).

In a systematic review of randomised control trials (RCTs) that compared the use of infant or follow-on formula milks supplemented with probiotics and/or prebiotics, the ESPGHAN Committee on Nutrition noted that, whilst there was some evidence available to suggest an association between the use of specific probiotics in formula milk and a reduction in the incidence of gastrointestinal infections and antibiotic use, there was too much uncertainty to draw reliable conclusions. Where formula milks were supplemented with synbiotics, the committee found that the quantity of data from RCTs was too sparse and again concluded that there was too much uncertainty to draw reliable conclusions. The routine use of probiotic supplements in formula milk for infants was not recommended. Whilst the committee found no evidence for adverse effects of probiotic use in products for infants, they did raise some specific concerns:

"First, timing, that is, the administration often begins in early infancy, sometimes at birth when the gut microbiota is not fully established, and factors that influence microbiota may permanently affect the development of the ecosystem. Second, duration, that is, the daily administration of such products is often prolonged (several weeks or months). Last but not least, delivery is in the form of a specific matrix (infant formula) that could be the only source of feeding of an infant." (Braegger et al, 2011)

Hipp Organic has been the only one of the market-leading formula milk companies to try and add probiotic bacterial strains to their infant milks. However, in spring 2013 the Department of Health informed Hipp that it did not approve of the addition of probiotic bacteria to their powdered formula milks. The Department of Health requested additional information on the suitability of the bacterial strain for nutritional use in infant foods and reiterated that the manufacturer's instruction for reconstitution at 40-50ºC was at variance with Department of Health recommendations that all standard infant formula milk powders should be reconstituted at 70ºC. Hipp Organic formula milks marketed in the UK make no claims for added probiotics and have labelling instructions in line with UK recommendations. The placing on the market and subsequent removal of milks supplemented with probiotics highlight the need for more stringent regulatory frameworks around the addition of optional ingredients to infant milks.

EFSA (2014) has reiterated in their *Scientific opinion on the essential composition of infant and follow-on formulae* that there is no benefit to infant health from adding probiotics or synbiotics to infant or follow-on formula.

Postbiotics

The term 'postbiotics' refers to soluble products or metabolic byproducts secreted by live bacteria (probiotics), or released after bacterial break down, such as enzymes, peptides, polysaccharides, cell surface proteins, and organic acids. It is being suggested that postbiotics may have anti-inflammatory, immunomodulatory, anti-obesogenic, antihypertensive, hypocholesterolemic, anti-proliferative, and antioxidant activities (Aguila-Toalâ et al, 2018). These suggested properties could mean that postbiotics might contribute to the improvement of host health by improving specific physiological functions. Currently exact mechanisms of action for postbiotics have not been entirely elucidated and there has been no expert review to determine whether these components added to infant formula have any benefit. A number of claims are being made about the use of postbiotics in new Aptamil products but we have yet to find out what processing mechanism is being used to derive these postbiotics, and what specific factors may be present. We will investigate claims about postbiotics and any evidence for these in the nest update of this report.

3.12.1 Acidified Infant Milks

Acidified infant milks are *"Infant and follow-on formulae that have been fermented with lactic acid-producing bacteria during the production process, but do not contain live bacteria in the final product due to inactivation of the fermenting bacteria by heat treatment or other means".* (ESPGHAN, 2007). Whilst no infant milks are marketed in the UK as having been acidified or fermented, they are available in other european countries such as France and in African countries where they are typically marketed as being useful in preventing a range of gastrointestinal symptoms and in particular, in preventing diarrohoeal disease. Despite widespread use, there is little published data available to support their use.

There are a small number of studies that have investigated the effects of fermented formula milks on diarrhoeal disease amongst infants who are receiving complementary foods. Brunser et al,1989 showed a reduction in the incidence of diarrhoea as well as a lower proportion of days with diarrhoea and shorter duration of episodes in Chilean children fed acidified Nestlé Pelargon formula, compared to those receiving the same formula but non acidified. In a more recent controlled clinical trial that examined the effect of a fermented formula on the incidence of acute diarrhoea in healthy 4–6-months-old infants, reductions in the severity, but not in the incidence of diarrhoea were reported (Thibault et al, 2004).

During the fermentation process beneficial bacteria may produce a range of metabolites including lactic acid, lactase and oligosaccharides as well as many others which are as yet unknown (van de Heijning et al ,2014). It is these fermentation products that have been suggested as being responsible for some of the effects on gastrointestinal symptoms reported in clinical trials of fermented infant milks. In 2007 The ESPGHAN Committee on Nutrition carried out a systematic review of the literature to assess knowledge on the effects of fermented infant formula without live bacteria. They concluded that "*the published data on the effects of fermented infant formulae without live bacteria are limited and do not allow firm conclusions"* and that "*the effects of fermented infant formulae on infectious diarrhea and other relevant outcomes should be assessed in further randomized controlled trials"* (Agostoni et al, 2007).

3.13 Non-essential trace elements: fluoride content of infant milks

Key points

Fluoride protects against dental caries, but too much fluoride during the development of teeth may result in brown mottling and pitting (fluorosis) of tooth enamel. EU specifications currently set only maximum levels of fluoride in infant and follow-on formula milks and as a non-essential nutrient it is not included in compositional recommendations.

Most ready-to-feed infant milks are made using demineralised tap water, allowing tighter control over the final fluoride content of the product. The fluoride content of powder formula reconstituted with tap water will vary depending on whether or not the water supply used is fluoridated. In the UK not all water supplies are fluoridated.

Infants who are fed on formula milk in areas where water is fluoridated will receive considerably more fluoride than breastfed babies.

Whilst no essential function of fluoride has been proven in humans, it protects against dental caries, however, an excess of fluoride during the development of teeth may cause dental fluorosis (an enamel development defect causing brown mottling and pitting). The intake of fluoride, and other minerals, of infants who are fed on formula milk will be largely dependent on the mineral content of the water used to make their milk. Most ready-to-feed (RTF) infant milks use demineralised tap water as the diluent. This has the advantage of allowing tighter control over the final mineral content of the product. The final mineral content of reconstituted powder formulas will depend on the mineral content of the water used as a diluent. The mineral content of tap water is subject to considerable geographical variation and in the UK some, but not all, water supplies are fluoridated. The panel on dietary reference values of COMA recommends that water is fluoridated to a level of 1 part per million (ppm). Consumption of water fluoridated to this level results in a daily consumption of fluoride of 0.22mg/kg of body weight (bw) in formula-fed infants aged 1 month. This is the level of safe intake established for infants aged up to 6 months (Department of Health, 1991). As fluoride is not considered essential in the diet, EC regulations specify only maximum levels for fluoride in infant or follow-on formula.

Although the water used to make up powdered formula milks heavily influences infants' fluoride intake, the concentration in powder will have some influence, particularly in areas where the water supply is not fluoridated. In a study of the fluoride content of infant food and drinks, Bussell et al, 2016 reported a range of 0.002ppm to 0.028ppm across 17 powdered first infant milks when reconstitted with non-fluoridated tap water. Across 8 RTF first infant milks the fluoride concentration ranged from 0.008ppm to 0.022ppm. This study also found that the fluoride concentration in specialised powdered formula milks for use in hospital settings or on prescription was higher than that for over the counter infant milks and that the fluoride content stated on labels was often higher than the analysed values (Bussell et al, 2016).

An earlier analysis of the fluoride content of infant milks in the UK showed considerable variation in the fluoride concentration of powdered infant milks which, in this study, ranged from 0.07µg/ml to 0.32µg/ml when reconstituted with non-fluoridated water, and from 0.49µg/ml to 1.4µg/ml when reconstituted with fluoridated water (Zohoori et al, 2012). The mean values of 0.15µg/ml for milk reconstituted with non-fluoridated water and 0.91µg/ml for fluoridated water would result in fluoride intakes for infants up to one month of age of 0.029mg/kg/bw* of body weight and 0.17mg/kg/bw* respectively. Whilst this data suggests that fluoride intakes among formula-fed infants in fluoridated areas are likely to be below the safe fluoride intake threshold of 0.22mg/kg bw/day, they may be higher than the Tolerable Upper Intake Level of 0.1mg/kg bw/day defined by EFSA for 1-8 year olds (European Food Safety Authority, 2005). Infants fed on powdered formula milks may also receive considerably more fluoride than infants who are fed human milk, which has been reported to contain up to 0.02ppm (0.02µg/ml) fluoride (Koparal et al. 2000). As there is a lack of agreement among expert groups on the optimal level of fluoride intake in relation to dental fluorosis in children, it is difficult to conclude whether infants living in fluoridated areas are potentially at risk of receiving excessive amounts of fluoride from infant milks.

* Calculated on the basis of average weight of male and female infants up to one month from 50th percentile weight for age from the UK-WHO charts and calculations for daily feed volume based on energy requirements from the SACN report Dietary Reference Values for Energy (2011) and energy content of formula 65kcal/100ml, the mid range stipulated in the EU directive.

3.14 Additives in infant milks

Most infant milks contain additives which are needed to ensure that formulations do not separate, that acidity is regulated or ingredients resist oxidation, or if liquid formula, that they remain emulsified. There has been a suggestion by the FAO/WHO Codex Alimentarius Committee that, whenever foods are given to infants under 12 weeks of age, they should be made up from fresh ingredients every day, as infants may not have developed to a point where they are able to cope with substances used to prolong shelf-life that present no problem to adults (Codex Alimentarius Committee, 2006). This is obviously not possible, but highlights the fact that additives used for preservation in infant formula are unregulated in relation to their effects on infants. The additives that can be used in infant milks are regulated within the EU (Scientific Committee on Food, 1997) with some permitted in all infant formula and follow-on formula, and some permitted in foods for special medical purposes only. Some of the permitted additives and their uses are outlined in Table 3.

TABLE 3
Examples of additives permitted in infant formula, follow-on formula and foods for special medical purposes for infants and young children

Additive	Why is the additive used?	Permitted in infant formula and follow-on formula?	Permitted in foods for special medical purposes?
Acacia gum E414	Thickening agent	✓	✓
Citric acid E330	Preservative	✓	✓
Sucrose esters of fatty acids E473	Emulsifier	✓	✓
Guar gum E412	Thickening agent	✓	✓
Lactic acid E270	Preservative	✓	✓
L-ascorbyl palmitate E304	Antioxidant	✓	✓
Locust bean gum E410	Thickening agent	✗	✓
Mono- and di-glycerides of fatty acids E471	Emulsifier	✗	✓
Pectin E440	Thickening agent	✗	✓
Potassium citrate E332	To prevent casein in milk coagulating when heat-treated	✓	✓
Potassium phosphate E340	To prevent casein in milk coagulating when heat-treated	✓	✓
Sodium carboxymethyl cellulose E466	Thickening and gelling agent	✗	✓
Sodium citrate E331	To prevent casein in milk coagulating when heat-treated	✓	✓
Sodium phosphate E339	To prevent casein in milk coagulating when heat-treated	✓	✓
Sodium-L-ascorbate E301	Antioxidant	✓	✓
Soya lecithin E322	Emulsifier	✓	✓
Xanthan gum E415	Thickening agent	✗	✓

4 Contaminants in infant milks

4.1 Bacterial contamination of powdered infant milks

Powdered infant milks are not sterile and they may contain harmful bacteria. However, if milks are made up appropriately for infants, they should be safe (see section 6.6). *Salmonella* and *Cronobacter sakazakii* (previously known as *Enterobacter sakazakii)* are the organisms of greatest concern in infant formula (European Food Safety Authority, 2004), but a range of *Cronobacter* species can be present in powdered infant milks. Powdered infant formula milks contaminated with *Cronobacter sakazakii* or *Salmonella* have been the cause of infection in infants. *Cronobacter sakazakii* is regarded as an emerging opportunistic human pathogen. It can be found ubiquitously in the environment, in the human and animal gut, and in foods. The widespread distribution of the bacterium suggests that, in healthy infants, consuming small numbers of the bacteria in powdered infant formula milks does not lead to illness. However, younger infants are more susceptible to infection than older infants, and the neonates at greatest risk are pre-term or low-birthweight infants and those who are immunocompromised (European Food Safety Authority, 2004). Whilst the occurrence of infections with *Cronobacter sakazakii* is rare, the prognosis for those infected is poor, with mortality rates in infants of between 40% and 80% (Willis and Robinson, 1988). Infection can cause meningitis, necrotising enterocolitis and bacteraemia (Nazarowec-White and Farber, 1997). There are nearly 2,000 strains of the *Salmonella* bacteria that can cause illness in humans. Symptoms include diarrhoea, fever and vomiting, and infection can cause serious illness in infants. In 2008 in Spain, 31 cases of *Salmonella* infection in infants were found to be the result of infant formula contamination, and 10 of these infants needed hospitalisation (Rodríguez-Urrego et al, 2010).

Salmonella and *Cronobacter sakazakii* do not survive the pasteurisation process, but recontamination may occur during handling or from production methods where ingredients are mixed and added at different stages (see section 3.3) (Mullane et al, 2006; EFSA, 2004). Due to its ubiquitous nature, *Cronobacter sakazakii* seems to be more difficult to control in the processing environment. *Salmonella* and *Cronobacter sakazakii* can grow in the reconstituted product if stored above 5°C and can multiply rapidly at room temperature. It is therefore essential that good hygiene practices are observed during preparation, storage and feeding in order to avoid recontamination and/or multiplication in the reconstituted product (EFSA, 2004). The key recommendation from all international bodies to reduce risk to infants from bacterial infection has been to encourage the reconstitution of infant formula with water at no less than 70˚C (WHO, 2007). It has been reported that there has been considerable resistance from the infant formula industry and some segments of the medical community to this recommendation (Hormann, 2010). It is apparently argued that this temperature might destroy some nutrients present in the milk (for example, thiamin, folate and vitamin C), and may carry a risk of scalding the infant if the milk is not allowed to cool sufficiently, and that powder may clump when mixed with hotter water. Hormann suggests that these arguments are used to suggest both that the risks of bacterial contamination are small and that it is too difficult for parents and carers to make up milk safely, neither of which is true. The only nutrient significantly affected by the water temperature will be vitamin C, and the content of this vitamin is unlikely to be reduced below recommended levels during the reconstitution process (WHO, 2007).

Currently we do not have infant formula or follow-on formula marketed in the UK which contain probiotics, although these are present in some specialised formula and are commonly added to infant formula and follow on formula in other countries. For information on making up milks safely, see section 6.6.

4.2 Aluminium contamination of powdered infant milks

There has been a long and significant history documenting the contamination of infant milks with aluminium and the consequent health effects of this, with aluminium toxicity associated with anaemia, bone disease and impaired neurological development (Fewtrell et al, 2011). Infant milks typically have 10 to 40 times more aluminium in them than breastmilk (Burrell and Exley, 2010; Chuchu et al, 2013). Warnings have been made to manufacturers over several decades in relation to aluminium toxicity and the vulnerability of developing infants to this, and therefore it could be assumed that levels in current infant milks would be low. However, in recent analyses of ready-to-feed formula milks, aluminium levels were found to vary from 155-422µg/litre, and in powdered milks from 106-756µg/litre, and there has been little change in content despite calls for a reduction (Chuchu et al, 2013).

Soya protein based infant formula and pre-term infant formula have typically been found to have the highest amounts of aluminium (Burrell and Exley, 2010) and more recent analyses show that soya-based milks remain the highest, although all infant formula, follow-on formula and growing-up milks tested were contaminated with aluminium (Chuchu et al, 2013). Products are likely to be contaminated with aluminium from processing equipment and packaging, and a lack of progress in reducing this contaminant suggests that manufacturers do not consider it to be a health issue, despite evidence of both immediate and delayed toxicity in infants, especially pre-term infants. A recent study of pre-term infants fed intravenous fluids which were high in aluminium showed both impaired neurological development at 18 months and reduced bone mass at 13-15 years, and although there is likely to be much greater toxicity associated with intravenous administration of fluid, these findings suggest that significantly more should be done to reduce intakes (Fewtrell et al, 2011). EFSA considered aluminium toxicity in 2008 (EFSA, 2008) and suggested that 3 month old infants were typically exposed to aluminium at around 0.6-0.9mg/kg bw/week and 0.75-1.1mg/kg bw/week for soya formula, but acknowledged that the concentration in some formula brands was four times higher and that intakes could frequently exceed the current tolerable weekly intake of 1mg/kg bw/week. Breastfed infants are exposed to less than 0.07mg/kg bw/week.

Another study of milks in the UK in 2001 (Ikem et al, 2002) also reported that in some cases the amounts of aluminium, barium and thallium in infant milks exceeded stipulated water contamination levels, and again that soya protein based infant formula had higher aluminium contents than other formula, as did some milks made with partially hydrolysed protein.

Recent evidence suggests that levels of aluminium are higher in milks that are sold ready-to-feed in plastic bottles where the seal between the cap and the product is made of aluminium, and long-life cartons are also composed of packaging which has an aluminium foil central layer. However, variations between products with similar packaging means that there must be other sources of contamination (Chuchu et al, 2013). It appears that manufacturers have not addressed issues relating to aluminium contamination and we believe precautionary practical solutions to this public health issue should be sought. We have asked manufacturers what measures they have taken to reduce the aluminium content of infant milks but none have so far provided any information.

4.3 Uranium contamination of infant milks

There has been some concern that infant formula made up with some waters could contain high levels of uranium, which is thought to have potential toxic effects on kidney function. The World Health Organization (WHO) has set a guideline maximum level of 15µg/litre for uranium in water, but there is some concern that giving infants infant formula made up with water that has 15µg/litre could result in infants under 6 months consuming up to four times the tolerable dietary intake (TDI) also set by WHO (Committee on Toxicity, 2006). At the present time there are not thought to be any health concerns to infants related to uranium in infant milk, but COT (the Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment) acknowledges that it has little data in this area and the impact of these intakes is uncertain. Some bottled waters may have high levels of uranium and so it is important that, if a bottled water is used to make up a feed, the bottled water should specify that it is suitable for infant formula.

4.4 Cadmium contamination of infant milks

It is suggested that long-term excessive intakes of cadmium can cause adverse effects on kidney function and bone mineralisation (Ljung et al, 2011). Little is known about early-life exposure to cadmium, and associated adverse effects, although absorption appears to be higher in infants than in adults (Kippler et al, 2010). Calculated weekly intakes of cadmium in the study by Ljung et al, varied between 0.10 and 1.5g/kg bw at 6 weeks of age, depending on the type of infant formula consumed, compared to 0.06 g/kg bw in breastfed babies. Recent studies from rural Bangladesh reported elevated urinary cadmium concentrations in 3 month old infants, indicating high rates of intestinal absorption, probably because of the immature regulation of the transport system for divalent metal ions, and it is likely that the developing kidney is particularly susceptible to cadmium, as both glomerular and tubular functions continue to develop until 2 to 3 years of age (Sekine and Endou, 2009). It has also been suggested that cadmium has oestrogen-like effects in the case of early-life exposure (Johnson et al, 2003).

4.5 Process contaminants from oil refining in infant milks

There has been recent concern that formula fed infants may be exposed to harmful levels of Glycidyl fatty acid esters (GE) and 2- and 3-monochloropropanediol (2-MCPD and 3-MCPD) and their fatty acid esters. These substances are formed when palm oils and fats and other vegetable oils are heated to temperatures in excess of 200°C during the refinement process.

These potentially harmful substances have subsequently been identified in a range of oils and fats and foods that are made from them, including infant and follow-on formula milks. A recent study conducted by the Dutch National Institute for Public Health and the Environment found that samples of powdered infant formula contained significant amounts of 3-MCPD, although the levels varied widely between different products (RIVM, 2016). The European Food Safety Authority (EFSA) panel on Contaminants in the Food Chain (CONTAM) recently delivered a scientific opinion on the risks to human health posed by the presence of these contaminants in food. Based on evidence from animal studies the CONTAM panel concluded that GE is potentially genotoxic and carcinogenic and that 3-MCPD can cause kidney damage. There was insufficient data available to come to any conclusions on the toxicity of 2-MCPD (EFSA, 2016).

3-MCPD was first identified in the late 1970's and since then, it's presence in specific foods where high levels have been reported has been monitored. In 2001 the Scientific Committee on Food set a safe tolerable daily intake (TDI) for 3-MCPD of 2.0 µg/kg/bw per day (SCF, 2001). Based on the available evidence the CONTAM panel have lowered the (TDI) to 0.8 µg/kg/bw per day (EFSA , 2016). In the dietary surveys included in their study, EFSA found that younger age groups were at greatest risk of exposure to 3-MCPD. In over half of the dietary surveys reviewed, the average exposure for infants, toddlers and other children up to ten years of age was at or above TDI. For infants who were exclusively formula fed, average exposure was more than three-times TDI at 2.4 µg/kg/bw per day and for those with greatest exposure more than four times TDI at 3.2µg/kg/bw per day. The CONTAM panel concluded that this level of exposure was cause for concern. It is worth noting that the TDI is set with a generous safety margin far in excess of the levels identified as causing harmful effects in animal studies.

Due to the potentially genotoxic and carcinogenic nature of GE, TDI are not set and the risk to consumers is expressed as a Margin of Exposure (MoE). The higher the MoE, the lower the level of concern and vice versa. An MoE of lower than 25,000 was considered by EFSA, to be a health concern. EFSA estimated MoE for infants aged 0-3 years with average exposure to GE range from 11,300 to 25,500. Infants who were exclusively fed on formula mik were at significantly greater risk. The MoE for average exposure was around 5,400 and for high exposure 2,100. EFSA have said that in infants MoE estimates were particularly low due to the contribution of glycidyl esters from infant formula and also point out that there were uncertainties involved in the setting of the level of MoE at 25000.

The CONTAM Panel have recommended that all potentially contaminated foods are included in future monitoring of 3-MCPD, 2-MCPD and glycidol. EFSA's scientific opinion is being used to inform EU food safety regulators considerations on how to manage the risk of exposure to these substances in foods. Recently, in 2017, EFSA issued draft regulations setting maximum levels for the presence of glycidyl fatty esters in vegetable oils and fats placed on the market for the final consumer or for use as an ingredient in food. Because of the health concern for infants, toddlers and young children stricter maximum levels have been set for vegetable oils and fats destined for the production of baby food and processed cereal-based food for infants and young children. Taking into account the possible exposure to glycidyl esters of infants solely fed on infant formula, a specific strict maximum level for infant formula, follow-on formula and food for special medical purposes intended for infants and young children has been established. The draft regulation proposes that until 30/06/19 the maximum level of GE permitted in infant and follow-on formula milk powder and foods for special medical purposes intended for infants and young children would be reduced to <75ug/kg and after that to <50ug/kg. Lower levels of <10ug/kg and <6ug/kg are proposed for liquid formulations (EFSA, 2017). The draft regulations are available here:

https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-4129615_en

The removal of palm oil from infant milks and baby foods would be a prudent response. Kendamil and Castlemil brand milks have recently removed palm oil from their milks manufactured in the UK. There are other brands of infant milk in the UK that do not use palm oil in their products but the main brands, Aptamil, Cow & Gate, Hipp Organic and SMA still use palm oil.

5 Infant milks available in the UK

This section describes the types of infant milk currently available in the UK and the composition of those milks. The compositional requirements are currently determined by the Infant Formula and Follow-on Formula Regulations (2007) and any amendments to this directive.

Where a product is marketed as a food for special medical purpose (FSMP) these products must comply with the FSMP Directive (1999/21/EC).

When a new product is placed on the market, or when the reformulation of an existing product requires a labelling change, infant milk manufacturers and importers are required by the 2007 regulations to notify the competent authority of the member state where it is to be marketed. (In the UK, there are four competent authorities, but only one needs to be notified and this is usually the Department of Health.)

Information on new product notifications will not be released by the Department of Health to consumers. Also, as there is no requirement to provide notification of the withdrawal of a product, notifications do not reflect the current milk market.

Information about infant milks has been taken from the most recent website information or promotional material designed for health professionals, or from conversations with consumer carelines or company staff.

5.1 Macro and micronutrient requirements of the Infant Formula and Follow-on Formula Regulations, and Foods for Special Medical Purposes regulations

The current macro and micronutrient requirements for infant formula and follow-on formula are set out in EC/UK legislation (EU Commission Directive, 2006, Food Standards Agency, 2007) and Foods for Special Medical Purposes (EU Commission Directive, 1999).

On the 20th July 2016 these directives were replaced by new EU Regulations on Foods for Specific Groups (FSG) (609/2013). This directive contains delegated acts relating to infant and follow on formula and infant milks that are marketed as foods for special medical purposes. Whilst the FSG directive has been in force since July 2016, companies are given up to four years to make changes in line with the delegated acts, and therefore for this report we compare all products to existing legislation.

Points of note in the new delegated acts relating to the composition of infant and follow-on formula and foods for special medical purposes include a reduction in the upper limit of total energy, some changes to the upper and lower limits of micronutrients and the mandatory addition of Docosahexanoic acid (DHA) to all infant and follow-on formula milks. In the meantime, existing legislation will continue to apply. We will include further information on the changes and how the UK will support these new regulations in future reports.

Table 4 gives a summary of the current compositional requirements of the Infant Formula and Follow-on Formula (England, Scotland, Wales and Northern Ireland) Regulations 2007.

Table 5 provides a summary of the composition of first milks available in the UK compared with the composition of mature breastmilk and the current regulations for composition calculated per 100ml of milk.

Table 6 provides a comparison of the current regulations relating to foods for special medical purposes (FSMP) with the infant formula and follow-on formula regulations.

NB. Infant milks currently marketed in the UK do so in line with these regulations. We will review the new EU regulations and any product change relevant to those in future iterations of this report.

TABLE 4
Macro and micronutrient requirements for infant formula and follow-on formula

	Infant formula		Follow-on formula	
	Min/100ml	Max/100ml	Min/100ml	Max/100ml
Energy kJ	250	295	250	295
kcal	60	70	60	70
	Min/100kcal	Max/100kcal	Min/100kcal	Max/100kcal
Protein g	1.8	3.0	1.8	3.5
Carbohydrate g	9.0	14.0	9.0	14.0
of which lactose g	4.5	N/S	4.5	N/S
Fat g	4.4	6.0	4.0	6.0
Linoleic acid mg	300	1200	300	1200
Linolenic acid mg	50	N/S	50	N/S
Prebiotic fibre g	N/S	0.8[1]	N/S	0.8[1]
VITAMINS				
Vitamin A µg-RE	60	180	60	180
Vitamin C mg	10	30	10	30
Vitamin E mg	0.5[2]	5.0	0.5[2]	5.0
Vitamin D µg	1.0	2.5	1.0	3.0
Vitamin K µg	4	25	4	25
Thiamin (B_1) µg	60	300	60	300
Riboflavin (B_2) µg	80	400	80	400
Niacin µg	300	1500	300	1500
Vitamin B_6 µg	35	175	35	175
Vitamin B_{12} µg	0.1	0.5	0.1	0.5
Folic acid µg	10	50	10	50
Biotin µg	1.5	7.5	1.5	7.5
Pantothenic acid µg	400	2000	400	2000
MINERALS				
Calcium mg	50	140	50	140
Chloride mg	50	160	50	160
Copper µg	35	100	35	100
Fluoride µg	N/S	100	N/S	100
Iodine µg	10	50	10	50
Iron[3] mg	0.3	1.3	0.6	2.0
Magnesium mg	5.0	15	5.0	15
Manganese µg	1.0	100	1.0	100
Phosphorus[3] mg	25	90	25	90
Potassium mg	60	160	60	160
Selenium µg	1.0	9.0	1.0	9.0
Sodium mg	20	60	20	60
Zinc mg	0.5	1.5	0.5	1.5
OTHER				
Choline mg	7	50	N/S	N/S
Taurine mg	N/S	12	N/S	12
Nucleotides mg	N/S	5.0	N/S	5.0
Inositol mg	4.0	40	N/S	N/S
L-carnitine mg	1.2[4]	N/S	N/S	N/S

N/S = not stated

1 Fructo-oligosaccharides and galacto-oligosaccharides (prebiotic fibre) may be added to infant formula. In that case their content shall not exceed 0.8g/100ml in a combination of 90% oligogalactosyl-lactose and 10% high molecular weight oligofructosyl-saccharose.

2 Vitamin E: 0.5mg/g of polyunsaturated fatty acids expressed as linoleic acid as corrected for the double bonds but in no case less than 0.5mg per 100kcal, maximum 5.0mg/100kcal.

3 For products manufactured from soya protein isolates or in a mixture with cows' milk, minimum and maximum values for iron for infant formula are 0.45mg and 2.0mg respectively and for follow-on formula 0.9mg and 2.5mg respectively. For phosphorus, minimum and maximum values for both infant and follow-on formula are 30mg and 100mg respectively.

4 The L-carnitine concentration is only specified for formula containing protein hydrolysates or soya protein isolates.

Source: Infant Formula and Follow-on Formula (England) Regulations 2007.

TABLE 5
Macro and micronutrient composition of the three main first infant milks sold in the UK and mature breastmilk, compared to regulations for infant formula

	Average for first infant milks	Mature breastmilk	Regulations for infant formula (re-calculated by volume)	
	Per 100ml	Per 100ml	Min/100ml	Max/100ml
MACRONUTRIENTS				
Energy kJ	277	290	250	295
kcal	66	69	60	70
Protein g	1.3	1.3	1.2	2.0
Carbohydrate g	7.2	7.2	6.0	9.4
of which lactose g	7.0	6-7[1]	3.0	N/S
Fat g	3.5	4.1	2.9	4.0
Linoleic acid mg	500	560[2]	200	800
Linolenic acid mg	81	72[2]	33.5	N/S
VITAMINS				
Vitamin A µg-RE	61	58	40	121
Vitamin C mg	10.5	4.0	6.7	20.1
Vitamin E mg	1.1	0.34	0.34*	3.35
Vitamin D µg	1.1	0.2-3.1[1]	0.67	1.68
Vitamin K µg	4.8	0.2-0.9[1]	2.68	16.75
Thiamin (B_1) µg	67	20	40.2	201
Riboflavin (B_2) µg	117	30	53.6	268
Niacin µg	453	200	201	1005
Vitamin B_6 µg	40	10	23.45	117.25
Vitamin B_{12} µg	0.17	0.02-0.1[1]	0.07	0.34
Folic acid µg	11.7	5	6.7	33.5
Biotin µg	1.5	0.7	1.01	5.03
Pantothenic acid µg	370	250	268	1340
MINERALS				
Calcium mg	51	34	34	94
Chloride mg	44	42	33.5	107.2
Copper µg	43	40	23.45	67
Fluoride µg	3.1	7[1]	N/S	67
Iodine µg	13	7	6.7	33.5
Iron** mg	0.58	0.07	0.2	0.87
Magnesium mg	5.6	3	3.35	10
Manganese µg	10	2.7[1]	0.67	67
Phosphorus**mg	29	15	16.8	60.3
Potassium mg	69	58	40.2	107.2
Selenium µg	1.9	1	0.67	6.0
Sodium mg	19	15	13.4	40.2
Zinc mg	0.57	0.3	0.34	1.0
OTHER				
Choline mg	10.8	16[3]	4.7	33.5
Taurine mg	5.1	3.8[4]	N/S	8.0
Nucleotides mg	2.1	3-7[5]	N/S	3.35
Inositol mg	4.8	2.6[6]	2.68	26.8
L-carnitine mg	1.3	0.7[7]	0.8***	N/S

See the notes on the next page.

Note: Where regulations do not state a minimum amount, they are not considered a requirement. In these cases, the average stated for currently available first infant milks does not include those milks where the ingredient is not present.

N/S = not stated

* Vitamin E: 0.5mg/g of polyunsaturated fatty acids expressed as linoleic acid as corrected for the double bonds but in no case less than 0.5mg/100kcal, maximum 5.0mg/100kcal.

** For products manufactured from soya protein isolates or in a mixture with cows' milk, minimum and maximum values for iron for infant formula are 0.45mg and 2.0mg respectively and for follow-on formula 0.9mg and 2.5mg respectively. For phosphorus, minimum and maximum values for both infant and follow-on formula are 30mg and 100mg respectively.

*** The L-carnitine concentration is only specified for formula containing protein hydrolysates or soya protein isolates.

Sources:
Average for first infant milks: taken from an average of Aptamil 1, Cow & Gate 1 First Infant Milk and SMA Pro First Infant Milk.

Mature breastmilk composition: Finglas et al (2015) except for:
1 Royal College of Midwives (2009)
2 Specker et al (1987)
3 Holmes-McNary et al (1996)
4 Agostoni et al (2000)
5 Carver (2003)
6 Pereira et al (1990)
7 Mitchell et al (1991).

Regulations for infant formula: Infant Formula and Follow-on Formula (England, Scotland, Wales, Northern Ireland) Regulations 2007.

TABLE 6
Macro and micronutrient requirements for infant formula, follow-on formula and foods for special medical purposes

	Infant formula		Follow-on formula		Foods for Special Medical Purposes	
MACRONUTRIENTS						
	Min/100ml	Max/100ml	Min/100ml	Max/100ml	Min/100ml	Max/100ml
Energy kJ	250	295	250	295	250	295
kcal	60	70	60	70	60	70
	Min/ 100kcal	Max/ 100kcal	Min/ 100kcal	Max/ 100kcal	Min/ 100kcal	Max/ 100kcal
Protein g	1.8	3.0	1.8	3.5	As per infant formula and follow-on formula values	
Carbohydrate g	9.0	14.0	9.0	14.0		
– of which lactose g	4.5	N/S	4.5	N/S		
Fat g	4.4	6.0	4.0	6.0		
Linoleic acid mg	300	1200	300	1200		
Linolenic acid mg	50	N/S	50	N/S		
Prebiotic fibre g	N/S	0.8[1]	N/S	0.8[1]		
VITAMINS						
Vitamin A µg	60	180	60	180	As per infant formula and follow-on formula values	
Vitamin D µg	1.0	2.5	1.0	3.0		
Vitamin B_{12} µg	0.1	0.5	0.1	0.5		
Vitamin C mg	8	30	10	30	8	25
Vitamin E mg	0.5[2]	5.0	0.5[2]	5.0	0.5[2]	3.0
Thiamin µg	60	300	60	300	40	300
Riboflavin µg	80	400	80	400	60	450
Niacin µg	300	1500	300	1500	800	3000
Vitamin B_6 µg	35	175	35	175	35	300
Folic acid µg	10	50	10	50	4	25
Biotin µg	1.5	7.5	1.5	7.5	1.5	20
Pantothenic acid µg	400	2000	400	2000	300	2000
MINERALS						
Calcium mg	50	140	50	140	50	250
Chloride mg	50	160	50	160	50	125
Copper µg	35	100	35	100	20	120
Fluoride µg	N/S	100	N/S	100	N/S	200
Iodine µg	10	50	10	50	5	35
Iron[3] mg	0.3	1.3	0.6	2.0	0.5	2.0
Magnesium mg	5.0	15	5.0	15	5.0	15
Manganese µg	1.0	100	1.0	100	1.0	100
Phosphorus[3] mg	25	90	25	90	25	90
Potassium mg	60	160	60	160	60	145
Selenium µg	1.0	9.0	1.0	9.0	1.0	3.0
Sodium mg	20	60	20	60	20	60
Zinc mg	0.5	1.5	0.5	1.5	0.5	2.4
OTHER						
Choline mg	7	50	N/S	N/S	7	50
Taurine mg	N/S	12	N/S	12	N/S	12
Nucleotides mg	N/S	5.0	N/S	5.0	N/S	5
Inositol mg	4.0	40	N/S	N/S	4	40
L-carnitine mg	1.2[4]	N/S	N/S	N/S	1.2[4]	N/S

N/S = not stated
See the notes on the next page.

1 Fructo-oligosaccharides and galacto-oligosaccharides (prebiotic fibre) may be added to infant formula. In that case their content shall not exceed 0.8g/100ml in a combination of 90% oligogalactosyl-lactose and 10% high molecular weight oligofructosyl-saccharose.
2 Vitamin E: 0.5mg/g of polyunsaturated fatty acids expressed as linoleic acid as corrected for the double bonds but in no case less than 0.5mg/100kcal, and maximum 5.0mg/100kcal.
3 For products manufactured from soya protein isolates or in a mixture with cows' milk, minimum and maximum values for iron for infant formula are 0.45mg and 2.0mg respectively and for follow-on formula 0.9mg and 2.5mg respectively. For phosphorus, minimum and maximum values for both infant and follow-on formula are 30mg and 100mg respectively.
4 The L-carnitine concentration is specified only for formula containing protein hydrolysates or soya protein isolates.

Sources:
Infant Formula and Follow-on Formula (England) Regulations 2007; European Commission Directive 2006/141/EC on Infant Formulae and Follow-on Formulae; and EC Directive 1999/21/EC on Dietary Foods for Special Medical Purposes 1999.

5.2 Infant milks currently available in the UK

TABLE 7
Infant milks available in the UK
These milks can be bought in pharmacists, supermarkets, specialist food shops or through online supermarket shopping websites.

Category of infant milk	Names of infant milks included in this category
Infant formula suitable from birth (cows' milk based)	Aptamil 1 First Milk Aptamil Profutura 1 First Infant Milk Cow & Gate 1 First Infant Milk Hipp Organic Combiotic First Infant Milk Holle Organic Infant Formula 1 Kendamil First Infant Milk[1] Kendamil Mehadrin First Infant Milk[2] Kendamil Organic First Infant Milk[3] Mamia First Infant Milk Sainsbury's Little Ones First Infant Milk SMA Organic First Milk SMA Pro First Infant Milk
Infant formula suitable from birth (goats' milk based)	Holle Organic Infant Goat Milk Formula 1 Kabrita Gold 1 First Infant Milk NANNYcare First Infant Milk
Infant formula marketed for hungrier babies, suitable from birth (cows' milk based)	Aptamil Hungry Milk Cow & Gate Infant Milk for Hungrier Babies Hipp Organic Combiotic Hungry Infant Milk SMA Extra Hungry
Thickened (anti-reflux) infant formula suitable from birth	Aptamil Anti-reflux Cow & Gate Anti-reflux Hipp Organic Combiotic Anti-reflux SMA Pro Anti-Reflux
Soya protein based infant formula suitable from birth	SMA Wysoy
Lactose-free infant formula suitable from birth	Aptamil Lactose Free SMA LF
Partially hydrolysed infant formula suitable from birth	Aptamil Comfort Cow & Gate Comfort Hipp Combiotic Comfort SMA Comfort SMA HA

TABLE 7 (continued)
Infant milks available in the UK

Category of infant milk	Names of infant milks included in this category
Follow-on formula suitable from 6 months of age	Aptamil 2 Follow-on Milk Aptamil Profutura 2 Follow-on Milk Cow & Gate 2 Follow-on Milk Hipp Organic Combiotic Follow-on Milk 2 Holle Organic Infant Follow-on Formula 2 Kendamil Follow-on Milk[1] Kendamil Organic Follow-on Milk[3] Mamia Follow-on Milk Sainsbury's Little Ones Follow On Milk SMA Organic Follow-on Milk SMA Pro Follow-on Milk
Follow-on formula suitable from 6 months of age (goats' milk based)	Holle Organic Infant Goat Milk Follow-on Formula 2 Kabrita Gold 2 Follow-on Milk NANNYcare Follow-on Milk
Good night milks	Hipp Organic Good Night Milk
Growing-up milks and toddler milks suitable from around 1 year of age (cows' milk based)	Aptamil 3 Growing Up Milk 1-2 Years Aptamil Profutura 3 Growing Up Milk Cow & Gate 3 Growing Up Milk 1-2 Years Hipp Organic Combiotic Growing Up Milk 3 Holle Organic Growing Up Milk 3 Kendamil Toddler Milk[1] Kendamil Mehadrin Toddler Milk[2] Kendamil Organic Toddler Milk[3] PaediaSure Shake SMA Organic Growing up Milk SMA Pro Toddler Milk
Growing-up milks and toddler milks suitable from around 1 year of age (goats' milk based)	Holle Organic Infant Goat Milk Follow-on Formula 3 Kabrita Gold 3 Toddler Milk NANNYcare Growing Up Milk
Soya protein toddler milk suitable from 1 year of age	Alpro Soya Growing Up Drink
Growing-up milks and toddler milks suitable from around 2 years	Aptamil 4 Growing Up Milk 2-3 Years Cow & Gate 4 Growing Up Milk 2-3 Years Hipp Combiotic Growing Up Milk 4

1 Kendamil infant, follow-on and toddler milks are currently available regionally in Booths stores in the North West of England and from selected Morrisons and Asda stores nationally.
2 Kendamil Mehadrin milks are distributed by Global Kosher and are currently available only in stores they supply in London, Manchester and Liverpool.
3 Kendamil Organic milks are currently available in 200 Sainsbury's stores nationally

NB. Castlemil brand milks are no longer available in the UK.

5.3 Milks suitable for specific population groups

Parents and carers who do not have English as a first language and who may have access to infant milks that have been imported to the UK from elsewhere should be strongly advised to use milks which are manufactured for use in the UK and which are known to comply with UK compositional and labelling regulations.

5.3.1 Infant milks for vegetarians

Formula milks derived from cows' milk or goats' milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process. Rennet is used to separate curds from whey and the additional lactose added to milks are taken from the whey. Powdered Holle Organic Infant Goat Milk Formula 1, Kendamil First Infant Milk, Kendamil Mehadrin First Infant Milk and Sainsbury's Little Ones First Infant Milks are currently the only first milks available that are suitable for vegetarians. None of the ready-to-feed infant formula are suitable for vegetarians.

5.3.2 Infant milks for vegans

There are no infant or follow-on formula milks currently on the market suitable for vegans for both the reasons outlined above and because the vitamin D used is sourced from sheep's wool. Alpro Soya Growing Up Drink is a soya protein based milk for children from 1 year of age. It contains a plant-based source of vitamin D and is suitable for vegans. However, there is no need to use a special milk for children over 1 year of age and unsweetened calcium-fortified soya milk (or oat milk or almond milk) can be used if care is taken that the whole diet is suitably energy and nutrient dense. It is recommended that parents who want to bring up their baby as a vegan seek expert advice to make sure that all their baby's nutritional needs are met. Guidance on how to ensure a breastfed baby with a vegan mum gets all the nutrients he or she needs, can also be found in the resource *Eating well: vegan infants and under-5s*, which can be downloaded from www.firststepsnutrition.org.

5.3.3 Halal and kosher milks

Many infant milks have sought approval for use by communities who choose halal products. We have been informed by manufacturers that it is the factory that is often given halal approval status rather than the product itself, so that milks of the same brand but of different types may not both be Halal – for example, powdered versus ready-to-feed. Currently all of the powdered Aptamil, Cow and Gate, Kendamil and SMA brands of standard infant milk are halal approved. Ready to feed formulations may or may not be halal approved dependent on the brand and the pack size. Currently Aptamil Pronutra, Aptamil Profutura and Cow and Gate First Infant Milks 200ml RTF are halal approved as are Aptamil Pronutra and Cow and Gate First Infant Milk 70ml RTF. All SMA Pro First Infant Milk RTF formats are halal approved. The halal status of products is subject to change and is not necessarily printed on the product packaging. It is important therefore that those who wish to use halal approved products check the halal status on the product packaging or contact the manufacturer.

Many of those who choose a kosher diet will use infant milks which are vegetarian or halal approved, but some groups who choose a stricter kosher diet may seek products that are approved by a Rabbi or other religious organisation. This may be the case particularly during Passover. Kendal Nutricare have introduced 2 products that do not compromise the beliefs and practices of Orthodox Jewish parents, Kendamil Mehadrin First Infant Milk and Kendamil Mehadrin Toddler Milk. These products have been formulated and manufactured to the exacting requirements of the Jewish Orthodox religion, in a kashered factory. They have not been certified halal.

TABLE 8
Infant milks suitable for vegetarians and vegans, and for those wanting halal products

Note: Always check the label or contact the manufacturer as formulations can change and are often not the same for powdered and ready-to-feed milks or for all sizes of ready-to-feed milks. Check the footnotes at the bottom of this table.

Category of infant milk*		Suitable for vegetarians	Suitable for vegans	Halal approved
Infant formula suitable from birth (cows' milk based)	Aptamil 1 First Milk			✓[1]
	Aptamil Profutura 1 First Infant Milk			✓[2]
	Cow & Gate 1 First Infant Milk			✓[1]
	Hipp Organic Combiotic First Infant Milk			
	Holle Organic Infant Formula 1			
	Kendamil First Infant Milk	✓		✓
	Kendamil Mehadrin First Infant Milk	✓		
	Kendamil Organic First Infant Milk			✓
	Mamia First Infant Milk			✓
	Sainsbury's Little Ones First Infant Milk	✓		
	SMA Organic First Milk			✓
	SMA Pro First Infant Milk			✓
Infant formula suitable from birth (goats' milk based)	Holle Organic Infant Goat Milk Formula 1	✓		
	Kabrita Gold 1 First Infant Milk			
	NANNYcare First Infant Milk			✓
Infant formula marketed for hungrier babies, suitable from birth (cows' milk based)	Aptamil Hungry Milk			✓[3]
	Cow & Gate Infant Milk for Hungrier Babies			✓[3]
	Hipp Organic Combiotic Hungry Infant Milk			
	SMA Extra Hungry	✓*		✓[4]
Thickened (anti-reflux) infant formula suitable from birth	Aptamil Anti-reflux			
	Cow & Gate Anti-reflux			
	Hipp Organic Combiotic Anti-reflux			
	SMA Pro Anti-Reflux			
Soya protein based infant formula suitable from birth	SMA Wysoy	✓		✓
Lactose-free infant formula suitable from birth	Aptamil Lactose Free			
	SMA LF	✓		✓

TABLE 8 (continued)
Infant milks suitable for vegetarians and vegans, and for those wanting halal products

Category of infant milk		Suitable for vegetarians	Suitable for vegans	Halal approved
Partially hydrolysed infant formula suitable from birth	Aptamil Comfort			
	Cow & Gate Comfort			
	Hipp Combiotic Comfort			
	SMA Comfort	✓		✓
	SMA HA			
Follow-on formula suitable from 6 months of age (cows' milk based)	Aptamil 2 Follow-on Milk			✓[3]
	Aptamil Profutura 2 Follow-on Milk			✓[2]
	Cow & Gate 2 Follow-on Milk			✓[3]
	Hipp Organic Combiotic Follow-on Milk 2			
	Holle Organic Infant Follow-on Formula 2			
	Kendamil Follow-on Milk	✓		✓
	Kendamil Organic Follow-on Milk	✓		✓
	Mamia Follow-on Milk			✓
	Sainsbury's Little Ones Follow-on Milk	✓		
	SMA Organic Follow-on Milk			✓
	SMA Pro Follow-on Milk			✓
Follow-on formula suitable from 6 months of age (goats' milk based)	Holle Organic Infant Goat Milk Follow-on Formula 2	✓		
	Kabrita Gold 2 Follow-on Milk			
	NANNYcare Follow On Milk			✓
Good night milks	Hipp Organic Good Night Milk			
Growing-up milks and toddler milks suitable from around 1 year of age (cows' milk based)	Aptamil 3 Growing-up Milk 1-2 Years			✓[4]
	Aptamil Profutura 3 Growing Up Milk			
	Cow & Gate 3 Growing Up Milk 1-2 Years			✓[4]
	Hipp Organic Combiotic Growing Up Milk 3			
	Holle Organic Growing Up Milk 3			
	Kendamil Toddler Milk	✓		✓
	Kendamil Mehadrin Toddler Milk	✓		✓
	Kendamil Organic Toddler Milk	✓		✓
	PaediaSure Shake	✓		✓
	SMA Organic Growing up Milk			✓
	SMA Pro Toddler Milk	✓*		✓
Growing-up milks suitable from around 1 year of age (goats' milk based)	Holle Organic Infant Goat Milk Follow-on Formula 3			
	Kabrita Gold 3 Toddler Milk			
	NANNYcare Growing Up Milk			✓

TABLE 8 (continued)
Infant milks suitable for vegetarians and vegans, and for those wanting halal products

Category of infant milk		Suitable for vegetarians	Suitable for vegans	Halal approved
Soya protein based growing-up milks and toddler milks suitable from 1 year of age	Alpro Soya Growing Up Drink	✓	✓	
Growing-up milks and toddler milks suitable from around 2 years of age	Aptamil 4 Growing Up Milk 2-3 Years			✓[4]
	Cow & Gate 4 Growing Up Milk 2-3 Years			✓[4]
	Hipp Combiotic Growing Up Milk 4			

1 Powdered formulation, 70ml and 200ml but not 1L RTF

2 200ml RTF formulation but not powdered formulation

3 Powdered formulation and 200ml RTF but not 1L RTF

4 Powder formulation only. Check the packaging of ready to feed milks.

5.4 Infant formula suitable from birth (cows' milk based)

Key points

Whey-based infant formula suitable to use from birth, based on modified cows' milk, is the most commonly used infant formula.

For infants who are not breastfed, or receiving breastmilk, first infant formula should be used as the sole source of nutrition up to 6 months of age, and then, alongside complementary foods, up to 12 months of age.

Compositional differences between brands are primarily due to the addition of some non-mandatory ingredients, but the composition of milks is generally very similar as they are designed to meet compositional regulations. Claims made for most non-mandatory ingredients added to infant formula are not supported by expert committee reviews.

Infant formula made from cows' milk suitable from birth are designed to meet the nutritional requirements of healthy term infants as the sole source of nutrition in the first six months of life, but can be used alongside complementary foods throughout the first year. These milks have been modified to make them similar nutritionally in composition to breastmilk, but many of the unique ingredients in breastmilk cannot be reproduced and some nutrients have to be added in higher quantities than are found in breastmilk as they are less well absorbed.

Based on modified cows' milk, most of these infant milks have whey:casein ratios of around 60:40 but Aptamil First Infant Milk has a whey:caein ratio of 50:50. . There is little variation between brands in the macronutrient and micronutrient content, but there is some variation in the additional ingredients used which are permissible but not considered mandatory (under the Infant Formula and Follow-on Formula Regulations 2007). These include long chain polyunsaturated fatty acids (LCPUFA), nucleotides and prebiotics. (See sections 3.7-3.9 for more information about these ingredients.)

SMA Pro First Infant Milk, Hipp Organic Combiotic First Infant Milk, Kendamil First Infant Milk and Sainsbury's Little Ones First Infant Milk all contain enhanced proportions of the whey protein α-lactalbumin compared to other first formula (although all formula have similar low protein contents and all contain sufficient of all the amino-acids to meet regulations). The manufacturers use different methods to enhance the proportions of α-lactalbumin but all have used it as a means to reduce the amount of total protein in their milks whilst maintaining sufficient quantities of each amino acid. A higher protein content in infant formula is associated with higher weight in the first two years of life, although there is no evidence that growth is affected in terms of length or height (Koletzko et al, 2009). Details of the association between protein intake and weight gain and the specific claims made by manufacturers for increased proportions of α-lactalbumin are outlined in sections 3.7 and 3.7.1.

The nutritional composition and ingredients used in powdered first milks suitable for use from birth based on cows' milk are given in Table 9. First milks available as ready-to-feed formula are given in Table 10.

TABLE 9
The nutritional composition of powdered infant formula suitable from birth (cows' milk based)

Nutrients per 100ml	Aptamil 1 First Milk	Aptamil Profutura 1 First Infant Milk	Cow & Gate 1 First Infant Milk	Hipp Organic Combiotic First Infant Milk	Holle Organic Infant Formula 1	Kendamil First Infant Milk
MACRONUTRIENTS						
Energy kcal	66	66	66	66	68	67
Protein g	1.3	1.3	1.3	1.3	1.4	1.4
Whey:casein ratio	50:50	60:40	60:40	60:40	60:40	57:33
Alpha-lactalbumin enriched whey	×	×	×	✓	×	✓
Carbohydrate g	7.3	7.3	7.3	7.3	7.4	7.2
– of which lactose g	6.9	7.0	7.0	7.1	5.9	6.6
Source of added carbohydrate	Lactose, oligo-saccharides	Lactose, oligo-saccharides	Lactose, oligo-saccharides	Lactose, oligo-saccharides,	Maltodextrin	Lactose, oligo-saccharides
Fat g	3.4	3.4	3.4	3.5	3.6	3.6
Fat source	Palm, rapeseed, coconut high oleic sunflower oil and sunflower oil	Anhydrous milk fat, rapeseed, sunflower and coconut oils	Palm, rapeseed, coconut and sunflower oils	Palm, rapeseed and sunflower oils	Palm, rapeseed and sunflower oils	Sunflower, coconut and canola oils and whole milk fat
Added LCPUFAs **ARA**	✓	✓	✓	✓	×	✓
DHA	✓	✓	✓	✓	×	✓
In approved ratio	✓	✓	✓	✓	NA	✓
LCPUFA source	Fish and single cell oils	Fish and single cell oils	Fish and single cell oils	Fish and single cell oils	NA	Single cell oils
MICRONUTRIENTS						
Vitamins meeting regulations	✓	✓	✓	✓	✓	✓
Minerals meeting regulations	✓	✓	✓	✓	✓	✓
VITAMINS						
Vitamin A µg-RE	49	58	54	70	58	59
Vitamin C mg	9.3	8.3	9.2	10	11	12
Vitamin E mg	1.1	1.1	1.1	0.9	1.8	1.5
Vitamin D µg	1.2	1.2	1.2	1.2	1.2	0.8
Vitamin K µg	5.5	3.6	4.4	5.0	7.7	3.1
Thiamin (B_1) µg	50	50	50	60	70	70
Riboflavin (B_2) µg	120	120	120	100	200	160
Niacin µg (mg NE)	520	430	430	400	600	730
Vitamin B_6 µg	50	35	40	40	50	50
Vitamin B_{12} µg	0.19	0.18	0.19	0.15	0.2	0.17
Folic acid µg	13	15	13	10	24	13

TABLE 9 (continued)
The nutritional composition of powdered infant formula suitable from birth (cows' milk based)

Nutrients per 100ml	Aptamil 1 First Milk	Aptamil Profutura 1 First Infant Milk	Cow & Gate 1 First Infant Milk	Hipp Organic Combiotic First Infant Milk	Holle Organic Infant Formula 1	Kendamil First Infant Milk
Biotin µg	1.4	1.6	1.4	1.5	2.4	2.3
Pantothenic acid µg	350	330	340	500	700	500
MINERALS						
Calcium mg	54	51	55	50	56	44
Chloride mg	48	45	46	45	51	46
Copper µg	45	39	40	45	40	53
Iodine µg	14	12	12	15	15	16
Iron mg	0.6	0.52	0.53	0.5	0.6	0.7
Magnesium mg	5	5.3	5.1	5	6.6	6.3
Manganese µg	8.0	8.0	8.0	7.5	15	8
Phosphorus mg	39	32	31	27	40	26
Potassium mg	81	71	72	70	91	71
Selenium µg	1.8	1.7	1.7	1.3	2.3	2.5
Sodium mg	19	17	17	20	30	21
Zinc mg	0.54	0.51	0.51	0.5	0.6	0.5
ADDED INGREDIENTS						
Structured vegetable oils (beta-palmitate)	×	×	×	×	×	×
Prebiotics	✓	✓	✓	✓	×	✓
Probiotics	×	×	×	×	×	×
Nucleotides	✓	✓	✓	×	×	✓
Inositol	✓	✓	✓	✓	×	✓
Taurine	✓	✓	✓	×	×	✓
Choline	✓	×	✓	×	×	✓
L-carnitine	✓	×	✓	×	×	✓
Added antioxidants	✓	✓	✓	✓	✓	✓
Contains soya	✓	✓	✓	×	×	✓
Contains fish oil	✓	✓	✓	✓	×	×
Contains egg lipid	×	✓	×	×	×	×
Suitable for vegetarians[1]	×	×	×	×	×	✓
Halal approved	✓	×	✓	×	×	✓
Osmolality mOsm/kg	350	330	335	307	NK	NK

ARA = arachidonic acid DHA = docosahexaenoic acid LCPUFA = long chain polyunsaturated fatty acid
NA = not applicable NK = not known

1 Formula milks derived from cows' milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process. Rennet is used to separate curds from whey and, although vegetarian alternatives are available, they are not used by all manufacturers.

TABLE 9 continued
The nutritional composition of powdered infant formula suitable from birth (cow's milk based)

Nutrients per 100ml	Kendamil Mehadrin First Infant Milk	Kendamil Organic First Infant Milk	Mamia First Infant Milk	Sainsbury's Little Ones First Infant Milk	SMA Organic First Milk	SMA Pro First Infant Milk
MACRONUTRIENTS						
Energy kcal	66	67	67	67	67	67
Protein g	1.4	1.4	1.6	1.4	1.3	1.3
Whey:casein ratio	60:40	60:40	60:40	60:40	70:30	70:30
Alpha-lactalbumin enriched whey	×	×	×	✓	×	✓
Carbohydrate g	7.0	7.2	7.6	7.1	7.6	7.1
– of which lactose g	7.0	7.1	7.4	6.6	NK	7.1
Source of added carbohydrate	Lactose	Lactose	Lactose, oligo-saccharides	Lactose, oligo-saccharides	Lactose, maltodextrin	Lactose, oligo-saccharides
Fat g	3.6	3.7	3.3	3.6	3.5	3.6
Fat source	Rapeseed, coconut and sunflower oils and whole milk fat	Sunflower, coconut and rapeseed oils and whole milk fat	Palm, palm kernal, sunflower, rapeseed and soya bean oils	Sunflower, coconut and canola oils and whole milk fat	Sunflower oil, rapeseed oil	Palm, rapeseed, coconut and sunflower oils
Added LCPUFAs						
ARA	✓	×	✓	✓	✓	✓
DHA	✓	×	✓	✓	✓	✓
In approved ratio	✓	NA	✓	✓	✓	✓
LCPUFA source	Single cell oils	NA	Fish and soya oils	Single cell oils	Fish oil	Fish and single cell oils
MICRONUTRIENTS						
Vitamins meeting regulations	✓	✓	✓	✓	✓	✓
Minerals meeting regulations	✓	✓	✓	✓	✓	✓
VITAMINS						
Vitamin A µg-RE	65	58	68	58.1	62	75
Vitamin C mg	12	12.3	9.5	12	12	13
Vitamin E mg	1.4	1.4	1.1	1.4	1.4	1.1
Vitamin D µg	0.8	1.4	1.1	0.8	1.1	0.9
Vitamin K µg	3.0	3.6	7.6	3.9	7.1	5.5
Thiamin (B_1) µg	60	60	90	60	70	100
Riboflavin (B_2) µg	60	140	140	150	210	110
Niacin µg	750	720	430	720	700	500
Vitamin B_6 µg	60	50	60	50	40	40
Vitamin B_{12} µg	0.2	0.13	0.14	0.2	0.22	0.13

TABLE 9 (continued)
The nutritional composition of powdered infant formula suitable from birth (cow's milk based)

Nutrients per 100ml	Kendamil Mehadrin First Infant Milk	Kendamil Organic First Infant Milk	Mamia First Infant Milk	Sainsbury's Little Ones First Infant Milk	SMA Organic First Milk	SMA Pro First Infant Milk
Folic acid µg	16	18.1	12	12.9	13	9.2
Biotin µg	1.8	1.9	2.2	2.3	1.6	1.7
Pantothenic acid µg	500	480	420	480	520	430
MINERALS						
Calcium mg	44	46.4	51	44	40	43
Chloride mg	39	45.8	52	45	41	39
Copper µg	53	53	30	50	45	50
Iodine µg	18	15.5	14	15.5	15.5	14
Iron mg	0.7	0.7	0.59	0.7	0.7	0.7
Magnesium mg	6.1	6.5	5.3	6	5	6.6
Manganese µg	8	9	9	6	18	10
Phosphorus mg	25	24.5	32	25.8	22	24
Potassium mg	66	64.5	74	71	70	62
Selenium µg	2.5	2.3	2.2	2.5	3	2.2
Sodium mg	17	18	22	20	23	24
Zinc mg	0.5	0.5	0.54	0.5	0.7	0.7
ADDED INGREDIENTS						
Structured vegetable oils (beta-palmitate)	✗	✗	✗	✗	✗	✗
Prebiotics	✗	✗	✓	✓	✗	✓[2]
Probiotics	✗	✗	✗	✗	✗	✗
Nucleotides	✓	✗	✓	✓	✗	✗
Inositol	✓	✓	✓	✓	✓	✓
Taurine	✓	✗	✓	✓	✗	✓
Choline	✓	✓	✓	✓	✓	✓
L-carnitine	✗	✗	✓	✓	✗	✓
Added antioxidants	✓	✓	✓	✓	✓	✓
Contains soya	✗	✗	✓	✗	✓	✓
Contains fish oil	✗	✗	✓	✗	✓	✓
Contains egg lipid	✗	✗	✗	✗	✗	✗
Suitable for vegetarians[1]	✓	✓	✗	✓	✗	✗
Halal approved	✓	✓	✓	✗	✓	✓
Osmolality mOsm/kg	NK	NK	334	NK	278	296

ARA = arachidonic acid DHA = docosahexaenoic acid LCPUFA = long chain polyunsaturated fatty acid NK = not known ANS= approval not sought

1 Formula milks derived from cows' milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process.
2 Only powder formulations contain prebiotics.

TABLE 10
The nutritional composition of ready-to-feed infant formula suitable from birth (cows' milk based)

Nutrients per 100ml	Aptamil 1 First Milk (1L RTF)	Aptamil Profutura 1 First Infant Milk (200ml RTF)	Cow & Gate 1 First Infant Milk (1L RTF)	Hipp Organic Combiotic First Infant Milk (200ml RTF)	SMA Pro First Infant Milk (200ml RTF)
MACRONUTRIENTS					
Energy kcal	66	66	66	66	67
Protein g	1.3	1.3	1.3	1.3	1.3
Whey:casein ratio	60:40	60:40	60:40	60:40	70:30
Alpha-lactalbumin enriched whey	×	×	×	×	✓
Carbohydrate g	7.4	7.3	7.3	7.3	7.5
– of which lactose g	7.1	7.0	7.0	7.3	7.5
Source of added carbohydrate	Lactose, oligo-saccharides	Lactose, oligo-saccharides	Lactose, oligo-saccharides	Lactose, oligo-saccharides	Lactose
Fat g	3.4	3.4	3.4	3.5	3.6
Fat source	Palm, rapeseed, coconut and sunflower oils	Anhydrous milk fat, rapeseed, maize, coconut (contains soy) and sunflower oils	Palm, rapeseed, coconut and sunflower oils	Palm, rapeseed and sunflower oils	Sunflower, coconut, rapeseed and palm oils
Added LCPUFAs					
ARA	✓	✓	✓	✓	✓
DHA	✓	✓	✓	✓	✓
In approved ratio	✓	✓	✓	✓	✓
LCPUFA source	Fish and single cell oils	Fish and single cell oils	Fish and single cell oils	Single cell oils	Fish and single cell oils
MICRONUTRIENTS					
Vitamins meeting regulations	✓	✓	✓	✓	✓
Minerals meeting regulations	✓	✓	✓	✓	✓
VITAMINS					
Vitamin A µg-RE	55	65	55	70	75
Vitamin C mg	8.3	8.7	8.3	10	12
Vitamin E mg	1.1	0.9	1.1	0.7	1.4
Vitamin D µg	1.2	1.3	1.2	1.2	1.1
Vitamin K µg	4.5	4.6	4.5	5	6.4
Thiamin (B_1) µg	50	60	50	60	100
Riboflavin (B_2) µg	100	110	100	120	200
Niacin µg	430	470	430	400	500
Vitamin B_6 µg	40	50	40	40	40

TABLE 10 (continued)
The nutritional composition of ready-to-feed infant formula suitable from birth (cows' milk based)

Nutrients per 100ml	Aptamil 1 First Milk (1L RTF)	Aptamil Profutura 1 First Infant Milk (200ml RTF)	Cow & Gate 1 First Infant Milk (1L RTF)	Hipp Organic Combiotic First Infant Milk (200ml RTF)	SMA Pro First Infant Milk (200ml RTF)
Vitamin B_{12} µg	0.18	0.18	0.18	0.15	0.13
Folic acid µg	12	12	12	10	11
Biotin µg	1.5	1.1	1.5	1.5	1.7
Pantothenic acid µg	330	310	330	500	600
MINERALS					
Calcium mg	49	49	50	50	39
Chloride mg	41	40	41	45	39
Copper µg	40	40	40	45	50
Iodine µg	13	13	12	15	18
Iron mg	0.5	0.5	0.55	0.5	0.7
Magnesium mg	5	4.8	5	5	5.2
Manganese µg	6	6	8	7	20
Phosphorus mg	27	29	28	27	24
Potassium mg	66	65	68	70	77
Selenium µg	1.2	1.2	1.5	1.5	1.3
Sodium mg	17	16	18	20	24
Zinc mg	0.5	0.5	0.5	0.5	0.7
ADDED INGREDIENTS					
Structured vegetable oils (beta-palmitate)	✗	✗	✗	✗	✗
Prebiotics	✓	✓	✓	✓	✗
Probiotics	✗	✗	✗	✗	✗
Nucleotides	✓	✓	✓	✗	✓
Inositol	✓	✓	✓	✗	✓
Taurine	✓	✓	✓	✗	✓
Choline	✓	✓	✓	✗	✗
L-carnitine	✓	✓	✓	✗	✓
Added antioxidants	✓	✓	✓	✓	✓
Contains soya	✓	✓	✓	✓	✓
Contains fish oil	✓	✓	✓	✗	✓
Contains egg lipid	✗	✓	✗	✗	✗
Suitable for vegetarians[1]	✗	✗	✗	✗	✗
Halal approved	✗[2]	✓	✗[2]	✗	✓
Osmolality mOsm/kg	310	NK	315	301	295

ARA = arachidonic acid   DHA = docosahexaenoic acid   LCPUFA = long chain polyunsaturated fatty acid   NK = not known

1 Formula milks derived from cows' milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process.

2 200ml and 70ml RTF are halal approved

5.5 Infant formula suitable from birth (goats' milk based)

From March 2014, infant formula based on protein from goats' milk was allowable within the infant formula and follow-on formula regulations throughout the EU (see section 3.7). There is considered to be no difference between first infant formula made from cows' milk protein, or goats' milk protein, in terms of their allergenicity or their digestibility (EFSA, 2012).

There are currently three brands of goats' milk based first infant formula available in the UK.

NANNYcare market a goats' milk based first infant formula, based on whole goats' milk. This infant formula is made from 43% pasteurised goats' milk solids, with additional amino-acids, to fulfil current legislative requirements. This milk has a whey: casein ratio of 20:80 reflecting the use of whole goats' milk as the main source of protein. Holle Organic Infant Goat Milk Formula 1 also uses goats' milk solids (41%) with additional amino-acids added to meet regulatory requirements. This milk has a whey: casein ratio of 14:83. Current recommendations in the UK are that a first infant formula should be whey based. Goats' milk protein based infant formula manufacturers argue that the recommendation to have a whey based first formula is only applicable to cows' milk based formula and should be reviewed.

Holle Organic Infant Goat Milk Formula 1 uses maltodextrin as a source of carbohydrate, and this provides almost 50% of the carbohydrate in this milk. Holle are the only brand that uses maltodextrin as opposed to lactose as a carbohydrate source in first milks. The fats used include palm oil, sunflower oil and rapeseed oil and this milk contains 1.5 protein/100ml. This is the only goats' milk based first formula suitable for vegetarians.

Kabrita Gold 1 goats' milk based formula is a more modified formula which also contains added long chain fatty acids and prebiotics. This has a whey: casein ratio of 65:35, which is closer to the 60:40 ratio in most whey-based formula based on cows' milk. Kabrita Gold 1 is not suitable for vegetarians as it contains fish oils. It is the only first infant milk to have some added glucose syrup as a carbohydrate source and has the highest protein content of the first infant milks at 1.7g/100ml (compared to an average of 1.3g/100ml in the four main cows' milk based first formula).

It is important that health professionals are aware that goats' milk based formula are unsuitable for infants with cows' milk protein allergy.

Table 11 outlines the nutritional composition of goats' milk based infant formula suitable from birth.

TABLE 11
The nutritional composition of infant formula suitable from birth (goats' milk based)

Nutrients per 100ml	Holle Organic Infant Goat Milk Formula 1	Kabrita Gold 1 First Infant Milk	NANNYcare First Infant Milk
MACRONUTRIENTS			
Energy kcal	66	67	66
Protein g	1.5	1.7	1.3
Whey:casein ratio	14:83	65:35	20:80
Carbohydrate g	7.5	7.3	7.4
– of which lactose g	3.6	6.1	7.4
Source of added carbohydrate	Maltodextrin, lactose	Lactose, glucose syrup solids, oligosaccharides	Lactose
Fat g	3.4	3.4	3.4
Fat source	Palm, rapeseed and sunflower oils	High sn-2 palmitic acid oil, soyabean, palm kernel and sunflower oil	High oleic sunflower,rapeseed and sunflower oils
Added LCPUFAs **ARA**	×	✓	×
DHA	×	✓	×
In approved ratio	NA	✓	NA
LCPUFA source	NA	Fish and single cell oils	NA
MICRONUTRIENTS			
Vitamins meeting regulations	✓	✓	✓
Minerals meeting regulations	✓	✓	✓
VITAMINS			
Vitamin A µg-RE	84	61	70
Vitamin C mg	12	9.9	10
Vitamin E mg	1.2	1.1	1.5
Vitamin D µg	1.1	1.1	1.0
Vitamin K µg	6.7	5.4	6.7
Thiamin (B_1) µg	70	64	62
Riboflavin (B_2) µg	130	120	120
Niacin µg (mg NE)	510	620	680
Vitamin B_6 µg	44	49	36
Vitamin B_{12} µg	0.16	0.18	0.18
Folic acid µg	17.8	10	8.7
Biotin µg	2.4	1.6	2.3
Pantothenic acid µg	590	380	350
MINERALS			
Calcium mg	64.3	57	65

TABLE 11 (continued)
The nutritional composition of infant formula suitable from birth (goats' milk based)

Nutrients per 100ml	Holle Organic Infant Goat Milk Formula 1	Kabrita Gold 1 First Infant Milk	NANNYcare First Infant Milk
Chloride mg	68.5	51	68
Copper µg	53	45	45
Iodine µg	20.8	8.5	8.1
Iron mg	0.66	0.61	0.71
Magnesium mg	6.2	5.7	5.9
Manganese µg	13	8.1	8.4
Phosphorus mg	43.9	37	43
Potassium mg	86.2	70	74
Selenium µg	2.1	1.8	1.2
Sodium mg	19.7	20	18
Zinc mg	0.57	0.58	0.49
ADDED INGREDIENTS			
Structured vegetable oils (beta-palmitate)	×	✓	×
Prebiotics	×	✓	×
Probiotics	×	×	×
Nucleotides	×	×	×
Inositol	×	✓	×
Taurine	×	✓	✓
Choline	✓	✓	✓
L-carnitine	×	✓	✓
Added antioxidants	✓	✓	✓
Contains soya	×	✓	×
Contains fish oil	×	✓	×
Suitable for vegetarians[1]	✓	×	×
Halal approved	×	×	✓
Osmolality mOsm/kg	NK	NK	310

ARA = arachidonic acid DHA = docosahexaenoic acid LCPUFA = long chain polyunsaturated fatty acid
NA = not applicable

1 Formula milks derived from animal milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process. Rennet is used to separate curds from whey and, although vegetarian alternatives are available, they are not used by all manufacturers.

5.6 Infant formula marketed for hungrier babies, suitable from birth (cows' milk based)

Key points

Formula marketed for hungrier babies has a casein: whey ratio similar to animal milk.

It is suggested that a higher casein content can slow gastric emptying, resulting in greater satiety and a better night's sleep, but there is no evidence to support this.

The nutritional composition of casein-dominant formulas is slightly different to that of whey-dominant infant formulas. However, the reported nutrient composition for both types of milk is within recommended levels. A whey-based infant formula is recommended for use throughout the first year of life.

In addition to first infant formula, most manufacturers also offer an infant formula for 'hungrier babies'. These milks are predominantly casein-based and it is suggested that a whey:casein ratio of approximately 20:80 (which is similar to that in cows' milk) can result in slower gastric emptying, resulting in greater satiety. Studies used to support this suggestion have, however, been from small studies of infants with reflux difficulties (Billeaud et al, 1990; Tolia et al, 1992) and these findings are not supported by all studies. It has also been suggested that the use of these milks may help delay weaning, but there is no scientific evidence to support this. Cow & Gate suggest on their website that infants under 6 months may get a better night's sleep if they have hungry baby formula in the evening, but give no evidence to support this claim. The higher casein content of hungrier baby formula is likely to cause larger and more indigestible curds to form in the stomach, but there is no evidence that this helps a baby to settle better or sleep longer (Taitz and Scholey, 1989; Thorkelsson et al, 1994).

The nutritional composition of hungry baby formulas does not differ significantly from those of standard infant formulas, but they have a slightly higher carbohydrate and protein content balanced by a slightly lower fat content, which maintains the total energy value at recommended levels. The vitamin and mineral content of these milks also differs slightly from those in first infant formula. However, all milks available report vitamin and mineral contents within the recommended levels.

The nutritional composition and ingredients used in infant formula marketed for hungrier babies suitable from birth are given in Table 12.

TABLE 12
The nutritional composition of infant formula marketed for hungrier babies, suitable from birth (cows' milk based)

Nutrients per 100ml	Aptamil Hungry Milk	Cow & Gate Infant Milk for Hungrier Babies	Hipp Organic Combiotic Hungry Infant Milk	SMA Extra Hungry
MACRONUTRIENTS				
Energy kcal	66	66	67	67
Protein g	1.6	1.6	1.6	1.6
Whey:casein ratio	20:80	20:80	20:80	20:80
Carbohydrate g	7.7	7.7	7.3	7.0
– of which lactose g	7.4	7.4	7.1	7.0
Source of added carbohydrate	Lactose, oligo-saccharides	Lactose, oligo-saccharides	Lactose, oligo-saccharides	Lactose
Fat g	3.1	3.1	3.5	3.6
Fat source	Palm, rapeseed, coconut and sunflower oils	Palm, rapeseed, coconut and sunflower oils	Palm, rapeseed and sunflower, oils	Palm, sunflower, coconut and soya oils
Added LCPUFAs **ARA**	✓	✓	✓	✓
DHA	✓	✓	✓	✓
In approved ratio	✓	✓	✓	✓
LCPUFA source	Fish and single cell oils	Fish and single cell oils	Fish and single cell oils	Single cell oils
MICRONUTRIENTS				
Vitamins meeting regulations	✓	✓	✓	✓
Minerals meeting regulations	✓	✓	✓	✓
VITAMINS				
Vitamin A µg-RE	55	55	70	75
Vitamin C mg	8.2	8.1	10	9
Vitamin E mg	1.1	1.1	0.8	0.74
Vitamin D µg	1.2	1.2	1.0	1.1
Vitamin K µg	4.4	4.4	5.5	6.7
Thiamin (B_1) µg	50	50	60	100
Riboflavin (B_2) µg	110	100	110	110
Niacin µg (mg NE)	440	440	440	500
Vitamin B_6 µg	30	40	45	60
Vitamin B_{12} µg	0.18	0.18	0.15	0.18
Folic acid µg	12	12	10	13
Biotin µg	1.3	1.6	1.5	2
Pantothenic acid µg	330	340	500	370

TABLE 12 (continued)
The nutritional composition of infant formula marketed for hungrier babies, suitable from birth (cows' milk based)

Nutrients per 100ml	Aptamil Hungry Milk	Cow & Gate Infant Milk for Hungrier Babies	Hipp Organic Combiotic Hungry Infant Milk	SMA Extra Hungry
MINERALS				
Calcium mg	76	70	80	56
Chloride mg	53	53	45	55
Copper µg	40	40	45	33
Iodine µg	11	10.8	15	10
Iron mg	0.53	0.53	0.7	0.64
Magnesium mg	5.2	5.2	5.0	5.3
Manganese µg	8	8	7.0	10
Phosphorus mg	50	49	44	44
Potassium mg	86	81	75	80
Selenium µg	1.5	1.5	1.5	1.4
Sodium mg	25	20	20	22
Zinc mg	0.5	0.5	0.5	0.6
ADDED INGREDIENTS				
Structured vegetable oils	✗	✗	✗	✗
Prebiotics	✓	✓	✓	✗
Probiotics	✗	✗	✗	✗
Nucleotides	✓	✓	✗	✓
Inositol	✓	✓	✓	✓
Taurine	✓	✓	✗	✓
Choline	✓	✓	✗	✓
L-carnitine	✓	✓	✗	✗
Added antioxidants	✓	✓	✓	✓
Contains soya	✓	✓	✗[3]	✓
Contains fish oil	✓	✓	✓[3]	✗
Suitable for vegetarians[1]	✗	✗	✗	✓[3]
Halal approved	✓[2]	✓[2]	✗	✓[3]
Osmolality mOsm/kg	360	360	280	287

ARA = arachidonic acid DHA = docosahexaenoic acid LCPUFA = long chain polyunsaturated fatty acid

1 Formula milks derived from cows' milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process. Rennet is used to separate curds from whey and, although vegetarian alternatives are available, they are not used by all manufacturers.
2 Powder formulation and 200ml RTF but not 1L RTF.
3 Powder formulation only.

5.7 Thickened (anti-reflux) infant milks suitable from birth

Key points

Thickened infant milks are classified as foods for special medical purposes and should only be used under medical supervision (as must be stated on the label by law).

Thickened (anti-reflux) infant milks with added corn (maize) potato starch or carob bean gum are marketed to manage reflux and regurgitation in infants. These products are widely available over the counter.

NICE guidance published in January 2015 (NICE, 2015) and a NICE Quality Standard (QS112, NICE 2016) outline how gastro-oesophageal reflux should be diagnosed and managed in infants. Regurgitation is a common and normal occurrence in infants and does not usually need any investigation or treatment. Where (rarely) there are significant symptoms of frequent regurgitation with marked distress, thickener added to milk or a thickened formula is recommended for trial, only after a review of feeding history, and a reduction in feed volumes where appropriate or an increase in frequency of feeds have been attempted.

Manufacturer guidance on how to make up thickened infant milks **is not in line with current recommendations for making up infant formula safely**, since they suggest using cold or hand-hot water rather than water boiled and left to cool to 70^{O}C. Where these milks are prescribed, advice should be taken from a health professional on how to make them up appropriately.

Thickened infant milks are marketed as reducing gastro-oesophageal reflux (bringing up milk into the oesophagus) and vomiting or spitting up feeds in formula-fed infants. Whilst reflux does not generally result in health consequences and resolves spontaneously by about 3 months of age in the majority of cases, many parents seek remedies (Vanderhoof et al, 2003) and these milks have been developed to meet this actual or perceived need.

In the UK there are four thickened infant milks available over the counter: Aptamil Anti-reflux (Danone), Cow & Gate Anti-reflux (Danone), Hipp Organic Anti-reflux and SMA Pro Anti-reflux (Nestlé). The on-pack nutritional information for Aptamil Anti-reflux and Cow & Gate Anti-reflux suggests that the products have an identical composition. They both have whey:casein ratios of 20:80 and the thickening agent used is carob bean gum. The thickening agent used in Hipp Organic Anti-reflux is also carob bean gum and the product has a whey:casein ratio of 60:40. There is as yet, no marketing information available on the Hipp Organic website to support the use of this product. SMA Pro Anti-reflux replaced SMA Staydown in 2017. This reformulated infant milk is thickened with potato starch and unlike other anti-reflux milks the protein component is partially hydrolysed 100% whey.

Clinical trials which have examined the impact of thickened milks on reflux have had mixed results. The thickening agent used in Danone products is carob bean gum and it is suggested that this is not split by salivary amalyse and therefore maintains the viscosity of the feed in the stomach (Wenzl et al, 2003). Danone supports the use of its anti-reflux product by reference to clinical trials using its products. A prospective, double-blind trial in 20 infants reported that there was no change in the regurgitation frequency between groups receiving the thickened milk and the placebo group, but there was a significant decrease in the length of time of oesophageal acid exposure in the groups receiving the thickened milk (Vandenplas et al, 1994). In a further placebo-controlled crossover study in 14 healthy infants, the frequency and amount of regurgitation were reduced after consuming an infant formula thickened with carob bean gum, compared to when the infants were fed the same milk without thickener. However, there was no significant reduction in the occurrence or duration of acid gastro-oesophageal reflux. The decrease in regurgitation was thought to have resulted from the decrease in the number of non-acid gastro-oesophageal reflux episodes when thickened infant milk was consumed (Wenzl et al, 2003).

A more recent clinical trial including 60 infants and their carers was designed to evaluate the efficacy of parental reassurance in combination with different types of infant milk. This trial reported that regurgitation frequency was reduced in all of the three groups, and there was no significant difference in regurgitation frequency between groups receiving standard formula milk, infant milk thickened with rice cereal, or infant milk thickened with bean gum. All participating parents were reassured in the same way. The only significant difference between groups was that infants receiving infant milk thickened with bean gum experienced a greater increase in weight during the trial. The authors suggest that this effect may be due to the greater (although not statistically significant) decrease in regurgitation frequency in this group (Hegar et al, 2008).

All of the anti-reflux milks on the market are thickened with starches or gums, however, systematic reviews of non-pharmacological and non-surgical therapies for gastro-oesophageal reflux in infants, have concluded that thickened infant formulas do not appear to reduce measurable reflux, although they may reduce regurgitation (vomiting) (Horvath et al, 2008; Carroll et al ,2002). It has been suggested that commercially prepared thickened infant milks have an advantage over thickeners added to milk at home as the latter type may lead to inconsistencies in composition (Ramirez-Mayans et al, 2003). Milk thickeners to add to milk include Instant Carobel (Cow & Gate), which uses carob bean gum as a thickening agent. However the use of a thickener given on a spoon before a feed allows the infant to be given a first infant formula, a product that will be why based, have a lower protein content and which does not contain additional sugars such as maltodextrins.

Many clinical trials examining the safety and efficacy of thickened milks have used test formula milks that are also predominantly casein-based. Both Aptamil and Cow & Gate anti-reflux milks are predominantly casein based. The proposed mechanism of action is that casein predominant formula milks form larger curds in the stomach and this is thought to result in fewer episodes of reflux (Ramirez-Mayans et al, 2003). It is however, also suggested that casein dominant formula milks can result in slower gastric emptying compared to whey based formula milks (Ramirez-Mayans et al , 2003; Tolia et al, 1992.) The role of delayed gastric emptying in the pathogenesis of gastro-oesophageal reflux in infants is considered to be controversial (Tolia et al, 1992) with some authors suggesting that delayed gastric emptying is more common in infants with symptoms of reflux, but this is mainly in populations with neurological disorders (Fonkalsrud, 1996 and Fried et al, 1992).

Nestlé have recently relaunched SMA Staydown as SMA Pro Anti-reflux. The updated formulation differs from its predecessor in a number of ways. It now contains less protein per 100ml, is based on 100%, partially hydrolysed whey rather than on 80% casein and the thickening agent has changed from pre-cooked corn starch to potato starch. Whilst use of SMA Staydown was supported by reference to clinical trials which showed reductions in the number of episodes of regurgitation in infants fed thickened casein based formula milks compared to those fed standard whey based formula milks (Moukarzel et al, 2007; Ramirez-Mayans et al, 2003; Xinias et al, 2003) the use of the new product, SMA Pro Anti-reflux is supported by reference to abstracts from clinical trials. One of these is based on a hydrolysed whey based infant formula which also contains probiotics (Indrio et al, 2015) whilst the other is based on Nestlé milks thickened with potato/corn starch of undisclosed composition (Toporovski et al, 2013).

SMA suggest on their website that:

'Whey dominant formulas containing partially hydrolysed protein accelerate gastric emptying time making the formula easy to digest'

Whilst some studies do suggest that gastric emptying is more rapid with hydrolysed whey based formula milks than with casein based milks, it remains unclear whether or not delayed gastric emptying contributes to reflux. It is also interesting to note that in a Nestlé sponsored study using NAN and NAN H.A products, Staelens et al,(2008), found no difference in the rate of gastric emptying between a partially hydrolysed whey protein formula and a standard whey based infant milk with intact protein. The authors of this study did highlight the fact that other differences between the test formulas may have influenced rates of gastric emptying.

There is some evidence that thickened infant milk can reduce regurgitation in some infants, however, their use in infants with simple reflux is not supported by the ESPGHAN Committee on Nutrition on the grounds that there is no conclusive information available on the potential effects of thickening agents on the bioavailability of nutrients and growth of children, or on mucosal, metabolic and endocrine responses (Aggett et al, 2002b). There is also very little evidence to suggest that these milks confer any benefits with respect to acid exposure of the oesophageal mucosa or bronchopulmonary complications of gastro-oesophageal reflux. It is suggested that, where infants have simple reflux and no complications, parents and carers require advice and information rather than a different type of formula (Aggett et al, 2002b).

This is supported by NICE guidance and quality standards in the UK (NICE, 2015, NICE 2016), which outlines how gastro-oesophageal reflux should be diagnosed and managed in infants. The guidance reiterates that regurgitation is a common and normal occurrence in infants and does not usually need any investigation or treatment. Where (rarely) there are significant symptoms of frequent regurgitation with marked distress, thickener added to milk or a thickened infant milk is recommended for trial, only after a review of feeding history, and a reduction in feed volumes where appropriate or an increase in frequency of feeds, have been attempted.

It is hoped that these NICE guidelines will support health professionals, including midwives, health visitors, GPs and hospital doctors, as well as lactation consultants, to provide consistent evidence-based support for anyone concerned about infant reflux and regurgitation. The guidance can be accessed from www.nice.uk

Thickened anti-reflux infant milks are foods for special medical purposes (FSMP) rather than infant formula and they should therefore be labelled with the statement *'For use under medical supervision'.*

The Department of Health has not asked manufacturers to change the instructions for making up these milks in line with recommendations for infant formula because the milks are foods for special medical purposes, but we believe that, as they are FSMP, they should not be sold over the counter.

Currently, manufacturers suggest that these milks are made up with cold or hand-hot water, rather than with water boiled and cooled to 70^{o}C. This is because anti-reflux milk made up with water at 70^{o}C is likely to become lumpy. However, if the milk is made up with cold or hand-hot water, there is an increased risk of bacteria being present in the milk. We do not recommend that any milks are made up using water at a temperature of less than 70^{o}C unless the risks have been assessed by a medical practitioner.

The nutritional composition and ingredients used in thickened (anti-reflux) infant milks suitable from birth are given in Table 13.

TABLE 13
The nutritional composition of thickened (anti-reflux) infant milks suitable from birth

Nutrients per 100ml	Aptamil Anti-reflux	Cow & Gate Anti-reflux	Hipp Organic Combiotic Anti-reflux	SMA Pro Anti-reflux
MACRONUTRIENTS				
Energy kcal	66	66	67	67
Protein g	1.6	1.6	1.4	1.3
Whey:casein ratio	20:80	20:80	60:40	100:0
Carbohydrate g	6.8	6.8	7.1	7.8
– of which lactose g	6.0	6.0	6.2	5.1
Source of added carbohydrate	Lactose, maltodextrin, carob bean gum	Lactose, maltodextrin, carob bean gum	Maltodextrin, carob bean gum, lactose	Lactose, potato starch
Fat g	3.5	3.5	3.5	3.4
Fat source	Palm,rapeseed, coconut and sunflower oils	Palm,rapeseed, coconut and sunflower oils	Palm,rapeseed, and sunflower oils	Sunflower, coconut and rapeseed oils
Added LCPUFAs ARA	✓	✓	✓	✗
DHA	✓	✓	✓	✗
In approved ratio	✓	✓	✓	N/A
LCPUFA source	Fish and single cell oils	Fish and single cell oils	Fish and single cell oils	N/A
MICRONUTRIENTS				
Vitamins meeting regulations	✓	✓	✓	✓
Minerals meeting regulations	✓	✓	✓	✓
VITAMINS				
Vitamin A µg-RE	50	50	70	68
Vitamin C mg	8.3	8.3	10	9
Vitamin E mg	1.0	1.0	0.8	1.2
Vitamin D µg	1.2	1.2	1.1	0.9
Vitamin K µg	4.5	4.5	5.0	5.1
Thiamin (B_1) µg	50	50	60	70
Riboflavin (B_2) µg	100	100	130	150
Niacin µg (mg NE)	(0.82)	(0.82)	670	700
Vitamin B_6 µg	50	50	40	50
Vitamin B_{12} µg	0.17	0.17	0.15	0.14
Folic acid µg	9.4	9.4	10	10.6
Biotin µg	1.5	1.5	1.7	1.5
Pantothenic acid µg	300	300	500	600
MINERALS				
Calcium mg	77	77	70	46
Chloride mg	52	52	45	50
Copper µg	40	40	45	60
Iodine µg	13	13	15	10

TABLE 13 (continued)
The nutritional composition of thickened (anti-reflux) infant milks suitable from birth

Nutrients per 100ml	Aptamil Anti-reflux	Cow & Gate Anti-reflux	Hipp Organic Combiotic Anti-reflux	SMA Pro Anti-reflux
Iron mg	0.68	0.68	0.8	0.7
Magnesium mg	5.1	5.1	5.5	6.8
Manganese µg	33	33	7	10
Phosphorus mg	43	43	38	26
Potassium mg	76	76	70	72
Selenium µg	1.3	1.3	1.5	2.4
Sodium mg	24	24	20	26
Zinc mg	0.59	0.59	0.6	0.7
ADDED INGREDIENTS				
Structured vegetable oils	✗	✗	✗	✗
Prebiotics	✗	✗	✗	✗
Nucleotides	✓	✓	✗	✓
Inositol	✓	✓	✗	✓
Taurine	✓	✓	✗	✓
Choline	✓	✓	✗	✓
L-carnitine	✓	✓	✗	✓
Added antioxidants	✓	✓	✓	✓
Contains soya	✓	✓	✗	✗
Contains fish oil	✓	✓	✓	✗
Suitable for vegetarians[1]	✗	✗	✗	✗
Halal approved	ANS	ANS	✗	✗
Osmolality mOsm/kg	290	290	266	240

ARA = arachidonic acid DHA = docosahexaenoic acid LCPUFA = long chain polyunsaturated fatty acid
ANS = approval not sought NA = not applicable

1 Formula milks derived from cows' milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process. Rennet is used to separate curds from whey and, although vegetarian alternatives are available, they are not used by all manufacturers.

5.8 Soya protein based infant formula suitable from birth

Key points

Soya protein based infant formula use protein from soya beans, and the carbohydrate source is glucose syrup. They contain no animal protein or lactose.

Concerns have been raised over the potential allergenic effect of soya protein based formula in infants at high risk of atopy and over the effects that the phyto-oestrogens present in soya protein based formula might have on future reproductive health.

Whilst soya protein based formula have been shown to support normal growth and development in healthy term infants, the Chief Medical Officer has recommended that soya protein based formula should not be routinely used for infants under 6 months of age who have cows' milk protein allergy or intolerance.

The Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) concluded that the high levels of phyto-oestrogens present in soya protein based milks posed a potential risk to the future reproductive health of infants (Committee on Toxicity, 2003).

When the carbohydrate source is glucose rather than lactose, milks have a greater potential to cause dental caries. Parents and carers using soya based formula are advised to avoid prolonged contact of milk feeds with their baby's teeth and ensure that they clean their baby's teeth after the last feed at night.

Advice in the UK is that parents and carers should always seek advice before feeding their infant soya protein based infant formula.

Soya protein based formula combine protein from soya beans with water, vegetable oils, glucose syrup and vitamins and minerals.

The amino acid profile of soya protein is deficient in sulphur-containing amino acids, and soya protein based milks must therefore be fortified with the sulphur-containing amino acid L-methionine. Soya protein based milks are available both over the counter and by prescription and may be used from birth. They have sometimes been used for children who require an alternative to cows' milk based infant milks because they have an allergy or intolerance to cows' milk, or because they have a specific condition such as galactosaemia or galactokinase deficiency.

There is currently controversy over the use of soya protein based infant formula for children aged under 6 months. Concerns have been raised over the potential allergenic effect of soya protein based milks in infants at high risk of atopy and over the effects that the phyto-oestrogens present in soya protein based formula might have on future reproductive health (Committee on Toxicity, 2003).

In a systematic review of clinical studies examining measures of infant health and development and comparing soya protein based infant formula with cows' milk protein based infant formula and/or human milk, Mendez et al (2002) concluded that modern soya protein based formula (supplemented with methionine) support normal growth and development in healthy term infants during the first year of life.

Soya protein based infant formulas have often been used as an alternative to cows' milk protein based infant milks in children with cows' milk protein allergy (CMPA). In a review of trials comparing the effect of prolonged feeding of soya protein based infant formula and of cows' milk protein based infant formula, meta-analysis found no significant difference in childhood asthma incidence, childhood eczema incidence or childhood rhinitis. The authors concluded that soya protein based formula cannot be recommended for allergy prevention or food intolerance in infants at high risk of atopy (Osborn and Sinn, 2006).

It is recognised that a proportion of children with CMPA are also allergic to soya protein. The Chief Medical Officer has recommended that soya protein based milks should not be used as the first line of treatment for infants under 6 months of age who have CMPA or cows' milk protein intolerance, as this is the period when they are most likely to become sensitised to soya protein (Chief Medical Officer, 2004). ESPGHAN recommends that soya protein based infant formulas should not be used for infants under 6 months of age and that the use of therapeutic milks based on extensively hydrolysed proteins (or amino acid preparations if hydrolysates are not tolerated) should be preferred to the use of soya protein formula in the treatment of cows' milk protein allergy (Agostoni et al, 2006).

Soya protein based formula contain much higher levels of phyto-oestrogens than formula based on cows' milk protein. Setchell et al (1998) estimated that infants aged 1 to 4 months who were fed soya protein based formula would receive 6-12mg/kg of body weight of phyto-oestrogens per day, compared to 0.7-1.4mg/kg bw per day for adults consuming soya protein based products. There has been very little research into the effects of consumption of phyto-oestrogens from soya protein based formula in very young infants. However, research in animals suggests that phyto-oestrogens can have detrimental effects on reproductive function, immune function and carcinogenesis. In a review of the scientific evidence on soya protein based formula, the Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) concluded that the high levels of phyto-oestrogens present in soya protein based formula posed a potential risk to the future reproductive health of infants (Committee on Toxicity, 2003).

More recent research has looked at potential links between soya infant formula and seizures in children with autism (Westmark, 2014) with a hypothesis that phyto-oestrogens in soya protein based infant formula can contribute to lower seizure threshold. Whilst this study reports links using data from retrospective data collection and therefore cannot confirm an association, it reiterates the need for caution in the use of soya protein based formula in infancy.

The required composition of soya protein based infant formula is different to that of cows' milk based formula for a number of micronutrients including iron and phosphorus due to differences in bioavailability. Soya protein based formula are suitable for vegetarians but not for vegans. Advice in the UK is that parents should always seek advice before feeding their infant soya protein based infant formula.

There is now only one soya protein based infant formula on the market, as Cow & Gate Infasoy has been withdrawn from sale. The nutritional composition and ingredients used in SMA Wysoy is given in Table 14.

TABLE 14
The nutritional composition of soya protein based infant formula suitable from birth

Nutrients per 100ml	SMA Wysoy
MACRONUTRIENTS	
Energy kcal	67
Protein g	1.8
Carbohydrate g	6.9
Source of added carbohydrate	Glucose syrup
Fat g	3.6
Fat source	Palm, soya, coconut and sunflower oils
Added LCPUFAs ARA	✓
DHA	✓
LCPUFA Source	Single cell oils
MICRONUTRIENTS	
Vitamins meeting regulations	✓
Minerals meeting regulations	✓
VITAMINS	
Vitamin A µg-RE	75
Vitamin C mg	9
Vitamin E mg	0.74
Vitamin D µg	1.2
Vitamin K µg	10
Thiamin (B_1) µg	100
Riboflavin (B_2) µg	110
Niacin µg (mg NE)	500
Vitamin B_6 µg	60
Vitamin B_{12} µg	0.18
Folic acid µg	13
Biotin µg	2
Pantothenic acid µg	370
MINERALS	
Calcium mg	67
Chloride mg	43
Copper µg	30
Iodine µg	12
Iron mg	0.8
Magnesium mg	6.7
Manganese µg	20

TABLE 14 (continued)
The nutritional composition of soya protein based infant formula suitable from birth

Nutrients per 100ml	**SMA Wysoy**
Phosphorus mg	50
Potassium mg	72
Selenium µg	1.4
Sodium mg	19
Zinc mg	0.6
ADDED INGREDIENTS	
Structured vegetable oils	×
Prebiotics	×
Nucleotides	✓
Inositol	✓
Taurine	✓
Choline	✓
L-carnitine	✓
Added antioxidants	✓
Contains soya	✓
Contains fish oil	×
Suitable for vegetarians	✓
Halal approved	✓
Osmolality mOsm/kg	204

ARA = arachidonic acid DHA = docosahexaenoic acid LCPUFA = long chain polyunsaturated fatty acid

5.9 Lactose-free infant milks suitable from birth

Key points

Lactose-free infant milks are foods for special medical purposes and should only be used under medical supervision.

Primary and congenital lactose intolerance are clinical syndromes which can cause abdominal pain, diarrhoea, flatulence and/or bloating after ingestion of food containing lactose. These conditions are very rare in infants and require treatment with lactose-free infant formula under medical supervision.

There is limited evidence that treating acute gastroenteritis in a hospital setting with lactose free formula is beneficial, and the routine use of lactose free formula for treating gastroenteritis in an outpatient setting is not recommended. Lactose intolerance in infants following a bout of gastroenteritis is usually temporary and there is no evidence that a lactose-free milk is beneficial. Continued breastfeeding is always encouraged if a baby has, or has had, gastroenteritis. Lactose-free milks are of no benefit in treating colic.

There is a risk associated with feeding infant milks which have glucose as the carbohydrate source rather than lactose, as these milks have a greater potential to cause dental caries. Parents and carers using these milks are advised to avoid prolonged contact of milk feeds with their baby's teeth and ensure that they clean their baby's teeth after the last feed at night.

There may be further risks associated with using a lactose free milk as diets without lactose might have disadvantages for the composition of the infants' colonic microflora and colonic physiological function, and they might compromise calcium absorption.

In the UK, the lactose-free milks Aptamil Lactose Free and SMA LF are both marketed as suitable from birth and are widely available over the counter.

The main difference between lactose-free and standard cows' milk based infant formulas is that in lactose-free milk the carbohydrate is glucose rather than lactose. Lactose intolerance is a clinical syndrome which can cause abdominal pain, diarrhoea, flatulence and/or bloating after ingestion of food containing lactose. The underlying physiological problem is lactose malabsorption, which is caused by an imbalance between the amount of lactose ingested and the capacity of the enzyme lactase to hydrolyse it, and therefore the amount of lactose that can cause symptoms varies (Heyman et al, 2006).

Heyman et al (2006) identify the following different types of lactose intolerance:

- Primary lactose intolerance is caused by an absolute or relative lack of the enzyme lactase and is the most common cause of lactose malabsorption worldwide. It is known to be more prevalent among black and Asian populations but is extremely rare in infants.
- Secondary lactose intolerance results from injury to the small bowel such as might occur during acute gastroenteritis and persistent diarrhoea and is likely to be temporary.

- Congenital lactase deficiency is a rare condition in infants, in which the infant develops persistent diarrhoea as soon as any lactose, from human milk or formula, is introduced.
- Developmental lactase deficiency is observed among premature infants. Lactase production is deficient in the immature gastrointestinal tract until at least 34 weeks' gestation.

In the very rare cases of primary or congenital lactose intolerance, lactose-free formula are necessary, but infants should be managed by a clinician. The continued use of breastmilk does not seem to have any adverse effects on pre-term infants with developmental lactose intolerance (Shulman et al, 1995).

In the UK, the lactose-free milks Aptamil Lactose Free (Danone) and SMA LF (Wyeth) are widely available. These milks are both nutritionally complete for use from birth. SMA LF is presented as being suitable not only for infants with congenital lactose intolerance, but also for infants who have been diagnosed with lactose intolerance following a bout of gastroenteritis. It is also suggested to help in the dietary management of post-infectious diarrhoea in infants who are not breastfed. Aptamil Lactose Free is suggested for use for infants with lactose or sucrose intolerance or those suffering from diarrhoea, bloating or wind caused by temporary lactose intolerance.

In developed countries, the use of lactose-free milks as a treatment for acute gastroenteritis has been shown to have no clinical advantage over standard lactose-containing formula (Kukuruzovic and Brewster, 2002). The most recent ESPGHAN guidelines for the management of acute gastroenteritis in children (Guarino et al, 2014) suggest that there is weak evidence for the use of lactose-free milk for the treatment of acute diarrhoea in hospital settings, but that the routine use of lactose free milks in community settings is not recommended. It is also suggested that diets without lactose might have disadvantages for the composition of the infants' colonic microflora and colonic physiological function, and they might compromise calcium absorption (Ziegler & Fomon, 1983).

There are also potential risk associated with the use of lactose free formula. Diets without lactose might have disadvantages for the composition of the infants' colonic microflora and colonic physiological function, and they might compromise calcium absorption (Ziegler& Fomon, 1983). Moreover, feeding lactose free diets from birth (for example, for preventive purposes), will cause false negative results of most neonatal screening tests for galactosaemia (Hǒst et al, 1999).

Despite the fact that lactose free formula are of little benefit for infants with acute diarrhoea, in a multi-centre study conducted in 29 European countries in 2000, when doctors were asked, in a questionnaire, what they would recommend for an infant with acute diarrhoea, 36% said they would use normal lactose-containing infant formula, 35% would use lactose-free milk, and 19% would use a lactose and milk protein free product (Szajewska et al, 2000). This suggests there may be considerable confusion among health professionals about the treatment of temporary lactose intolerance in infants caused by gastroenteritis. Lactose-free milks are also not recommended for the treatment of colic (NICE 2017). Some newer evidence also suggests that infants fed a lactose free formula will have higher blood glucose and some circulating amino acid levels after 120 minutes than infants fed standard infant formula, suggesting that lactose free formula may have a negative impact on the infant metabolism which require further investigation (Slupsky et al, 2017).

Lactose-free milk has a greater potential to cause dental caries. Lactose is a non-cariogenic sugar whereas the common replacement carbohydrate, glucose, is cariogenic (Bowen et al, 1997). It is therefore vital that parents using lactose-free milk follow advice to avoid prolonged contact of milk feeds with their baby's teeth and ensure that they clean their baby's teeth after the last feed at night.

The nutritional composition and ingredients used in lactose-free infant milks suitable from birth are given in Table 15.

TABLE 15
The nutritional composition of lactose-free infant milks suitable from birth

Nutrients per 100ml	Aptamil Lactose Free	SMA LF
MACRONUTRIENTS		
Energy kcal	66	67
Protein g	1.3	1.5
Whey:casein ratio	0:100	60:40
Carbohydrate g	7.3	7.2
– of which lactose mg	less than 6	less than 6.7
Source of added carbohydrate	Glucose syrup	Dried glucose syrup
Fat g	3.5	3.6
Fat source	Palm, rapeseed, coconut and sunflower oils	Palm, soya, coconut and sunflower oils
Added LCPUFAs **ARA**	✓	✓
DHA	✓	✓
In approved ratio	✓	✓
LCPUFA source	Fish and single cell oils	Single cell oils
MICRONUTRIENTS		
Vitamins meeting regulations	✓	✓
Minerals meeting regulations	✓	✓
VITAMINS		
Vitamin A µg-RE	55	75
Vitamin C mg	9.3	9.0
Vitamin E mg	1.2	0.74
Vitamin D µg	1.2	1.2
Vitamin K µg	4.5	6.7
Thiamin (B_1) µg	50	100
Riboflavin (B_2) µg	100	150
Niacin µg (mg NE)	(0.8)	500
Vitamin B_6 µg	40	60
Vitamin B_{12} µg	0.11	0.2
Folic acid µg	8.9	8.0
Biotin µg	1.8	2.0
Pantothenic acid µg	330	300
MINERALS		
Calcium mg	55	55
Chloride mg	41	43
Copper µg	42	30
Iodine µg	12	10
Iron mg	0.79	0.8
Magnesium mg	5.1	6
Manganese µg	34	40

TABLE 15 (continued)
The nutritional composition of lactose-free infant milks suitable from birth

Nutrients per 100ml	Aptamil Lactose Free	SMA LF
Phosphorus mg	30	37
Potassium mg	65	70
Selenium µg	1.6	1.4
Sodium mg	17	16
Zinc mg	0.56	0.6
ADDED INGREDIENTS		
Structured vegetable oils	×	×
Prebiotics	×	×
Nucleotides	✓	✓
Inositol	✓	✓
Taurine	✓	✓
Choline	✓	✓
L-carnitine	✓	✓
Added antioxidants	✓	✓
Contains soya	✓	✓
Contains fish oil	✓	×
Suitable for vegetarians[1]	×	✓
Halal approved	×	✓
Osmolality mOsm/kg	170	204

ARA = arachidonic acid DHA = docosahexaenoic acid LCPUFA = long chain polyunsaturated fatty acid
NK = not known

1 Formula milks derived from cows' milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process. Rennet is used to separate curds from whey and, although vegetarian alternatives are available, they are not used by all manufacturers.

5.10 Partially hydrolysed infant milks suitable from birth

Key points

Partially hydrolysed infant milks are foods for special medical purposes and do not have to conform to the infant formula and follow-on formula regulations. Despite the fact that these products should only be used under medical supervision, and must be labelled as such, they are commonly sold over the counter in supermarkets and pharmacies.

Most infant milks containing partially hydrolysed proteins are marketed as 'comfort milks' and claim to be easier to digest and designed for the management of colic and constipation. One is marketed as preventing cows' milk protein allergy. All these milks are based on modified cows' milk with 100% whey protein.

No convincing evidence is presented by manufacturers to support the efficacy of these milks in preventing colic, wind or gastrointestinal discomfort. NICE clinical guidance is clear there is no infant formula solution for colic (NICE CKS, 2017) and NICE advise against a change in formula type. NHS Choices only suggests practical and soothing strategies for colic (NHS Choices, 2017a). NHS Choices suggest that constipation in formula fed infants can be treated with additional drinks of water but there is no advice to change formula (NHS Choices, 2017b). The EFSA review on infant formula composition (EFSA, 2014) reported no benefits for infants of the addition of prebiotic oligosaccharides or the use of palmitate in the *sn-2* position in infant formula which manufacturers make claims for in these formula.

A systematic review commissioned by The Food Standards Agency and published in the British Medical Journal in 2016 (Boyle et al, 2016) concluded that there was no consistent evidence that partially hydrolysed formula reduce risk of allergic disease. An ESPGHAN working group consensus (Vandenplas et al, 2016) also concluded that evidence on efficacy of partially hydrolysed formula on prevention of atopic disease is limited and also highlighted the lack of any evidence on potential negative long term metabolic consequences and outcomes of using these products.

5.10.1 Partially hydrolysed whey-based milks marketed as comfort milks

Most infant milks containing partially hydrolysed proteins are marketed as comfort milks which are 'easier to digest' and which the manufacturers claim are designed for the management of colic and constipation. In the UK there are four comfort milks available: Aptamil Comfort, Cow & Gate Comfort, Hipp Combiotic Comfort and SMA Comfort. They are all modified cows' milk formula based on 100% whey protein. All three products contain lactose at lower levels than those found in standard infant formula milks and all contain structured vegetable oils. Aptamil Comfort, Cow & Gate Comfort and Hipp Combiotic Comfort milks also contain non-digestible oligosaccharides and added starch for a thicker feed. Aptamil Comfort and Cow & Gate Comfort milks have an identical nutrient profile, and we believe they are the same product marketed under different names and at different prices.

What claims are made, and what evidence is provided to support these claims?

Manufacturers support the claims made for their products by reference to clinical trials, but the trial data presented is often weak and many of the studies reported do not meet the criteria required to be considered for clinical evidence review. In most cases evidence is provided from just one study, and often these findings have not been supported by systematic expert evidence review.

SMA Comfort

SMA provide 4 references to support their claims that SMA comfort is easier to digest, can prevent wind and leads to softer stools. The evidence given for the claim that milks with hydrolysed proteins are easier to digest comes from one small under powered study measuring gastric emptying in infants with and without reflux (Billeaud et al, 1990). The evidence that the addition of a structured fat blend aids stool softness and fat and calcium absorption curiously comes from a paper which was looking at the usefulness of a handheld diary to facilitate a parent questionnaire rather than a clinical trial (Yao et al, 2010). However the EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* (2014) concluded that there was no convincing evidence for any beneficial effects from the fat blend palmitic acid predominantly esterified in the *sn-2* position that SMA use in their comfort milk. One study from Italy is cited simply to give evidence for high numbers of infants having gastrointestinal problems in early life (Iacono et al, 2005) and a further study is quoted as evidence for infants having difficulty digesting lactose (Infante et al, 2011). This industry supported study looked at breath hydrogen in 20 2-6 week old formula fed infants with reported colic before, and after, treatment with a lower lactose formula. The formula used was not the same as SMA comfort, there was no reference group and the peer reviewers for this study had concerns about the data analysis. It is agreed in the UK that colic cannot be treated with a change in formula type (NICE CK, 2017)

Aptamil and Cow & Gate Comfort

Danone produces two comfort milks which have an identical composition: Cow & Gate Comfort milk and Aptamil Comfort milk. The Danone early life nutrition website provides evidence for both of these products: evidence is provided from 6 studies for Cow & Gate and the same 6 studies plus a further 7 studies for Aptamil comfort. The evidence provided by the same 6 studies for both milks provides evidence from three studies on the benefits of GOS/FOS prebiotic additions as stool softeners. Manufacturers use a number of single studies to support claims that there are benefits for the addition of prebotics to infant formula, for example the frequently cited study by Moro et al (2002) undertaken at the Numico (Danone) Research Centre. 90 healthy term infants were allocated to receive formula milk supplemented with oligosaccharides at a concentration of 0.4g/100ml or 0.8g/100ml or placebo, over a period of 28 days. The infants receiving the formula milk supplemented with oligosaccharides showed a dose-dependent increase in the amount of *Bifidobacteria* in stools. However, this does not mean that there is any clinical benefit to the addition of oligosaccharides. All of the studies cited were included in the review by EFSA (2014) but were not accepted as evidence of any benefit from the addition of GOS/FOS to infant formula.

Both Cow & Gate and Aptamil comfort milk use two references on the use of structured fats to aid absorption of calcium. The studies by Carnielli et al (1996) and Kennedy et al (1999) are used to support claims that use of synthetic triglycerides with a higher proportion of palmitate in the *sn-2* position improves fat and calcium absorption, but EFSA included these trials in their expert review and concluded that using these structured fats did not offer any benefit (EFSA, 2014). In addition The Kennedy et al study reported that a number of parents reported concern about runny stools after feeding formula containing high *sn*-2 palmitate.

Both Aptamil and Cow & Gate comfort milk quote a study by Kanabar et al (2001) as evidence for benefit of formula with a lower lactose content in preventing flatulence and wind (Cow & Gate) or reduced likelihood of flatulence and intestinal discomfort (Aptamil). This study, funded by a company which produces lactase enzyme drops, was a small study with high drop our rates and levels of non-compliance. The study used lactase enzyme drops in infant formula or in a small amount of expressed breastmilk, not a reduced lactose formula in the trial and is therefore inappropriate as evidence in this context.

Aptamil Comfort milk also uses an additional reference to support comfort milk as preventing colic. This evidence comes from a clinical trial including 932 formula fed infants with minor feeding problems who attended a physician, funded by Numico (which is now part of Danone Nutricia group). All were given a new formula (but not one of the same composition as Aptamil comfort) and over time a reduction in the number of episodes and frequency of colic and regurgitation and an increase in the number and frequency of stools was reported. There was no control group or breastfed reference group, and it would be expected that these symptoms would decrease as infants developed. This weak observational study cannot be used to establish whether the amelioration of symptoms was due to the type of infant milk used (Savino et al, 2003). This reference has been heavily used by Cow & Gate in its print advertisments to health professionals to make the claim that *'95% of paediatricians reported an improvement in common infant feeding problems with a formula like Cow & Gate Comfort'.* More information about claims made in the health professional literature can be found in the report *'Scientific and Factual? A review of breatmilk substitute advertisments to health professionals'* which can be found at www.firststepsnutrition.org.

Aptamil comfort milk also uses an additional 4 references to support its claims that galacto- and fructo-oligosaccharides(GOS/FOS) have a positive effect on intestinal microflora and have been shown to reduce the incidence of infections and need for antibiotics during the first 1-2 years of life (Moro et al, 2006, Arslanoglu et al 2007, 2008 and 2012). All of these studies (with the exception of Arslanoglu et al, 2012 which was a review follow up of the earlier studies) were included in the EFSA review where they concluded that the addition of prebiotics does not offer any benefit, and have been reviewed elsewhere in this report. An additional study funded by Numico (Bruzzeze et al, 2009) is also provided as evidence, but again this was considered as part of the evidence by EFSA which concluded that the addition of prebiotic oligosaccahrides offers no benefit to infants.

Hipp Combiotic Comfort

Hipp combiotic comfort milk (which unlike most other products in the Hipp range is not certified organic) claims that it has been specially developed with a reduced lactose content, hydrolysed protein, fibres and a special fat blend which makes it easier to digest than a standard infant formula. They provide no evidence to support these claims on the product page on their health professional website. In their additional learning resources in a factsheet about constipation they claim that infants presenting with symptoms of constipation may benefit from a specialist formula such as Hipp comfort and cite Kennedy et al (1999) already discussed above, and a paper by Quinlan et al (1995). This paper however looks at the difference in stool hardness between formula and breastfed infants and is not related to the use of a comfort formula. In the advice sheet on colic the claim is again made that Hipp comfort milk is suitable for the dietary management of colic, but no evidence is provided to support this.

Despite little evidence to support the claims that comfort milks can prevent colic, constipation and wind, and expert advice that this is not the case, weak regulation in the UK allows companies to make statements which are perceived as claims on products freely available on supermarket and pharmacy shelves. We believe these perceived claims both confuse families and undermine breastfeeding.

None of these partially hydrolysed formulas are available on prescription, and these milks represent the trend towards manufacturers 'medicalising' infant formula. A paper from a large randomised trial of healthy term infants given either a standard full-lactose non-hydrolysed cows' milk protein based infant milk or a 70% lactose, partially hydrolysed whey protein formula over 60 days reported that there was no difference in tolerance of intact compared to partially hydrolysed protein (Berseth et al, 2009). The authors noted that parents may mistake behaviours common in early infancy such as regurgitation and excessive crying as manifestations of intolerance to their infant milk and unnecessarily switch brands or types of milk.

5.10.2 Partially hydrolysed infant milk marketed as preventing cows' milk protein allergy

SMA HA was launched in November 2013 in the UK and was originally marketed as 'preventing 50% of eczema in infants from atopic families' who used this as the sole formula from birth. These claims have now been changed and currently the milk is marketed as preventing cows' milk protein allergy in babies from atopic families.

Hydrolysed formula are created by using enzymatic processes to break proteins naturally found in a food into smaller fragments. It is suggested that reducing exposure to intact allergens may prevent development of allergic diseases in infants and young children (Lowe et al, 2013). The development of atopic dermatitis (AD) or eczema is one of the allergic outcomes that has been extensively studied in infants and children in the first year of life. There have been many studies which have attempted to consider the role of early infant feeding on AD outcomes, in particular whether hydrolysed protein in formula can reduce the incidence in infants and children with a family history of allergic disease.

Partially hydrolysed whey-based infant formula is cheap to manufacture and palatable to children compared to fully hydrolysed formula or partially hydrolysed casein formula (Lowe et al, 2011). Nestlé originally promoted their NAN HA formula in 90 markets with the claim that it "*helps to reduce the risk of Atopic Dermatitis in infants"* (Nestlé, 2013). However, this claim is made using evidence from one trial and using statements from paediatric groups which may not reflect more recent evidence and opinion in this area. Neither the US Food and Drug Administration (FDA) nor the European Food Safety Authority (EFSA) has approved this claim. The milk now claims that it prevents cows' milk protein allergy in babies who are at risk (that is, babies with a family history of allergy). However, in our opinion this claim is very confusing, since the product is not suitable for infants with either suspected or diagnosed cows' milk protein allergy.

Most of the systematic reviews conducted reviewing evidence in this area highlight the lack of methodological rigour in many of the trials that have been carried out, and the lack of consistency in study protocols which make clear conclusions difficult. A Cochrane review (Osborn and Sinn, 2006) reported that:

"There is no evidence to support feeding with a hydrolysed formula to prevent allergy in preference to exclusive breastfeeding. In infants at high risk for allergy who are unable to be completely breastfed, there is limited evidence that feeding with a hydrolysed formula compared to a cow's milk formula reduces allergies in babies and children, including cow's milk allergy. Concerns regarding quality of the evidence and consistency of the results indicates further studies are needed." (Osborn and Sinn, 2006)

In the UK, public health guidance from the National Institute for Health and Clinical Excellence (NICE) concluded from an extensive literature review that:

"There is insufficient evidence that infant formulas based on partially or extensively hydrolysed cows' milk protein can prevent allergies." (National Institute for Health and Clinical Excellence, 2008)

This public health guidance remained unchanged when the NICE guidance was reviewed in 2012.

The key evidence used to support the use of partially hydrolysed whey-based formula in the reduction of allergy in infancy in children from atopic families used in some statements and by commercial companies comes from the German Infant Nutritional Intervention Study (GINI) (von Berg et al, 2003, 2008) which randomised formula-fed infants into four groups and compared the incidence of a number of allergy symptoms. Data from this study is widely quoted as evidence that a partially hydrolysed whey-based formula prevented atopic dermatitis (AD) in the first year of life, but it is important to note that the difference in the number of children who completed the study and who were diagnosed with AD at 12 months was relatively small (14.8% (n=38) in the cows' milk based formula group and 9.1% (n=22) in the partially hydrolysed formula group). Also, this study population had a high proportion of mothers exclusively breastfeeding in the first four months who were excluded from the study (42%). Some infants in the formula-fed groups were also receiving breastmilk, but this was not reported. Gender and family history are highlighted in this study as being of particular significance in AD development, suggesting that additional studies are needed to support these findings in other cohorts. In addition, the preferred intention to treat analysis failed to show any benefit of partially hydrolysed whey-based formula over cows' milk formula in this study (Lowe et al, 2011).

An Australian RCT published in 2011 (Lowe et al, 2011) considered the impact of a partially hydrolysed whey-based formula (NAN HA), a standard infant formula (NAN) and a soya protein based formula (ProSobee) in infants who were formula fed, partially breastfed or who moved from breastfeeding to formula feeding in the first four months of life. It reported that there was no evidence that introducing partially hydrolysed whey-based formula reduced the risk of allergic manifestations including eczema, in infants from atopic families and concluded *“that partially hydrolysed whey based formula should not be used as a preventive strategy for infants at high risk of allergic diseases”.*

In 2012 the Food and Drug Administration in the USA (Chung et al, 2012) produced a revised recommendation also supported by the American Academy of Allergy, Asthma and Immunology (2011). The FDA concluded:

“There is little to very little evidence, respectively, to support a qualified health claim concerning the relationship between intake of partially hydrolysed whey based formula and a reduced risk of AD in partially breastfed and exclusively formula-fed infants throughout the first year after birth and up to 3 years of age.”

In 2013 a ‘review of systematic reviews’ looking at evidence in prevention and aetiology of food allergy considered 14 systematic reviews in this area (Lodge et al, 2013) and again concluded that:

“There is insufficient evidence to conclude that the use of hydrolysed formula may reduce food allergy/sensitization when compared with standard formula in high atopy risk children.”

The EFSA *Scientific opinion on the essential composition of infant and follow-on formulae* in 2014 stated that reducing the size of protein molecules cannot reduce the risk of allergy in infants from at-risk families:

“The characterisation of protein hydrolysates by molecular weight of the protein cannot predict their potential to reduce the risk of developing allergic manifestations in genetically predisposed infants.”

The Food Standards Agency commissioned a systematic review of the evidence on diet and allergy in the first year of life and this was published in 2016 (Boyle et al, 2016). This review concluded that:

‘*Overall there was no consistent evidence that partially or extensively hydrolysed formulas reduce the risk of allergic or autoimmune outcomes in infants at high pre-existing risk of these outcomes’*

A recent consensus paper from ESPGHAN also concluded that there was insufficient evidence to recommend these milks to normal healthy infants as there is a lack of data for metabolic consequences and long-term outcomes (Vandenplas et al, 2016).

Safety issues related to partially hydrolysed whey-based infant formula

There are safety concerns about partially hydrolysed whey-based infant formula since they are unsuitable for the *treatment* of allergy in infants. The FDA requires the following warning statement be displayed to indicate to consumers that partially hydrolysed infant formulas are not hypoallergenic and should not be fed to infants who are allergic to milk or to infants with existing milk allergy symptoms.

"*Partially hydrolysed formulas* ***should not be fed to infants who are allergic to milk or to infants with existing milk allergy symptoms****. If you suspect your baby is already allergic to milk, or if your baby is on a special formula for the treatment of allergy, your baby's care and feeding choices should be under a doctor's supervision."*

The FDA concluded that the use of bold type is necessary, in light of the significant public health risk that would be created by the feeding of these formulas to infants who are allergic to milk or to infants with existing milk allergy symptoms. Manufacturer claims of a relationship between the consumption of partially hydrolysed whey-based formula and a reduced risk of developing AD could mislead consumers to think that these formulas are an appropriate choice for such infants.

NHS Choices makes the statement:
"Infant formula with partially hydrolysed proteins is available in the shops, but this is not suitable for babies with a cow's milk allergy." (NHS Choices, 2017c)

Any new partially hydrolysed formula made available to parents in the UK should therefore be required to carry a clear and bold warning on the label to this effect. Any promotion of partially hydrolysed whey-based formula milk products to health professionals must clearly warn of the risks associated with giving partially hydrolysed whey-based formula to infants and children with diagnosed cows' milk protein allergy or to infants showing symptoms of cows' milk protein allergy.The nutritional composition and ingredients used in partially hydrolysed infant milks suitable from birth are given in table 16.

TABLE 16

The nutritional composition of partially hydrolysed infant milks suitable from birth

Nutrients per 100ml	Aptamil Comfort	Cow & Gate Comfort	Hipp Combiotic Comfort	SMA Comfort	SMA HA
MACRONUTRIENTS					
Energy kcal	66	66	67	67	67
Protein g	1.5	1.5	1.6	1.6	1.3
Whey:casein ratio	100:0	100:0	100:0	100:0	100:0
Carbohydrate g	7.2	7.2	7.1	7.1	7.8
– of which lactose g	2.7	2.7	2.7	3.9	7.8
Source of added carbohydrate	Glucose syrup, potato and corn starch, oligosaccharides, lactose	Glucose syrup, potato and corn starch, oligosaccharides, lactose	Maltodextrin, lactose, starch, oligosaccharides	Lactose, corn syrup solids, maltodextrin	Lactose
Fat g	3.4	3.4	3.5	3.6	3.4
Fat source	Structured vegetable oil, rapeseed, coconut and sunflower oils	Structured vegetable oil, rapeseed, coconut, and sunflower oils	Structured vegetable oil, palm, rapeseed and sunflower oils	Structured vegetable oil, palm, soya, sunflower and coconut oils	Sunflower, coconut and rapeseed oils
Added LCPUFAs **ARA**	✓	✓	✓	✓	✓
DHA	✓	✓	✓	✓	✓
LCPUFA source	Fish and single cell oils	Fish and single cell oils	Fish and single cell oils	Single cell oils	Fish and single cell oils
MICRONUTRIENTS					
Vitamins meeting regulations	✓	✓	✓	✓	✓
Minerals meeting regulations	✓	✓	✓	✓	✓
VITAMINS					
Vitamin A µg-RE	50	50	67	66	67
Vitamin C mg	9.3	9.3	10	9	9
Vitamin E mg	0.74	0.74	0.8	0.74	1.2
Vitamin D µg	1.2	1.2	1.1	1.2	0.9
Vitamin K µg	4.1	4.1	5.0	6.7	5.2
Thiamin (B_1) µg	50	50	60	100	70
Riboflavin (B_2) µg	100	100	100	110	160
Niacin µg (mg NE)	(0.85)	(0.85)	670	500	710
Vitamin B_6 µg	40	40	40	60	50
Vitamin B_{12} µg	0.14	0.14	0.15	0.18	0.14
Folic acid µg	9.3	9.3	10	11	10.6
Biotin µg	2.1	2.1	1.5	2	1.4

TABLE 16 (continued)
The nutritional composition of partially hydrolysed infant milks suitable from birth

Nutrients per 100ml	**Aptamil Comfort**	**Cow & Gate Comfort**	**Hipp Combiotic Comfort**	**SMA Comfort**	**SMA HA**
Pantothenic acid µg	360	360	500	350	630
MINERALS					
Calcium mg	49	49	60	42	45
Chloride mg	41	41	45	43	50
Copper µg	40	40	45	33	60
Iodine µg	12	12	15	10	9.2
Iron mg	0.54	0.54	0.7	0.8	0.7
Magnesium mg	5.5	5.5	5.5	4.5	6.7
Manganese µg	8	8	8.6	5	10
Phosphorus mg	27	27	34	24	26
Potassium mg	75	75	70	65	76
Selenium µg	1.6	1.6	1.3	1.4	2.1
Sodium mg	20	20	20	16	26
Zinc mg	0.49	0.49	0.5	0.6	0.7
ADDED INGREDIENTS					
Structured vegetable oils	✓	✓	✓	✓	✗
Prebiotics	✓	✓	✓	✗	✗
Nucleotides	✓	✓	✗	✓	✓
Inositol	✓	✓	✓	✓	✓
Taurine	✓	✓	✓	✓	✓
Choline	✓	✓	✓	✓	✓
L-carnitine	✓	✓	✓	✓	✓
Added antioxidants	✓	✓	✓	✓	✓
Contains soya	✓	✓	✗	✓	✗
Contains fish oil	✓	✓	✓	✗	✓
Suitable for vegetarians[1]	✗	✗	✗	✓	✗
Halal approved	✗	✗	✗	✓	✗
Osmolality mOsm/kg	250	250	194	249	320

ARA = arachidonic acid DHA = docosahexaenoic acid
LCPUFA = long chain polyunsaturated fatty acid

1 Formula milks derived from cows' milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process. Rennet is used to separate curds from whey and, although vegetarian alternatives are available, they are not used by all manufacturers.

5.11 Follow-on formula marketed for infants from 6 months of age

Key points

In July 2013, WHO made a clear statement that follow-on formula were unnecessary (WHO, 2013), and this has also been made clear by UK health departments, who do not, for example, allow Healthy Start food vouchers to be used to purchase follow-on formula.

Follow-on formula were created to circumvent infant formula regulations relating to advertising, and are marketed for infants over the age of 6 months who are also receiving complementary foods. Whilst regulations currently differentiate between infant formula and follow-on formula in terms of composition, the new EFSA opinion on the essential composition of infant and follow-on formulae makes just one compositional distinction between the two (EFSA, 2014).

There is some evidence to suggest that excessive iron intakes in infancy may result in a reduced uptake of other trace metals, and the oxidation of lipids, and that high iron intakes among iron-replete infants and toddlers may actually have an adverse effect on growth and development. Follow-on formula currently contain higher amounts of iron than recommended, and two to three times more than the new EFSA (2014) scientific opinion suggests as the target value.

Current UK infant feeding guidelines recommend that, after 6 months of age, additional iron requirements should be met by including iron-rich complementary foods, and that the introduction of cows' milk, which has a lower iron content than breastmilk, should be postponed until 12 months of age. It is advised that first formula milks remain the milk of choice during the first year if babies are not breastfed. All first milks currently provide sufficient iron to meet the higher iron requirements of infants between 6-12 months as recommended by EFSA (2014).

Follow-on formula is marketed for infants over the age of 6 months who are receiving complementary foods, and contains more protein, micronutrients and iron than infant milks designed for use from birth. As infant formula are designed for use by infants from birth to 1 year of age, those receiving complementary foods with adequate protein, carbohydrate, fat and iron do not need to have their infant formula replaced by follow-on formula. The Scientific Advisory Committee on Nutrition (SACN), in their 2007 review of infant feeding, stated that:

"There is no published evidence that the use of any follow-on formula offers any nutritional or health advantage over the use of whey-based infant formula among infants artificially fed." (SACN, 2007)

For this reason, follow-on formula are not included in the UK Healthy Start scheme.

It is globally agreed that follow-on formula serve no nutritional purpose, and WHO clearly stated why it believes these milks are unnecessary (WHO, 2013). Follow-on formula have been vigorously marketed as a good source of iron for older infants, but follow-on formula has been shown to offer no advantage over standard infant formula after the age of 6 months (Moy, 2000). There is also some evidence that excessive iron intakes may result in a reduced uptake of other trace metals including copper and oxidation of lipids, due to the pro-oxidant effects of excess iron (Aggett et al, 2002a). A recent large study from Chile which looked at the impact of iron-fortified formula in infants aged 6-12 months on a range of cognitive and learning outcomes at 10 years of age, showed that iron-replete infants given iron-fortified formula did significantly less well in terms of long-term development than similar infants given low-iron formula, or iron-deficient infants given high-iron formula (Lozoff et al, 2011). There is some evidence that high iron intakes among iron-replete toddlers may actually have an adverse effect on growth (Idjradinata et al, 1994) and a large trial of nearly 500 infants and toddlers given follow-on formula between 9 and 18 months of age in the UK found that there were no developmental or growth advantages in children given iron-supplemented follow-on formula (Morley et al, 1999).

Current UK infant feeding guidelines recommend that complementary foods given alongside breastmilk in the second six months of life should include iron-rich foods, and that the introduction of cows' milk, which has a lower iron content than breastmilk, should be postponed until 12 months of age. It is currently advised that first formula remains the milk of choice during the first year if babies are not breastfed. EFSA (2014) in its *Scientific opinion on the essential composition of infant and follow-on formulae* did suggest that follow-on formula should have a higher minimum (target) iron content than infant formula. However, currently first infant formula meets this higher level and is therefore by EFSA criteria appropriate throughout the first year. A further discussion of the role of iron in infant and child health and information about current iron content can be found in section 3.10.2.

Some of the differences between infant formulas suitable from birth and follow-on formulas are shown in Table 17. The nutritional composition and ingredients used in follow-on formula based on cows' milk suitable from 6 months of age are given in Table 18, and those for follow-on formula based on goats' milk are given in Table 19.

TABLE 17
Summary of some of the differences in selected nutrients between major-brand first infant formulas suitable from birth and follow-on formulas suitable from 6 months of age

Nutrients per 100ml	**Energy** kcal	**Protein** g	**Carbo-hydrate** g	**Fat** g	**Vitamin D** µg	**Calcium** mg	**Iron** mg	**Zinc** mg
Aptamil 1 First Milk	66	1.3	7.3	3.4	1.2	54	0.6	0.54
Aptamil 2 Follow-on Milk	68	1.4	8.5	3.1	1.5	63	1.1	0.55
Cow & Gate 1 First Infant Milk	66	1.3	7.3	3.4	1.2	55	0.53	0.51
Cow & Gate 2 Follow-on Milk	68	1.4	8.6	3.0	1.5	68	1.0	0.57
Hipp Organic Combiotic First Infant Milk	66	1.3	7.3	3.5	1.2	50	0.5	0.5
Hipp Organic Combiotic Follow-on Milk 2	70	1.5	7.8	3.5	1.2	75	1.0	0.5
SMA Pro First Infant Milk	67	1.3	7.1	3.6	0.9	43	0.7	0.7
SMA Pro Follow -on Milk	67	1.3	7.9	3.2	1.2	75	1.0	0.8

TABLE 18
The nutritional composition of powdered follow-on formula marketed for infants from 6 months of age

Nutrients per 100ml	Aptamil 2 Follow-on Milk	Aptamil Profutura 2 Follow-on Milk	Cow & Gate 2 Follow-on Milk	Hipp Organic Combiotic Follow-on Milk 2	Holle Organic Infant Follow-on Formula 2	Kendamil Follow-on Milk
Energy kcal	68	68	68	70	69	67
Protein g	1.4	1.4	1.4	1.5	1.5	1.6
Whey:casein ratio	50:50	50:50	20:80	40:60	NK	34:66
Alpha-lactalbumin enriched whey	×	×	×	×	×	✓
Carbohydrate g	8.5	8.8	8.6	7.8	8.2	7.9
of which lactose g	8.1	8.4	8.3	7.4	N/K	7.4
Carbohydrate source	Lactose, oligo-saccharides	Lactose, oligo-saccharides	Lactose, oligo-saccharides	Lactose, oligo-saccharides	Malto-dextrin, starch	Lactose, oligo-saccharides
Fat g	3.1	2.9	3.0	3.5	3.3	3.2
Fat source	Palm, rapeseed, coconut and sunflower oils	Anhydrous milk fat, rapeseed, sunflower and coconut oils	Palm, rapeseed coconut, sunflower oils	Palm, rapeseed and sunflower oils	Palm, rapeseed and sunflower oils	Sunflower, coconut and canola oils and whole milk fat
Added LCPUFAs						
ARA	✓	✓	×	×	×	✓
DHA	✓	✓	×	×	×	✓
In approved ratio	✓	✓	NA	NA	NA	✓
LCPUFA source	Fish and single cell oils	Fish and single cell oils	NA	NA	NA	Single cell oils
MICRONUTRIENTS						
Vitamins meeting regulations	✓	✓	✓	✓	✓	✓
Minerals meeting regulations	✓	✓	✓	✓	✓	✓
VITAMINS						
Vitamin A µg-RE	61	64	67	70	62	65
Vitamin C mg	8.7	8.5	9.5	10	12	12
Vitamin E mg	1.2	1.2	1.2	1.0	1.4	1.7
Vitamin D µg	1.5	1.3	1.5	1.2	1.1	1.0
Vitamin K µg	6.2	4.4	5.1	5.0	8.3	4.1
Thiamin (B_1) µg	60	50	60	60	80	70
Riboflavin (B_2) µg	120	140	90	110	200	170
Niacin µg (mg NE)	520	450	450	600	600	900
Vitamin B_6 µg	50	40	40	40	50	60
Vitamin B_{12} µg	0.19	0.18	0.13	0.15	0.2	0.2
Folic acid µg	15	13	12	10	23	17
Biotin µg	1.9	1.4	1.5	1.5	2.0	3.0
Pantothenic acid µg	370	340	350	500	600	600

TABLE 18 (continued)
The nutritional composition of follow-on formula marketed for infants from 6 months of age

Nutrients per 100ml	Aptamil 2 Follow-on Milk	Aptamil Profutura 2 Follow-on Milk	Cow & Gate 2 Follow-on Milk	Hipp Organic Combiotic Follow-on Milk 2	Holle Organic Infant Follow-on Formula 2	Kendamil Follow-on Milk
MINERALS						
Calcium mg	63	64	68	75	75	61
Chloride mg	47	50	54	45	49	49
Copper µg	49	40	40	45	40	50
Iodine µg	15	15	13	15	16	14
Iron mg	1.1	1.0	1.0	1.0	0.9	0.75
Magnesium mg	4.9	5.2	4.5	6.0	5.5	7.0
Manganese µg	8.0	11	7.0	7.1	15	9.0
Phosphorus mg	43	41	37	42	49	32
Potassium mg	78	78	77	80	82	73
Selenium µg	1.7	1.7	1.6	1.5	2.0	2.8
Sodium mg	22	21	17	20	30	22
Zinc mg	0.55	0.62	0.57	0.5	0.5	0.5
ADDED INGREDIENTS						
Structured vegetable oils	✗	✗	✗	✗	✗	✗
Prebiotics	✓	✓	✓	✓	✗	✓
Probiotics	✗	✗	✗	✗	✗	✗
Nucleotides	✓	✓	✓	✗	✗	✓
Inositol	✓	✓	✓	✗	✗	✗
Taurine	✓	✓	✓	✗	✗	✓
Choline	✓	✗	✓	✗	✗	✓
Added antioxidants	✓	✓	✓	✓	✓	✓
Contains soya	✓	✓	✓	✓[4]	✗	✓
Contains fish oil	✓	✓	✗	✗	✗	✗
Contains egg lipid	✗	✓	✗	✗	✗	✗
Suitable for vegetarians[1]	✗	✗	✗	✗	✗	✓
Halal approved	✓[2]	✗[3]	✓[2]	✗	✗	✓
Osmolality mOsm/kg	400	380	380	317	NK	NK

ARA = arachidonic acid   DHA = docosahexaenoic acid   LCPUFA = long chain polyunsaturated fatty acid
NA = not applicable   NK = not known   ANS = approval not sought

1 Formula milks derived from cows' milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process.
2 Powder formualtion and 200ml RTF but not 1L RTF
3 200ml RTF only not powdered formualtion
4 Powder formulation only

TABLE 18 (continued)
The nutritional composition of follow-on formula marketed for infants from 6 months of age

Nutrients per 100ml	Kendamil Organic Follow-on Milk	Mamia Follow-on Milk	Sainsbury's Little Ones Follow On Milk	SMA Organic Follow On Milk	SMA Pro Follow-on Milk
Energy kcal	68	66	68	67	67
Protein g	1.6	1.8	1.6	1.3	1.3
Whey:casein ratio	40:60	54:46	40:60	50:50	50:50
Alpha-lactalbumin enriched whey	×	×	✓		✓
Carbohydrate g	8.2	7.6	8.0	8.3	7.9
of which lactose g	8.1	7.4	7.4	NK	5.3
Carbohydrate source	Lactose	Lactose, oligo-saccharides	Lactose, oligo-saccharides, maltodextrin	Lactose, maltodextrin	Maltodextrin, lactose, oligo-saccharides
Fat g	3.3	3.1	3.2	3.2	3.2
Fat source	Sunflower, coconut, rapeseed and whole milk fat	Palm, palm kernel, sunflower, rapeseed and soya bean oils	Sunflower, coconut and canola oils and whole milk fat	Sunflower oil, Rapeseed oil	Palm, rapeseed, coconut and sunflower oils
Added LCPUFAs **ARA**	×	✓	✓	✓	✓
DHA	×	✓	✓	✓	✓
In approved ratio	NA	✓	✓	✓	✓
LCPUFA source	NA	Fish and soya oils	Single cell oils	Fish oil	Fish and single cell oils
MICRONUTRIENTS					
Vitamins meeting regulations	✓	✓	✓	✓	✓
Minerals meeting regulations	✓	✓	✓	✓	✓
VITAMINS					
Vitamin A µg-RE	58	70	65	63	73
Vitamin C mg	11.1	8.9	12	12	12
Vitamin E mg	1.4	1.1	1.7	1.5	1.3
Vitamin D µg	1.4	1.1	1.0	1.2	1.2
Vitamin K µg	3.6	7	4.1	7.4	6.8
Thiamin (B_1) µg	60	90	70	70	150
Riboflavin (B_2) µg	120	140	200	190	140
Niacin µg (mg NE)	0.76	460	880	540	600
Vitamin B_6 µg	50	70	100	44	80
Vitamin B_{12} µg	0.17	0.14	0.2	0.23	0.19
Folic acid µg	20.7	15	17	13.4	17
Biotin µg	2.3	2.4	3.0	1.6	2.5
Pantothenic acid µg	510	430	580	600	820

TABLE 18 (continued)
The nutritional composition of follow-on formula marketed for infants from 6 months of age

Nutrients per 100ml	Kendamil Organic Follow-on Milk	Mamia Follow-on Milk	Sainsbury's Little Ones Follow On Milk	SMA Organic Follow On Milk	SMA Pro Follow-on Milk
MINERALS					
Calcium mg	63.6	50	61	70	75
Chloride mg	52.6	51	50	42	47
Copper µg	50	40	50	44	50
Iodine µg	13.8	12	14	16	18
Iron mg	0.76	0.89	0.76	0.89	1.0
Magnesium mg	7.1	4.1	7.0	6.3	6.8
Manganese µg	9.0	4.0	9.0	2,0	10,0
Phosphorus mg	32.5	38	32	40	41
Potassium mg	73.3	84	73	89	76
Selenium µg	2.5	2.2	2.8	3	1.4
Sodium mg	21	24	24	25	25
Zinc mg	0.53	0.43	0.48	0.66	0.8
ADDED INGREDIENTS					
Structured vegetable oils	✗	✗	✗	✗	✗
Prebiotics	✗	✓	✓	✗	✓[1]
Probiotics	✗	✗	✗	✗	✗
Nucleotides	✗	✓	✓	✗	✗
Inositol	✗	✓	✗	✗	✗
Taurine	✗	✓	✓	✗	✗
Choline	✗	✓	✓	✗	✗
Added antioxidants	✓	✓	✓	✓	✓
Contains soya	✗	✓	✗	✓	✓
Contains fish oil	✗	✓	✗	✓	✓
Contains egg lipid	✗	✗	✗	✗	✗
Suitable for vegetarians[2]	✓	✗	✓	✗	✗
Halal approved	✓	✓	✗	✓	✓
Osmolality mOsm/kg	NK	326	NK	266	262

ARA = arachidonic acid   DHA = docosahexaenoic acid   LCPUFA = long chain polyunsaturated fatty acid
NA = not applicable   NK = not known   ANS = approval not sought

1 Powder formulation only.
2 Formula milks derived from cows' milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process.

TABLE 19
The nutritional composition of follow-on formula marketed for infants from 6 months of age (goats' milk based)

Nutrients per 100ml	Holle Organic Infant Goat Milk Follow-on Formula 2	Kabrita Gold 2 Follow-on Milk	NANNYcare Follow On Milk
MACRONUTRIENTS			
Energy kcal	67	67	66
Protein g	1.5	1.8	1.3
Whey:casein ratio	N/K	55:45	20:80
Carbohydrate g	8.0	8.0	7.4
– of which lactose g	NK	6.7	7.4
Carbohydrate source	Maltodextrin, lactose	Lactose, glucose syrup solids, oligosaccharides	Lactose
Fat g	3.3	3.0	3.4
Fat source	Palm, rapeseed and sunflower oils	High sn-2 palmitic acid oil, soyabean, palm kernel and sunflower oil	High oleic sunflower, rapeseed and sunflower oils
Added LCPUFAs			
ARA	×	✓	×
DHA	×	✓	×
In approved ratio	NA	✓	NA
LCPUFA source	NA	Vegetable and fish oils	NA
MICRONUTRIENTS			
Vitamins meeting regulations	✓	✓	✓
Minerals meeting regulations	✓	✓	✓
VITAMINS			
Vitamin A µg-RE	65.1	61	70
Vitamin C mg	11	9.4	10
Vitamin E mg	1.1	1.0	1.5
Vitamin D µg	1.2	1.2	1.1
Vitamin K µg	6.5	5.3	6.7
Thiamin (B_1) µg	64	70	62
Riboflavin (B_2) µg	160	130	120
Niacin µg (mg NE)	560	510	680
Vitamin B_6 µg	54	48	36
Vitamin B_{12} µg	0.19	0.17	0.18
Folic acid µg	18.5	11	11
Biotin µg	2.0	1.8	2.3
Pantothenic acid µg	460	490	350

TABLE 19 (continued)
The nutritional composition of follow-on formula marketed for infants from 6 months of age (goats' milk based)

Nutrients per 100ml	Holle Organic Infant Goat Milk Follow-on Formula 2	Kabrita Gold 2 Follow-on Milk	NANNYcare Follow On Milk
MINERALS			
Calcium mg	59	71	71
Chloride mg	75.2	58	68
Copper µg	55	47	45
Iodine µg	23.4	9.8	9.0
Iron mg	0.68	1.0	0.89
Magnesium mg	6.7	5.6	5.9
Manganese µg	12	9.1	8.4
Phosphorus mg	45.6	46	48
Potassium mg	93	80	74
Selenium µg	1.9	1.5	1.2
Sodium mg	20	20	18
Zinc mg	0.5	0.7	0.49
ADDED INGREDIENTS			
Structured vegetable oils	×	✓	×
Prebiotics	×	✓	×
Probiotics	×	×	×
Nucleotides	×	×	×
Inositol	×	✓	✓
Taurine	×	✓	✓
Choline	×	✓	✓
Added antioxidants	✓	✓	✓
Contains soya	×	✓	×
Contains fish oil	×	✓	×
Suitable for vegetarians[1]	✓	×	×
Halal approved	×	×	✓
Osmolality mOsm/kg	NK	NK	310

ARA = arachidonic acid DHA = docosahexaenoic acid LCPUFA = long chain polyunsaturated fatty acid
NA = not applicable

1 Formula milks derived from animal milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process. Rennet is used to separate curds from whey and, although vegetarian alternatives are available, they are not used by all manufacturers.

5.12 Good night milk

Key points

Good night milk has a whey:casein ratio of 20:80 and contains cereal thickeners.

Good night milk is suggested to help babies settle at bedtime. However, there is no evidence to support this suggestion.

The Scientific Advisory Committee on Nutrition (SACN) has raised concerns over the use of good night milk products. Claims made about settling infants at night can undermine breastfeeding by convincing parents that children aged 6 months plus should sleep longer at night, and inappropriate use of these milks might result in the development of nursing bottle caries.

Hipp Organic and Cow & Gate introduced 'good night milks' to the market several years ago, but Cow & Gate Good Night Milk has since been discontinued. Good night milks differ from standard infant and follow-on formula in that they have added ingredients that make the products thicker than standard formulas. Products are suggested to help settle babies at bedtime, but there is no evidence that this is the case.

The principles behind the use of good night milks are that the addition of starch results in increased viscosity, and that the carbohydrate content makes the milk more 'satisfying'. The total energy content is maintained within regulations by a reduction in the fat component of the milk, and the use of these starches means the product is gluten-free.

Hipp Organic Good Night Milk has a similar nutritional composition to Hipp Organic Combiotic Follow-on Milk. The addition of organic corn starch, rice flakes and buckwheat flakes results in increased viscosity and the carbohydrate content is 35% starch.

The Scientific Advisory Committee on Nutrition (SACN) published a statement on the risks associated with the use of good night milk products (SACN, 2008) (see below). Since the publication of the report, the formulation of Hipp Organic Good Night Milk has changed. The product is now gluten-free, has a lower energy density, and conforms to the requirements for follow-on formula specified by European Commission Directive 2006/141/EC. Additionally, Hipp Organic used to promote the product as being a suitable replacement for a light evening meal. SACN did not agree with Hipp Organic that the product was suitable for this purpose. The literature available to health professionals on the Hipp Organic website no longer suggests that the product is a suitable meal replacement, but suggests that it may be used to replace the last follow-on formula feed at night.

SACN raised the following concerns over the use of 'good night' milks in its 2008 statement. SACN considers both the Cow & Gate product and the Hipp Organic product to be breastmilk substitutes and is therefore concerned that the claims made by manufacturers concerning their ability to soothe and settle babies at night might undermine breastfeeding.

There is no published scientific evidence to support a claim that these products offer any nutritional advantage over the use of infant or follow-on formula, nor is there any scientific evidence that they offer any advantage over infant or follow-on formula in settling babies at night.

- Statements relating to settling and soothing babies at night could encourage parents to believe that it is desirable for infants to sleep longer at night, at an age where infants show marked variation in sleep patterns. Parents might be tempted to use these products to settle babies more frequently, or when infants are younger than 6 months of age.
- The products might encourage poor dental hygiene, as parents might be tempted to put their babies to bed immediately after bottle-feeding. This could result in the development of nursing bottle caries. It was noted that both companies advised cleaning the baby's teeth after the last feed, although this advice appears contrary to the idea of using the milk for 'settling' babies at night.
- The manufacturer's recommendation for making up Hipp Organic Good Night Milk is different from the recommendations for making up infant and follow-on formula. The 2005 infant feeding survey (Bolling et al, 2007) showed that many parents do not follow manufacturers' recommendations for reconstituting feeds. SACN is therefore concerned that the new methods might cause further confusion and create additional risk.

Good night milk drinks are significantly more expensive than follow-on formula. Hipp Organic Good Night Milk is approximately 60% more expensive than their standard follow-on formula.

The nutritional composition and ingredients used in Hipp Organic Good Night Milk are given in Table 20.

TABLE 20
The nutritional composition of good night milk

Nutrients per 100ml	Hipp Organic Good Night Milk
MACRONUTRIENTS	
Energy kcal	70
Protein g	1.6
Whey:casein ratio	20:80
Carbohydrate g	8.0
– of which lactose g	5.0
Carbohydrate source	Organic corn starch, lactose, rice flakes and buckwheat flakes
Fat g	3.5
Fat source	Palm oil, rapeseed oil and sunflower oil
Added LCPUFAs **ARA**	×
DHA	×
MICRONUTRIENTS	
Vitamins meeting regulations	✓
Minerals meeting regulations	✓
VITAMINS	
Vitamin A µg-RE	71
Vitamin C mg	11
Vitamin E mg	1.2
Vitamin D µg	1.2
Vitamin K µg	5.7
Thiamin (B_1) µg	71
Riboflavin (B_2) µg	110
Niacin µg (mg NE)	640
Vitamin B_6 µg	70
Vitamin B_{12} µg	0.19
Folic acid µg	13
Biotin µg	2.5
Pantothenic acid µg	500
MINERALS	
Calcium mg	78
Chloride mg	47
Copper µg	39
Iodine µg	11
Iron mg	0.7
Magnesium mg	7.6
Manganese µg	23
Phosphorus mg	43
Potassium mg	75
Selenium µg	1.4
Sodium mg	20
Zinc mg	0.7

TABLE 20 (continued)
The nutritional composition of good night milk

Nutrients per 100ml	Hipp Organic Good Night Milk
ADDED INGREDIENTS	
Structured vegetable oils	✗
Prebiotics	✗
Nucleotides	✗
Inositol	✗
Taurine	✗
Choline	✗
Added antioxidants	✓
Contains soya	✓
Contains fish oil	✗
Suitable for vegetarians	✗
Halal approved	✗

ARA = arachidonic acid DHA = docosahexaenoic acid LCPUFA = long chain polyunsaturated fatty acid

5.13 Milks for which there are no compositional regulations: milks marketed for young children

Key points

Milks marketed for young children – often called growing-up milks, toddler milks, or young child formula – are offered by the infant milk manufacturers as an alternative to, or to complement, whole cows' milk for toddlers from about 1 year of age. These milks currently fall outside any compositional regulations, and for healthy children there is no rationale for giving these milks.

Promotion and marketing of these relatively new products led to a 21.5% increase in sales between 2009 and 2010 and very heavy marketing of Cow & Gate toddler milk in 2013/2014 may mean families mistakenly believe their toddlers need these milks to provide sufficient nutrition. Promotional materials compare the nutrients in these milks with the nutrients in cows' milk alone, rather than comparing them with a combination of milk and food, and the Advertising Standards Authority has several times upheld complaints about claims made.

Growing-up and toddler milks provide higher quantities of some micronutrients such as vitamin A, vitamin D, iron and zinc than cows' milk and infant and follow-on formula, but are also typically lower in iodine, can often be lower in calcium and riboflavin and are sweeter than cows' milk. They are at least three times more expensive than cows' milk and are not recommended by health professionals.

Full-fat cows' milk is a suitable choice as the main drink for most toddlers from the age of 1 year, who should be obtaining the majority of their nutrients from a balanced diet rather than relying on fortified milk products. The Department of Health recommends that, from the age of 2 years, children who are growing normally and eating a healthy balanced diet can move on to semi-skimmed cows' milk.

All children aged 1-4 years in the UK are recommended to take daily vitamin drops of vitamins A, D and C to act as a population-wide nutritional safety net and therefore fortified milks are not needed as a source of vitamin D. The European Food Safety Authority recently concluded that growing-up milks are not necessary in the diets of young children in the EU.

Growing-up milks and toddler milks are offered by the infant formula manufacturers as an alternative to, or to complement, whole cows' milk for toddlers from about 1 year of age, although some growing-up milks are labelled as suitable from 10 months of age. Growing-up and toddler milks provide higher quantities of some micronutrients such as vitamin A, vitamin D, iron and zinc than cows' milk and infant and follow-on formula, but are also typically lower in iodine and can often be lower in calcium and riboflavin than cows' milk. Recent additions to the market have been toddler milks aimed at older toddlers aged 2 to 3 years. These milks are offered as a semi-skimmed version of the manufacturers' original growing-up milks. These milks are lower in fat, carbohydrates and protein than growing-up milks for younger toddlers, but the vitamin and mineral content remains similar. Typically, they contain less protein and calcium than semi-skimmed cows' milk.

Growing-up milks are aimed at toddlers, who should be obtaining the majority of their nutrients from the food that they eat. It is generally recommended that toddlers eat a good variety of foods to supply the majority of their nutrients, rather than relying on fortified milk products to supply them. Full-fat cows' milk is a suitable choice as the main drink for most toddlers from the age of 1 year, alongside a varied diet. The Department of Health recommends that, from the age of 2 years, children who are growing normally and eating a healthy balanced diet can move on to semi-skimmed cows' milk. For more information on eating well for children under the age of 5 years see www.firststepsnutrition.org

There is some evidence that organic cows' milk has higher amounts of long chain fatty acids and lower amounts of saturated fatty acids than milk from cows conventionally farmed, and that the composition is more consistent across the year, and this may have some health benefits among those who are regular milk consumers (Butler et al, 2011). Hipp Organic claim on their website that research shows that *'babies consuming organic dairy products are less likely to suffer from atopic eczema*'. The authors of the referenced report speculate that the protective effect reported may be due to a high intake of n-3 fatty acids and/or conjugated linoleic acid from organic dairy products (Kummeling et al, 2008). In the study referenced, no information other than whether or not the infant received breastmilk was collected for the first year of life, during which time maternal diet was used as a proxy for infant diet. The authors concluded that it was uncertain whether their finding represented a true association and should be interpreted with caution (Kummeling et al, 2008).

Sugars in growing-up milks and toddler milks

The change from infant formula to cows' milk involves a taste transition for infants who should become accustomed to a less sweet taste in their main milk drink. Given that the development of taste preference is influenced by both genetic factors and experience, parents can influence their children's taste preferences through the food choices they make for them (Savage et al, 2007; Benton, 2004). Growing-up milks and toddler milks contain almost twice as much sugar per 100ml as cows' milk, and some Aptamil and Cow & Gate growing-up milks and SMA toddler milk contain vanilla flavouring. It is unclear whether repeated exposure to sweet drinks in infancy and toddlerhood might contribute to the development of a preference for sweet drinks in later life.

The naturally occurring sugar in milk is lactose, but this does not give milk an overly sweet taste. Adding sugars to fortified milks serves a number of purposes for manufacturers:

- The sweet taste it gives the product is attractive to children.
- The addition of extra carbohydrate allows the protein and fat content to be moderated.
- Sugars are cheap ingredients, particularly components such as maltodextrin.

Manufacturers rarely provide clear data on the added sugar content of their fortified milks in a form which allows the consumer to see clearly how much additional sugar they provide compared with whole animal milk.

What are the health consequences of additional sugar in the diets of children?

Plain animal milk has a composition which may be protective against the development of insulin resistance and chronic disease (Pereira et al, 2002) and therefore if alternatives to this increase risk of chronic disease, this is of concern to public health. The consumption of easily absorbed sugars can stimulate excessive postprandial hypoglycaemia and insulinaemia, which may be linked to risks of obesity, type 2 diabetes and coronary heart disease (Brand-Miller et al, 2013).

Fortified milk with glucose sugars is likely to contribute to higher levels of dental decay in infants and children (Grenby and Mistry, 2000), and the added sugars in many milks may present a risk of oral ill health to older children. The health risks associated with regular consumption of fortified sweetened milk products by young children could therefore be significant.

Other nutrients

Table 21 compares the micronutrient content of the main milks marketed for 1-2 year olds in the UK with whole cows' milk. Milks marketed for young children often claim they are 'nutritionally superior to cows' milk' (SMA Toddler Milk packaging) or are 'tailored to toddlers' nutritional needs' (Aptamil packaging). Growing-up milks have enhanced amounts of some nutrients, but may be lower in riboflavin, calcium, iodine, magnesium, potassium and phosphorus than whole cows' milk.

It is estimated in the UK from the last comprehensive survey of young children's diets that milk and milk products provide 51% of dietary riboflavin, 64% of dietary calcium, 58% of dietary iodine, 27% of dietary magnesium and 31% of dietary potassium, making milk a significant contributor to these nutrients in the diets of young children. The lower amounts of these nutrients in growing-up milks is therefore a matter of concern.

TABLE 21
Micronutrient composition of main milks marketed for young children, compared to whole cows' milk

Nutrients per 100ml	Full-fat cows' milk*	Aptamil 3 Growing-up Milk 1-2 Years	Cow & Gate 3 Growing Up Milk 1-2 Years	SMA Pro Toddler Milk 3
Vitamin A µg	38	68	68	70
Riboflavin mg	0.23	0.23	0.23	0.11
Vitamin C mg	2.0	15	15	12
Vitamin D µg	0.03[1]	3.1	3.1	1.9
Calcium mg	120	120	120	80
Magnesium mg	11	10	10	6.5
Iodine µg	31	20	20	12
Iron mg	0.02	1.2	1.2	1.2
Phosphorus mg	96	96	97	50
Potassium mg	157	150	150	90
Zinc mg	0.5	0.9	0.9	0.9

Sources: * Finglas et al (2015) except for
[1] Poskitt and Morgan (2005)

Despite the fact that milks marketed for young children are considerably more expensive than cows' milk, these so called growing-up milks are the fastest growing sector of the infant milk market and are being heavily advertised. In 2010 this sector increased sales by 21.5% (Mintel, 2012). It is interesting to note that in 2010 the Advertising Standards Authority found, for the second time, that television adverts for Cow & Gate toddler milks were misleading consumers in terms of the amount of iron needed by toddlers and the use of milk to supply this (ASA, 2010). In 2014 a further ruling by the ASA against Nutricia (ASA, 2014) upheld complaints that the Danone's 'Feed their personalities' beach babies television advertisement for Cow & Gate follow-on formula was misleading when it claimed:

"Cow & Gate follow-on milk provides Calcium for strong bones"

and

"Cow & Gate follow-on milk provides … iron for brain development".

Companies may only make claims as provided for in legislation and the ASA found that Danone had changed the wording and *"consumers would not understand the adapted wording used in the ad to have the same meaning as the authorised wording."*

In the UK, toddler milks aimed at children aged 2-3 years are available from Aptamil, Cow & Gate and Hipp Organic (note that the growing-up milk from Hipp Organic is not certified organic), and Cow & Gate have recently changed their formulation. The marketing centres heavily on the inability of the diet to provide enough vitamin D for children, but makes no mention of the public health policy for children to have vitamin drops between 1-4 years of age and the importance of playing outside in the summer sunshine for skin exposure to UV light which enables the body to make vitamin D. It is important that health claims on all foods for infants and children under the age of 5 are rigorously scrutinised to ensure that parents and carers are not misled when buying unnecessary and expensive fortified foods and drinks, and that health departments consider the need for regulation of these products which will fall outside any current regulatory frameworks.

The goats' milk based NANNYcare Growing Up Milk is marketed as suitable for children from 1-3 years and is based on pasteurised goats' milk solids (62%) with added lactose, vegetable oils and additional vitamins and minerals. Kabrita Gold 3 is a goats' milk based growing-up milk with added glucose syrup.

In 2013 the European Food Safety Authority (EFSA) produced a scientific opinion which stated:

"No unique role of young-child formulae with respect to the provision of critical nutrients in the diet of infants and young children living in Europe can be identified, so that they cannot be considered as a necessity to satisfy the nutritional requirements of young children when compared with other foods that may be included in the normal diet of young children."
(EFSA, 2013)

The nutritional composition and ingredients used in growing-up and toddler milks are given in Tables 22-24.

TABLE 22
The nutritional composition of growing-up milks and toddler milks suitable from around 1 year of age (powder formulation), compared with full-fat cows' milk

Nutrients per 100ml	Full-fat cows' milk*	Aptamil 3 Growing-up Milk 1-2 Years	Aptamil Profutura 3 Growing Up Milk	Cow & Gate 3 Growing Up Milk 1-2 Years	Hipp Organic Combiotic Growing Up Milk 3	Holle Organic Growing Up Milk 3
For use from age	12 months	12 months	12 months	12 months	12 months	12 months
Flavoured	×	×[2]	×	×[2]	×	×
MACRONUTRIENTS						
Energy kcal	63	65	65	65	66	68
Protein g	3.4	1.3	1.6	1.5	1.4	1.9
Whey:casein ratio	20:80	NK	30:70	33:67	20:80	NK
Carbohydrate g	4.6	8.9	8.4	8.5	8.0	8.2
– of which lactose g	4.6	6.6	6.1	6.2	7.6	5.7
Source of added carbohydrate	Lactose	Lactose, maltodextrin oligo-saccharides	Lactose, maltodextrin oligo-saccharides	Lactose, maltodextrin oligo-saccharides	Lactose, oligo-saccharides	Maltodextrin, starch
Fat g	3.6	2.6	2.6	2.6	3.0	3.0
Fat source	Milk fat	Palm, rapeseed, high oleic sunflower, coconut, sunflower oils	Rapeseed, sunflower and coconut oils and anhydrous milk fat	Palm, sunflower and rapeseed oils	Palm, rapeseed and sunflower oils	Palm, rapeseed and sunflower oils
Added LCPUFAs **ARA**	×	×	✓	×	×	×
DHA	×	✓	✓	×	×	×
LCPUFA Source	NA	Fish oils	Fish oils	NA	NA	NA
VITAMINS						
Vitamin A µg-RE	38	68	60	68	70	64
Vitamin C mg	2	15	15	15	10	12
Vitamin E mg	0.06	1.0	1.0	1.1	1.2	1.7
Vitamin D µg	0.03[3]	3.1	2.9	3.1	1.3	1.3
Vitamin K µg	0.49[4]	6.1	4.8	5.1	5.0	7.6
Thiamin (B_1) µg	30	40	40	40	60	80
Riboflavin (B_2) µg	230	230	230	230	120	200
Niacin µg (mg NE)	200	230	210	200	700	600
Vitamin B_6 µg	60	60	60	60	40	60
Vitamin B_{12} µg	0.9	0.4	0.45	0.4	0.2	0.3
Folic acid µg	8	8	12	12	20	26
Biotin µg	2.5	1.2	1.3	1.3	1.5	2.8
Pantothenic acid µg	580	580	590	580	500	600

TABLE 22 (continued)
The nutritional composition of growing-up milks and toddler milks suitable from around 1 year of age (powder formulation), compared with full-fat cows' milk

Nutrients per 100ml	Full-fat cows' milk*	Aptamil 3 Growing-up Milk 1-2 Years	Aptamil Profutura 3 Growing Up Milk	Cow & Gate 3 Growing Up Milk 1-2 Years	Hipp Organic Combiotic Growing Up Milk 3	Holle Organic Growing Up Milk 3
MINERALS						
Calcium mg	120	120	124	120	80	70
Chloride mg	89	51	55	51	45	45
Copper µg	Tr	NK	NK	NK	45	50
Iodine µg	31	20	20	20	15	18
Iron mg	0.02	1.2	1.2	1.2	1.2	0.9
Magnesium mg	11	10	10	10	7.0	7.7
Manganese µg	Tr	NK	NK	NK	6.5	15
Phosphorus mg	96	86	101	97	44	56
Potassium mg	157	150	156	150	80	101
Selenium µg	1.0	NK	NK	NK	1.5	2.1
Sodium mg	42	26	27	26	20	30
Zinc mg	0.5	0.4	0.9	0.9	0.7	0.6
ADDED INGREDIENTS						
Prebiotics	×	✓	✓	✓	✓	×
Probiotics	×	×	×	×	×	×
Nucleotides	×	×	×	×	×	×
Taurine	×	×	×	×	×	×
Choline	×	×	×	×	×	×
Contains soya	×	✓[2]	✓	✓[2]	✓[2]	×
Contains fish oil	×	✓	✓	×	×	×
Suitable for vegetarians[1]	✓	×	×	×	×	×
Halal approved		✓[2]	×	✓[2]	×	×

ARA = arachidonic acid DHA = docosahexaenoic acid EPA = eicosapentaenoic acid
LCPUFA = long chain polyunsaturated fatty acid NK = not known

1 Formula milks derived from cows' milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process. Rennet is used to separate curds from whey and, although vegetarian alternatives are available, they are not used by all manufacturers.
2 Powder formulation only

Sources * Finglas et al. (2015) except for
3 Poskitt and Morgan (2005)
4 Haroon et al. (1982)

TABLE 22 continued
The nutritional composition of growing-up milks and toddler milks suitable from around 1 year of age (powder formulation) compared with full-fat cows' milk

Nutrients per 100ml	Full-fat cows' milk*	Kendamil Toddler Milk	Kendamil Mehadrin Toddler Milk	Kendamil Organic Toddler Milk	SMA Organic Growing Up Milk	SMA Pro Toddler Milk
For use from age	12 months	12 months	12 months	12 months	12 months	12 months
Flavoured	✗	✗	✗	✗		Vanilla flavouring
MACRONUTRIENTS						
Energy kcal	63	64	65	65	67	64
Protein g	3.4	1.8	1.9	1.8	1.5	1.5
Whey:casein ratio	20:80	20:80	20:80	20:80		20:80
Carbohydrate g	4.6	8.0	7.4	8.1	8.4	7.0
– of which lactose g	4.6	7.2	7.4	8.1		7.0
Source of added carbohydrate	Lactose	Lactose, oligo-saccharides	Lactose	Lactose		Lactose
Fat g	3.6	2.8	3.1	2.8	3	3.3
Fat source	Milk fat	Sunflower, coconut and canola oils and whole milk fat	Rapeseed, coconut and sunflower oils and whole milk fat	Sunflower, coconut and rapeseed oils and whole milk fat		Palm, sunflower, soya and coconut oils
Added LCPUFAs ARA	✗	✓	✓	✗		✓
DHA	✗	✓	✓	✗		✓
LCPUFA source	NA	Single cell oils	Single cell oils	NA		Single cell oils
VITAMINS						
Vitamin A µg-RE	38	69	69	64	64	70
Vitamin C mg	2	13	13	13	12	12
Vitamin E mg	0.06	1.4	1.4	1.4	1.5	0.7
Vitamin D µg	0.03[2]	0.8	0.8	1.5	1.2	1.9
Vitamin K µg	0.49[3]	4.1	5.5	3.7	7.5	6.7
Thiamin (B_1) µg	30	80	80	70	70	100
Riboflavin (B_2) µg	230	130	100	80	200	110
Niacin µg (mg NE)	200	800	800	720	550	500
Vitamin B_6 µg	60	50	50	50	45	60
Vitamin B_{12} µg	0.9	0.2	0.2	0.19	0.22	0.18
Folic acid µg	8	15	15	20	13.6	13
Biotin µg	2.5	2.0	2.0	2.1	1.8	2.0
Pantothenic acid µg	580	500	500	460	570	450

TABLE 22 (continued)
The nutritional composition of growing-up milks and toddler milks suitable from around 1 year of age (powder formulation) compared with full-fat cows' milk

Nutrients per 100ml	Full-fat cows' milk*	Kendamil Toddler Milk	Kendamil Mehadrin Toddler Milk	Kendamil Organic Toddler Milk	SMA Organic Growing Up Milk	SMA Pro Toddler Milk
MINERALS						
Calcium mg	120	121	121	119	74	80
Chloride mg	89	52	49	51	42	55
Copper µg	Tr	40	50	40	45	50
Iodine µg	31	13	15	15	16.4	12
Iron mg	0.02	1.0	1.0	0.97	0.9	1.2
Magnesium mg	11	6.5	6.5	6.5	5.5	6.5
Manganese µg	Tr	9.9	10	9.0	0.02	10
Phosphorus mg	96	66	66	66	40	50
Potassium mg	157	105	105	103	86	90
Selenium µg	1.0	3.0	2.5	2.5	3	1.5
Sodium mg	42	24	24	22	24	29
Zinc mg	0.5	0.5	0.7	0.57	0.68	0.9
ADDED INGREDIENTS						
Prebiotics	×	✓	×	×		×
Probiotics	×	×	×	×		×
Nucleotides	×	✓	✓	×		✓
Taurine	×	×	×	×		✓
Choline	×	×	×	×		✓
Contains soya	×	×	×	×	✓	✓
Contains fish oil	×	×	×	×	✓	×
Suitable for vegetarians[1]	✓	✓	✓	✓	×	✓[4]
Halal approved	✓	✓	✓	✓	✓	✓

ARA = arachidonic acid DHA = docosahexaenoic acid LCPUFA = long chain polyunsaturated fatty acid
NA = not applicable NK = not known ANS = approval not sought

1 Formula milks derived from cows' milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process. Rennet is used to separate curds from whey and, although vegetarian alternatives are available, they are not used by all manufacturers.

Sources * Finglas et al. (2015) except for
2 Poskitt and Morgan (2005)
3 Haroon et al. (1982)

4 Powder formulation only

TABLE 23
The nutritional composition of goats' milk based growing-up milks suitable from around 1 year of age (powder formulation only) compared with full-fat cows' milk

Nutrients per 100ml	Full-fat cows' milk*	Holle Organic Infant Goat Milk Follow-on Formula 3	Kabrita Gold 3 Toddler Milk (suitable from 1-3 years)	NANNYcare Growing Up Milk (suitable from 1 to 3 years)
For use from age	12 months	12 months	12 months	12 months
MACRONUTRIENTS				
Energy kcal	63	67	68	67
Protein g	3.4	1.5	2.0	2.2
Whey:casein ratio	20:80	NK	42:58	NK
Carbohydrate g	4.6	7.9	8.1	6.7
of which lactose g	4.6	NK	6.7	6.7
Source of added carbohydrate	Lactose	Maltodextrin, lactose, starch	Lactose, glucose syrup solids, oligosaccharides	Lactose
Fat g	3.6	3.3	2.9	3.6
Fat source	Milk fat	Palm, rapeseed and sunflower oils	High sn-2 palmitic acid oil, soyabean, palm kernel and sunflower oil	Sunflower and rapeseed oils
Added LCPUFAs				
ARA	✗	✗	✓	✗
DHA	✗	✗	✓	✗
LCPUFA source	NA	NA	Vegetable and fish oils	NA
VITAMINS				
Vitamin A µg-RE	38	69.3	69	74
Vitamin C mg	2	13	9.7	10
Vitamin E mg	0.06	1.4	1.1	1.6
Vitamin D µg	0.03[2]	1.2	1.3	1.0
Vitamin K µg	0.49[3]	7.9	5.1	7.4
Thiamin (B1) µg	30	74	87	60
Riboflavin (B2) µg	230	130	145	120
Niacin µg (mg NE)	200	610	682	740
Vitamin B_6 µg	60	47	54	47
Vitamin B_{12} µg	0.9	0.14	0.2	0.38
Folic acid µg	8	19.6	13	8.7
Biotin µg	2.5	2.3	2.0	2.7
Pantothenic acid µg	580	550	435	400
MINERALS				
Calcium mg	120	57.3	75	100
Chloride mg	89	69.4	70	96
Copper µg	Tr	54	48	50
Iodine µg	31	22.4	11	9.4
Iron mg	0.02	0.68	1.1	0.91
Magnesium mg	11	6.0	6.2	8.6
Manganese µg	Tr	13	10	NK
Phosphorus mg	96	44.9	50	66
Potassium mg	157	82.8	97	110
Selenium µg	1.0	1.9	1.9	1.3

TABLE 23 (continued)

The nutritional composition of goats' milk based growing-up milks suitable from around 1 year of age (powder formulation only) compared with full-fat cows' milk

Nutrients per 100ml	**Full-fat cows' milk***	**Holle Organic Infant Goat Milk Follow-on Formula 3**	**Kabrita Gold 3 Toddler Milk** (suitable from 1-3 years)	**NANNYcare Growing Up Milk** (suitable from 1 to 3 years)
Sodium mg	42	18	21	27
Zinc mg	0.5	0.56	0.73	0.5
ADDED INGREDIENTS				
Structured vegetable oils	×	×	✓	×
Prebiotics	×	×	✓	×
Probiotics	×	×	×	×
Taurine	×	×	✓	✓
Choline	×	×	✓	✓
Contains soya	×	×	✓	×
Contains fish oil	×	×	✓	×
Suitable for vegetarians[1]	✓	×	×	×
Halal approved	✓	×	×	✓

ARA = arachidonic acid DHA = docosahexaenoic acid LCPUFA = long chain polyunsaturated fatty acid
NA = not applicable NK = not known

1 Formula milks derived from animal milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process. Rennet is used to separate curds from whey and, although vegetarian alternatives are available, they are not used by all manufacturers.

Sources * Finglas et al. (2015) except for
2 Poskitt and Morgan (2005)
3 Haroon et al. (1982)

TABLE 24
The nutritional composition of growing-up milks and toddler milks suitable from around 2 years of age (powder formulation), compared with semi-skimmed cows' milk

Nutrients per 100ml	Semi-skimmed cows' milk*	Aptamil 4 Growing Up Milk 2-3 Years	Cow & Gate 4 Growing Up Milk 2-3 Years	Hipp Combiotic Growing Up Milk 4
For use from age		2 years	2 years	2 years
Flavouring	×	Milk flavouring	Milk flavouring	×
MACRONUTRIENTS				
Energy kcal	46	59	50	48
Protein g	3.5	1.2	1.3	1.7
Whey:casein ratio	20:80	NK	30:70[3]	20:80
Carbohydrate g	4.7	8.0	6.5	5.0
– of which lactose g	4.7	6.0	5.5	4.8
Source of added carbohydrate	Lactose	Lactose, maltodextrin oligosaccharides,	Lactose, oligosaccharides, maltodextrin	Lactose, oligosaccharides
Fat g	1.7	2.4	1.9	2.2
Fat source	Milk fat	Palm, rapeseed, High oleic sunflower, coconut, sunflower oils	Palm, sunflower and rapeseed oils	Palm, rapeseed and sunflower oils
Added LCPUFAs				
ARA	×	×	×	×
DHA	×	✓	×	×
LCPUFA Source	NA	Fish oil	NA	NA
MICRONUTRIENTS				
Vitamin A µg-RE	20.5	62	62	36
Vitamin C mg	2	14	15	4.7
Vitamin E mg	0.04	1.0	1.0	0.6
Vitamin D µg	Tr	2.8	2.9	2.9
Vitamin K µg	Tr	5.5	4.6	NK
Thiamin (B_1) µg	30	40	40	NK
Riboflavin (B_2) µg	240	210	230	180
Niacin µg (mg NE)	100	210	200	NK
Vitamin B_6 µg	60	50	60	NK
Vitamin B_{12} µg	0.9	0.4	0.4	0.4
Folic acid µg	9	7.1	8.6	NK
Biotin µg	3.0	1.1	1.1	3.5
Pantothenic acid µg	680	530	580	NK
MICRONUTRIENTS				
Calcium mg	125	109	120	130
Chloride mg	87	48	39	NK
Copper µg	Tr	NK	NK	NK
Iodine µg	30	18	20	25

TABLE 24 (continued)
The nutritional composition of growing-up milks and toddler milks suitable from around 2 years of age (powder formulation), compared with semi-skimmed cows' milk

Nutrients per 100ml	Semi-skimmed cows' milk	Aptamil 4 Growing Up Milk 2-3 Years	Cow & Gate 4 Growing Up Milk 2-3 Years	Hipp Combiotic Growing Up Milk 4
Iron mg	0.02	1.1	1.2	0.7
Magnesium mg	11	9	10	12
Manganese µg	Tr	NK	NK	NK
Phosphorus mg	94	78	93	75
Potassium mg	156	136	117	155
Selenium µg	1	NK	NK	NK
Sodium mg	43	24	20	20
Zinc mg	0.4	0.4	0.9	NK
ADDED INGREDIENTS				
Prebiotics	✗	✓	✓	✓
Taurine	✗	✗	✗	✗
Choline	✗	✗	✗	✗
Contains soya	✗	✓[2]	✓[2]	✗
Contains fish oil	✗	✓	✗	✗
Suitable for vegetarians[1]	✓	✗	✗	✗
Halal approved	✓	✓[2]	✓[2]	✗

* Source: Finglas et al. (2015)
NK = not known
1 Formula milks derived from cows' milk are generally not suitable for vegetarians due to the inclusion of fish oils and/or the use of the animal-derived enzyme rennet during the production process. Rennet is used to separate curds from whey and, although vegetarian alternatives are available, they are not used by all manufacturers.
2 Powder formulation only
3 Whey: casein ratios may vary

5.14 Milks for which there are no compositional regulations: soya protein based milks marketed for young children

Key points

Soya protein based milks for children from about 1 year of age are offered by the manufacturer as an alternative to standard soya milk.

Alpro Soya Growing Up Drink provides more energy than standard unsweetened soya milk as it contains greater quantities of fats and carbohydrates, but it contains less protein than standard unsweetened soya milk. Whilst all soya milks are generally fortified with calcium and vitamins B_{12}, niacin, riboflavin, vitamin D and vitamin E, Alpro Soya Growing Up Drink is also fortified with iron and vitamin C and is sweetened with sucrose and fructose.

From the age of 1 year, children should be obtaining the majority of their nutrients from a balanced diet rather than relying on fortified milk products. Unsweetened fortified soya milk is a suitable alternative milk drink for children.

The typical ingredients used to make standard soya milks are water, hulled soya beans, sugars and vegetable oils. Alpro Soya Growing Up Drink is a liquid soya based milk and the first soya milk to be marketed in the UK specifically for children from 1 year of age. It provides more energy than standard soya milk due to the higher proportion of fats and carbohydrates it contains. The protein content of Alpro Soya Growing Up Drink is slightly lower than is typical of standard soya milks. Whilst standard soya milks are generally fortified with calcium and vitamins B_{12}, niacin, riboflavin, vitamin D and vitamin E, Alpro Soya Growing Up Drink is also fortified with iron and vitamin C.

Standard soya milks are generally sweetened with sugar, but there are unsweetened versions available. Alpro Soya Growing Up Drink is sweetened with sucrose and fructose and contains flavouring. The flavourings used are nature identical, which means that they are natural flavours which have been changed by enzymes or other chemical processes to mimic the flavour required. It is unclear whether repeated exposure to sweet drinks in infancy and toddlerhood might contribute to the development of a preference for sweet drinks in later life.

From 1 year of age, children should be obtaining the majority of their nutrients from the food that they eat. It is generally recommended that toddlers eat a good variety of foods to supply the majority of their nutrients, rather than relying on fortified products to supply them. However, for children who require soya milk rather than cows' milk, there is no unfortified milk alternative available and it is recommended that the most suitable alternative for toddlers who require a soya protein based milk drink is standard unsweetened, calcium-fortified soya milk.

The nutritional composition and ingredients used in Alpro Soya Growing Up Drink and a typical supermarket own brand, unsweetened soya milk are given in Table 25.

TABLE 25
The nutritional composition of a soya protein based growing-up milk suitable from around 1 year of age, compared with standard unsweetened soya milk

Nutrients per 100ml	Unsweetened calcium-fortified soya milk[1]	Alpro Soya Growing Up Drink
For use from age	12 months	12 months
MACRONUTRIENTS		
Energy kcal	26	64
Protein g	2.4	2.5
Carbohydrate g	0.5	8.3
– of which lactose g	0	0
Carbohydrate source	Maltodextrin	Maltodextrin, sucrose, fructose
Fat g	1.6	2.2
Fat source		Sunflower oil
Added LCPUFAs ARA	×	×
DHA	×	×
MICRONUTRIENTS		
Vitamin A µg	Tr	0.0
Vitamin C mg	0.0	12
Vitamin D µg	0.8	1.5
Riboflavin (B_2) µg	200	210
Vitamin B_{12} µg	0.4	0.38
Calcium mg	120	120
Iodine µg	1.0	24.5
Iron mg	0.43	1.1
Zinc mg	0.3	NK
ADDED INGREDIENTS		
Prebiotics	×	×
Probiotics	×	×
Taurine	×	×
Choline	×	×
Contains soya	✓	✓
Contains fish oil	×	×
Suitable for vegetarians	✓	✓
Halal approved	NK	NK

ARA = arachidonic acid DHA = docosahexaenoic acid LCPUFA = long chain polyunsaturated fatty acid
NK = not known Tr = trace

1 Data source: Finglas et al (2015)

5.15 PaediaSure Shake

PaediaSure Shake, marketed by Abbott Nutrition, is a ‘food supplement’ drink mix for children aged 1-10 years, but we have included this here as it is a fortified milk for children over 1 year of age for sale in the UK. The product is marketed as suitable for ‘fussy eaters’ and a dedicated website for its promotion has been set up at www.fussyeaters.co.uk.

PaediaSure Shake is made from hydrolysed corn starch, sugar and milk and soya proteins along with vegetable oils (soya oil, high oleic sunflower oil, medium change triglycerides from palm kernel oil), probiotics (*Lactobacillus bifidus* and *Lactobacillus acidophilus*) and micronutrients. It is lactose-free.

The product contains 7.5g sugar per 100ml from sucrose and a serving for a 1 year old is suggested as 225ml, twice a day. This would provide 34g of sucrose, considerably more sugar than is currently recommended for children of this age. In fact this milkshake will provide more sugar than recommended at all ages following portion sizes suggested and is not a suitable choice of milk for a young child.

A nutritional comparison with full-fat cows’ milk is given in Table 26. As well as being flavoured and high in sugar, the amounts of calcium, phosphorus, iodine, riboflavin and vitamin B_{12} are lower than in cows’ milk.

TABLE 26
The nutritional composition of PaediaSure Shake compared with full-fat cows' milk

Nutrients per 100ml	Full-fat cows' milk*	PaediaSure Shake
For use from age	12 months	12 months
Flavoured	✗	✓ (chocolate, strawberry and vanilla)
MACRONUTRIENTS		
Energy kcal	63	101
Protein g	3.4	3.0
Whey:casein ratio	20:80	NA
Carbohydrate g	4.6	13
– of which lactose g	4.6	0
Source of added carbohydrate	Lactose	Hydrolysed corn starch, sucrose, oligosaccharides
Fat g	3.6	3.9
Fat source		Soya and high oleic sunflower and palm kernel oils
Added LCPUFAs		
ARA	✗	✓
DHA	✗	✓
LCP source	N/A	Soya
VITAMINS		
Vitamin A µg-RE	38	60
Vitamin C mg	2	10
Vitamin E mg	0.06	1.6
Vitamin D µg	0.03[1]	2.0
Vitamin K µg	0.49[2]	5.9
Thiamin (B_1) µg	30	310
Riboflavin (B_2) µg	230	210
Niacin µg (mg NE)	200	1500
Vitamin B_6 µg	60	260
Vitamin B_{12} µg	0.9	0.3
Folic acid µg	8	25
Biotin µg	2.5	2.0
Pantothenic acid µg	580	700
MINERALS		
Calcium mg	120	96
Chloride mg	89	101
Copper µg	Tr	60
Iodine µg	31	9.7
Iron mg	0.02	1.4

TABLE 26 (continued)
The nutritional composition of PaediaSure Shake compared with full-fat cows' milk

Nutrients per 100ml	Full-fat cows' milk	PaediaSure Shake
Magnesium mg	11	19.8
Manganese mg	Tr	0.15
Phosphorus mg	96	83
Potassium mg	157	131
Selenium µg	1.0	3.2
Sodium mg	42	38
Zinc mg	0.5	0.67
ADDED INGREDIENTS		
Probiotics	×	✓
Taurine	×	✓
Choline	×	✓
Contains soya	×	✓
Contains fish oil	×	×
Suitable for vegetarians	✓	✓
Halal approved	✓	✓

ARA = arachidonic acid DHA = docosahexaenoic acid LCPUFA = long chain polyunsaturated fatty acid
NA = not applicable
Sources * Finglas et al. (2015) except for
1 Poskitt and Morgan (2005)
2 Haroon et al. (1982)

5.16 Other milks unsuitable for infants and toddlers

Cows' milk or milk from any other animal (eg. goat, sheep or buffalo), soya milks or milk substitutes such as oat milk or almond milk are not suitable as the main drink for infants in the first year of life. Rice milk is never appropriate to give to children under 5 years of age.

The majority of toddlers will be able to have whole cows' milk as their main milk drink during the second year of life and beyond, and there are no nutritional advantages to having other milks if cows' milk is tolerated. From 1 year of age, however, whole goats' milk, sheep's milk or buffalo milk or calcium-fortified unsweetened soya, hemp, nut or oat milk alternatives can be used as the main drink if desired, alongside a good mixed diet which will meet the majority of the child's energy and nutrient needs. Enriched and fortified milk substitutes should provide at least 120mg calcium per 100ml and preferably include other nutrients such as vitamin B_{12} and iodine which are importantly provided by animal milk in the diet of young children. The energy content of these milk alternatives is however lower than whole animal milk and care needs to be taken that the remainder of the diet is energy and nutrient dense if these milk alternatives are used.

There are particular concerns about rice milks, which can contain high levels of arsenic. The current recommendation from the Food Standards Agency (2009a) is:

"The Agency advises against the substitution of breastmilk, infant formula or cows' milk by rice drinks for toddlers and young children. This is both on nutritional grounds and because such substitution can increase their intake of inorganic arsenic, which should be kept as low as possible. If toddlers and young children (ages 1 - 4.5 years) consume rice drinks instead of breastmilk, infant formula or cows' milk, the Agency estimates that their intake of inorganic arsenic could be increased by up to four fold."

6 How much milk is needed and how to make it up safely

6.1 Birth to 6 months

The Royal College of Nursing (RCN) recommends that healthy infants are fed on demand and offered adequate food to satisfy their hunger (Royal College of Nursing, 2007). Healthy infants will naturally regulate their feeding and will take enough milk to meet their needs, and it is recommended that parents learn to recognise feeding cues given by their infants. An infant's milk requirements may vary from day to day, but most full-term infants will need to be fed every 2-3 hours, day and night, in the early weeks of life. Parents should bottle-feed in the same way that they are encouraged to breastfeed, offering one-to-one contact and meeting each individual infant's needs, being responsive to baby's cues. Babies should be allowed to feed on demand and not be encouraged to 'finish the bottle'. It is suggested that bottle-fed babies should be initially offered about 20ml formula milk/kg on the first day, divided into eight feeds, with the volume gradually increased over the following days to appetite, so that they are having about 150ml/kg by 7-14 days (Shaw, 2015).

Formula-fed infants have been shown to have higher milk intakes than breastfed infants, and this is particularly true in the first two weeks of life (Hester et al, 2012). Whilst there is variation in the amount of breastmilk consumed in the first few days of life, demand-fed babies in the Hester et al systematic review received about 20ml of milk on day 1, compared to 170ml in formula-fed babies. By day 14, breastfed babies received about 675ml a day compared to 760ml in formula-fed babies. The authors also noted that not only did formula-fed babies have a greater volume of milk in their early days, but formula milk is also higher in energy (65-67kca/100ml) than colostrum (54 kcal/100ml) and transitional milk (58kcal/100ml).

Most babies will need 150-180ml/kg/day of infant formula until they are 6 months old, although this will vary for the individual baby (Shaw, 2015). Using data from the Scientific Advisory Committee on Nutrition report on *Dietary Reference Values for Energy* (SACN, 2011), the volumes of milk required by infants by gender and age using average bodyweights have been calculated and are shown in Table 27.

This analysis suggests that the average formula milk requirements of infants are between about 130ml and 190ml/kg/day averaging at about 150ml/kg/day. The charts also highlight that at 4 months the energy requirement of infants drops slightly, reflecting changes in weight and growth patterns. This data suggests that infants in the first three months require about 170ml/kg/day, dropping to about 130ml/kg/day from 4-6 months. These are just guidelines as everyone is clear that feeding should be 'baby-led', but provide an evidence base for guidance.

TABLE 27

Estimated amounts of infant formula required, using energy requirements from the SACN report *Dietary Reference Values for Energy* (2011)

Age (months)	**Median weight** (boys)[1]	**Energy requirements** (kcal)	**EAR** (kcal/kg/day)	**ml formula/day**[2]	**ml/kg/day**
1	4.47	563	126	866	194
2	5.56	646	116	992	178
3	6.37	657	103	1,010	159
4	7.0	607	87	934	133
5	7.51	639	85	982	131
6	7.93	665	84	1023	129
Age (months)	**Median weight** (girls)[1]				
1	4.19	515	123	792	189
2	5.13	589	115	741	144
3	5.84	600	103	923	158
4	6.42	573	89	881	137
5	6.9	601	87	924	134
6	7.3	623	85	958	131

1 50th percentile weight for age from the UK-WHO charts

2 Energy content of infant formula assumed to be 65kcal/100ml, the middle of the range stipulated in the EU Directive

All manufacturers of infant milks provide guidelines on their packaging which show typical volumes of formula to use according to the age and weight of the infant. These can be confusing as they vary from brand to brand and do not always describe the same ages and stages.

The feeding guides for the three main brands of first infant milk are shown in Table 28. None align with current best practice guidance as they all suggest fewer feeds in the first few weeks, and the rationale on volume appears to relate to bottle size rather than requirement. Advice to offer a large volume of milk at birth could lead to parent and carer anxiety if this amount of milk is not accepted.

TABLE 28
Feeding guides suggested for the three main brands of first infant formula

Age of baby	Average intake formula required[1]	Aptamil 1 First Milk		Cow & Gate 1 First Infant Milk		SMA Pro First Infant Milk	
		Number of feeds	**Volume** (ml)	**Number of feeds**	**Volume** (ml)	**Number of feeds**	**Volume** (ml)
Birth	About 80ml over 8 feeds			6	540		
Up to 2 weeks	Increasing intakes to about 650ml over 8 feeds	6	540			6	540
2 weeks				6	720		
2-4 weeks		5	600			6	720
1 month	830ml						
4-8 weeks		5	750			6	720
2 months	870ml					5	750
8-12 weeks		5	900				
3 months	970ml					5	900
3-4 months		5	900				
4 months	910ml			5	1,050	5	900
4-5 months		5	1,050				
5 months	955ml						
5-6 months		5	1,050				
6 months	990ml			4	960	4	960
7-12 months	400-600ml[2]	3	630	3	630	3	630

1 Average intake for boys and girls estimated from energy requirement and based on breastmilk intakes.It is important to remember however that breastfed infants may feed many more times per day than this and that is perfectly normal. Breastfeeding women should be advised that they should be responsive to their baby's needs and not worry about the number of feeds in a 24h period.

2 See section 6.2.

All feeding guidelines are, however, just guidance, and it is important that parents and carers do not become too concerned about their infant accepting the exact amounts of milk as stated on packaging, as long as the infant is growing and developing well. Appetites vary between individuals and over time. It is important never to force infants to finish the milk in their bottle.

6.2 Older infants

General guidance on feeding infants is found in the Department of Health publication *Birth to five* (Department of Health, 2011). By 7-9 months of age, infants should be getting significant amounts of nutrients from food, and the amount of formula milk consumed should be around 600ml a day. By 10-12 months of age, the amount of milk consumed should be around 400ml per day as food takes over as the main source of energy and nutrients. Breastfed babies will continue to take the amount of milk they need as they obtain increasing energy from food and it is not necessary to know the volume of this. For more information about milk and food in the first year of life, see www.firststepsnutrition.org

6.3 Ready-to-feed milks

The main advantage of ready-to-feed (RTF) formula is that no errors can be made when making up the milk as can occur when using powdered formula. In addition, RTF formula is sterile until opened, whilst powdered milks are not. Infants may also accept RTF milk straight from the carton without it being warmed, which some parents may see as an advantage. The disadvantages are that RTF milks are very expensive, and considerable numbers of cartons are required which can be bulky to purchase and increases packaging waste. There is also reduced flexibility on serving sizes and it is not known how parents and carers manage portion sizes of milk when they buy cartons of formula. RTF milk that have been ultra heat treated may have a slightly different composition to equivalent powdered milks, but there is currently no analytical evidence to support this.

6.4 Powdered milks

There has been concern over a number of years that errors in the reconstitution of powdered milks might contribute to overfeeding of infants (Lucas, 1992). The potential for harm to infants from making up powdered formula milk feeds incorrectly is serious. Over-concentration of feeds may lead to hypernatraemic dehydration or obesity, while under-concentration may lead to growth faltering (Department of Health and Social Security, 1974; Chambers and Steel, 1975). A systematic review of formula feed preparation (Renfrew et al, 2003) reported that errors in reconstituting feeds were commonly reported and that there was considerable inconsistency in the size of scoops between milk brands. In addition there appears to be little information provided to parents antenatally on how to make up bottles appropriately. A study in which mothers at clinics were asked to measure powdered milk with the same scoop found wide variations in the amount of powder used, ranging from 2.75g to 5.2g per levelled scoop (Jeffs, 1989). Pre-weighed sachets of milk powder have been suggested as a way to reduce volume errors, although where part packets are required to make up smaller or larger feeds, it is likely that errors will still occur. Renfrew et al (2003) recommended that there should be a consistent approach in terms of uniform instructions in the making up of feeds and in scoop sizes to avoid confusion, led by the Food Standards Agency and the Department of Health, but these recommendations do not appear to have been taken forward. When preparing this report we made up powdered formula for the main first milk brands following the manufacturers' instructions, and 900g of dried powder made between 6,625ml and 7,520ml of milk, suggesting some varieties in the energy density of milks per scoop if the final products meet similar compositional standards.

6.5 Water used to make up powdered milk

It is recommended that powdered formula milks are made up using fresh water from the cold tap and that bottled water is only used if it specifically states that it is appropriate for making up infant formula, as some bottled waters have a high level of some minerals. It is recommended that bottled waters used to make up formula should have less than 200mg sodium (Na) per litre and less than 250mg sulphate (SO^4) per litre and that they are boiled before for use for infants under 6 months of age (NHS, 2011). However most bottled water has significantly less sodium than 200mg/litre and choosing a water with a level of 20mg Na/litre or less would ensure that a made up infant formula was closer in sodium composition to breastmilk.

There has been some discussion of the risks of using bottled water if an emergency arises and mains water supplies are disrupted. Often in these circumstances bottled water is made available to households and it is important that in emergency situations clear information is given to parents and carers on whether it is safe to use this for making up infant milks. A review of the safety of bottled water for making up infant formula concluded that this is likely to be a safe alternative to mains water in the event of an emergency and this should be made clear in appropriate guidance (Osborn and Lyons, 2010).

6.6 How to make up infant milks safely

In 2005, the Food Standards Agency (FSA) issued guidelines on the safe preparation and storage of powdered infant formula milks and these were updated and re-issued in 2011 (Food Standards Agency, 2005; NHS, 2011). In 2013, following concern over some manufacturers suggesting that their products be reconstituted at temperatures below 70°C, the Department of Health reiterated its position on the safe preparation of powdered infant formula milks:

"We would like to reiterate that the position of the Department of Health and the Food Standards Agency is that it is best practice to make up infant feeds by reconstituting formula powder using water at a temperature of 70°C or above ... we want to be clear that all standard, non-specialised infant formula and follow-on formulas, including those containing probiotics, should be prepared in-line with current best practice, regardless of the presence of any other contrary instruction on the product, in order to minimise the risk of infection." (Department of Health, 2013)

Bacteria multiply most rapidly at temperatures between 7°C and 65°C. Even at 5°C – the temperature recommended for domestic fridges – multiplication will continue but at a much reduced rate. The guidelines are designed to reduce the holding time between reconstituting and using feeds in order to minimise the amount of time during which bacterial multiplication can occur, and include recommendations for cleaning and sterilising all feeding equipment and for making up formula.

The guidelines are summarised in Table 29. Following these guidelines can reduce the risk of infection from micro-organisms in powdered infant formula milks.

TABLE 29
Guidelines on the safe preparation and storage of powdered infant formula milks

General recommendations	
Recommendation	**Rationale**
Make up feeds one at a time as the baby needs them.	To reduce the holding time between reconstituting and using feeds in order to minimise the amount of time during which bacterial multiplication can occur.
Sterilise all bottles and equipment to be used.	The infant's immune system is not as well developed as an adult's. This recommendation minimises the risk of illness and infection.
Use water from the cold tap to make up feeds. Do not use bottled or artificially softened water.	Bottled water is not sterile and may contain too much sodium or sulphate. If you must use bottled water, check on the label that the sodium (Na) level is less than 200mg/l and the sulphate (SO or SO^4) level is no higher than 250mg/l.
Recommendations for making up a feed using formula milk powder	
Recommendation	**Rationale**
Boil at least 1 litre of fresh water from the cold tap in a kettle. Do not use previously boiled water. Leave the water to cool for no more than 30 minutes.*	This step should ensure that the water used to reconstitute the feed is at a temperature above 70°C, which will kill most of the pathogenic micro-organisms that may be present in powdered formula.
Clean and disinfect all equipment and work surfaces to be used, and wash your hands. Keep teat and bottle cap on the up-turned lid of the steriliser. If using a cold-water steriliser, shake off excess solution and rinse bottles in cooled boiled water from the kettle. Do not use tap water.	To avoid contamination of bottles with bacteria from tap water or unclean work surfaces.
Pour the correct amount of cooled, boiled water (which should still be at a temperature of more than 70°C if it has been cooled for less than 30 minutes) into bottles and double-check the volume before adding the powder. Fill the scoop loosely with milk powder according to the manufacturer's instructions. Level off the scoop using the leveller provided or the back of a clean, dry knife. Always use the scoop provided with the powder you are using. Add the powder to the water in the bottle.	Scoop sizes differ between manufacturers and between different milk powders from the same manufacturer. Too much powder may result in constipation or dehydration.
Holding the edge of the teat, put it on the bottle and then secure the retaining ring and cap. Shake the bottle until the powder is dissolved.	
Cool the formula by holding the bottom of the bottle under cold running water. Do not allow the tap water to touch the bottle cap. Test the temperature of the milk by shaking a small amount onto the back of your wrist. It should be body temperature and feel warm or cool but not hot.	
Discard any of the feed that has not been used.	

Source: Food Standards Agency, 2005; NHS, 2011.

Data from an FSA-funded study at Nottingham Trent University (Food Standards Agency, 2009b) found that it is not feasible for those who make up formula milks to easily determine the temperature of reconstitution water in order to meet the ‘above 70°C’ guideline. The advice of reconstituting milk using water which had been boiled and left for 30 minutes resulted in temperatures ranging from 46°C to 74°C, depending on the volume of water boiled. This results in different degrees of lethality to bacteria. 1 litre of water boiled and left to cool at room temperature for 30 minutes will be at a temperature of above 70^{o}C. It is important that clear, consistent advice is given to parents and carers to ensure that the water is hot enough to offer protection from bacterial infection.

The Infant Feeding Survey 2005 and 2010 found that many parents and carers did not follow guidelines for the reconstitution of formula milk (Bolling et al, 2007; Health and Social Care Information Service, 2012). In 2005 just under half of all mothers who had prepared powdered infant formula in the seven days before being surveyed had not followed the key recommendations, either by not always using boiled water that had cooled for less than 30 minutes, or not always adding the water to the bottle before the powder. About a third of mothers did not follow the recommendations for preparing formula when away from the home, either by not keeping pre-prepared formula chilled, or by using cold or cooled water when making up feeds (Bolling et al, 2007).

The 2010 Infant Feeding Survey (Health and Social Care Information Service, 2012) reported that almost half (49%) of all mothers who had made up powdered formula in the last seven days followed all three recommendations of only making one feed at a time, making feeds within 30 minutes of the water boiling, and adding the water to the bottle before the powder. This is a substantial increase on the proportion of mothers following all three guidelines in 2005 (13%), and is likely to be primarily due to the increase in the proportion of mothers making up only one feed at a time. Mothers in Northern Ireland were the most likely to have followed all three recommendations (58%), while mothers in Scotland were the least likely to have done so (45%).

Guidelines for parents and carers on making up milks safely can be found at http://www.nhs.uk/conditions/pregnancy-and-baby/pages/making-up-infant-formula.aspx#close

The NCT also has a factsheet for parents – *Using infant formula: Your questions answered – available from* http://www.nct.org.uk/sites/default/files/related_documents/Using%20infant%20formula%20feeding%20-%20your%20questions%20answered%20FINAL%20FOR%20WEB.pdf

The Baby Feeding Law Group produce a DVD – *Infant milk explained* – showing how milk can be made up safely. See www.babyfeedinglawgroup.org.uk

6.6.1 Making milk up safely when away from home, using water kept warm in a vacuum flask

The Department of Health recommend that the safest way to make up feeds from powdered infant formula (PIF) when away from home is to make the feed up freshly using previously boiled water stored in a vacuum flask. The boiling water should kill any bacteria present in the flask. The feed can then be made up in a sterilised feeding bottle when needed, using PIF pre-measured into a small, clean, dry container and the correct amount of boiled water from the vacuum flask. The Department of Health state that vacuum flasks, if full and securely sealed, will keep the water temperature above 70˚C for several hours[1].

We have tested a 17.5oz (500ml) vaccum flask and a 33oz (1000ml/1 litre) vacuum flask filled with boiling water. Both were stainless steel flasks. The flasks were tested filled with boiling water, and the smaller flask was also tested when smaller volumes of water were used. This is because it has been reported that some families take just the amount of water they need for one feed in a flask, and it is important to note how quickly smaller volumes of water cool.

The thermos flasks were both warmed for 1 minute with boiling water before use and the flasks were stored at an ambient temperature of about 19°C. The tests were conducted three times, with each time test completed on a freshly stored batch of boiling water.

Table 30 shows the results for a 500ml flask and a 1litre flask. Please note these are just estimates made by us in a domestic kitchen, and others may find they get different readings depending on types of flasks and thermometers used.

TABLE 30
Temperature of boiling water stored in a 1000ml and 500ml vacuum flask

Amount of water in the flask	Temperature when boiling water first added to flask °C	Temperature after 30 minutes °C	Temperature after 1 hour °C	Temperature after 2 hours °C	Temperature after 3 hours °C
Full flask: (approx. 33oz, 1000ml)	94	86	82	78	75
Full flask: (approx. 17.5oz, 500ml)	94	92	90	86	76
10oz (280ml)	93	80	74	72	66
5oz (140ml)	92	72	70	64	58

[1] http://www.nhs.uk/start4life/documents/pdfs/start4life_guide_to_bottle_feeding.pdf

The 10oz flask of water was also tested at 2 hours and 30 minutes and the temperature had dropped to an average 68°C. This suggests that if smaller volumes are used, a minimum of 10oz of water should be carried in a flask, and that water should be used within 2 hours. Smaller amounts of 5oz will only remain at the correct temperature for about an hour.
A full flask of water securely sealed as suggested by The Department of Health remains at >70°C for at least 3 hours, and in our tests was still above 70°C after 4 hours. If a 1 litre flask is filled with boiling water, it is likely that the water remains at above 70°C for at least 7 hours. This provides an option for parents who want to make up bottles of milk on longer outings, or during the night.

Care must be taken to avoid scalds when handling hot water, especially when a full litre flask of water is being used. Great care must be taken that the milk given to the infant is at the correct temperature. Run the prepared bottle of formula under a cold tap to cool, shake vigorously and always test the milk temperature on the inside of the wrist before offering to a baby.

We have been asked whether it is possible to make up powder with smaller volumes of hot water to kill any bacteria present and then top up the bottle with cool, boiled water. There is however no evidence to suggest how much hot water is needed to mix with the powder to ensure that the powder has sufficient exposure to water at 70°C, and therefore standard advice remains to add the powder to the full volume of hot water, shake thoroughly, and then cool.

6.7 Formula preparation machines

Formula preparation machines are marketed as being a sterile and convenient method of preparing formula feeds at the correct temperature for consumption, within minutes. In the UK, the predominant formula preparation machine available at high street retailers is the Tommee Tippee Perfect Prep™ Machine. This machine claims to "*prepare a fresh bottle at just the right serving temperature within 2 minutes".* The machine uses a two-step process to prepare the feed. In the first step the machine dispenses a 'hot shot' of water directly into the bottle. The user then has 2 minutes to add the PIF, place the holding cap on the bottle, shake to mix and return the bottle to the machine. In step 2, cold water is added by the machine to make up the selected feed volume to a comfortable temperature to feed immediately.

Whilst research into the safety and efficacy of the Perfect Prep™ Machine has been carried out by the manufacturer, this is not currently in the public domain and the manufacturer has declined to release it for business competition reasons. Mayborn Group Ltd, who produce Tommy Tippee brand products, have said:

"Our Perfect Prep product has been tested by an independent laboratory that validated that the 'hot shot' of water addressed the (E.Sakazakii) species of concern. The laboratory used was Intertek Testing Services (UK) Limited. The filter we use is not a standard water filter, such as the ones you might find in a Britta system – it's an antibacterial filter. We have independently validated the removal of bacteria that may be present in water, and we have done this test in extreme circumstances, dosing the water with significantly higher levels of bacteria than typically found in water supplies, so we can be truly confident of the filter efficiency. Validation was carried out by Intertek Testing Services (UK) Limited."

Unpublished university-based research which investigated the efficacy and temperature profile of the Tommee Tippee Perfect Prep™ Machine using PIF inoculated with known amounts of *Cronobacter sakazakii* has suggested that, whilst the machine's hot shot of water dispensed onto a small volume of powder was able to eradicate more than 95% of the bacteria, it failed to reduce their numbers to an undetectable level. Whilst the machine produced water for the 'hot shot' at a temperature higher than the 70ºC stipulated in current guidelines, the temperature fell to around 60ºC after 2 minutes. Furthermore, when PIF was added at 30, 60 and 90 seconds after the 'hot shot', the temperatures in the bottle were only maintained for around five seconds before they fell again to between 52.5ºC and 55.5ºC.

This research showed that, depending on when the PIF is added, the water temperature may be too low to effectively eradicate all bacteria present. The volume of the initial hot shot of water used for a 4oz feed is about 1 fluid oz, and it is questionable whether this small volume of water can adequately make contact at the right temperature with the amount of PIF added. The research suggests that this volume of water is insufficient to maintain a temperature of greater than 70ºC for the duration of the 2-minute window recommended for the addition of PIF. This data has not been published in a peer-reviewed journal and therefore can only be considered as contributory evidence at the present time (First Steps Nutrition Trust, personal communication).

The Food Standards Agency made the following statement when asked about the safety of these formula machines in 2014:

"The issues we have with it are, although it states it dispenses a 'hot shot' at 70C to kill bacteria that potentially could be in the powder, the reality (if you watch the TT advert) is that this amount of hot water used is very small, and once this is dispensed into a cold bottle/cold powder the heat will be quickly lost (more so than when preparing a full bottle with cooled, boiled water to >70C), so we would be interested to see whether TT have done any validation to see what temperatures the hot shot/powder combo actually reaches (and whether this is enough to destroy any bacteria).The other issue, is that the rest of the bottle is then topped up with cold water, which TT state is filtered to remove impurities. Again we would be interested to know whether it has been validated that the TT filter removes potential bacteria in the tap water (as this won't previously have been boiled).
At present the Food Standards Agency would still advocate the use of our Best Practice Guidance, to use cooled, boiled water at >70C to make up infant formula."
(Email communication between Francesca Entwhistle (UNICEF) and Lorna Rowswell at FSA. February 2014)

Department of Health guidance on formula feeding does not cover the use of formula-making machines.

The convenience of this type of formula preparation machine is questionable, as users are still required to sterilise all feeding equipment and wash surfaces and hands before preparation and accurately measure and add the PIF to the feeds. There are also maintenance issues to address such as changing filters and running de-scaling cycles – which cost both time and money. The only benefit to parents appears to be the time-saving associated with not having to wait for water boiled in a kettle to cool before the milk powder can be added.

7 For more information

Useful organisations

The organisations listed below provide a range of information and resources on infant feeding.

Association of Breastfeeding Mothers
T: 08444 122 948
E: info@abm.me.uk
www.abm.me.uk
For breastfeeding information, a list of local support groups, and current breastfeeding news.

The Baby Café
www.thebabycafe.org
A charity which coordinates a network of breastfeeding drop-in centres and other services to support breastfeeding mothers.

The Baby Feeding Law Group
www.babyfeedinglawgroup.org.uk
Works for the implementation of the *International Code of Marketing of Breast-milk Substitutes* and subsequent, relevant World Health Assembly Resolutions into legislation in the UK.

Baby Milk Action
T: 01223 464420
E: info@babymilkaction.org
www.babymilkaction.org
A non-profit organisation which aims to save lives and to end the avoidable suffering caused by inappropriate infant feeding.

Best Beginnings
T: 020 7443 7895
www.bestbeginnings.org.uk
For simple, practical visual guidance on breastfeeding, aimed at parents.

BLISS (The Premature Baby Charity)
T: 020 7378 1122
E: information@bliss.org.uk
www.bliss.org.uk
Provides support and care to premature and sick babies across the UK.

The Breastfeeding Network
T: 0844 412 0995
www.breastfeedingnetwork.org.uk
An independent source of support and information for breastfeeding women and those involved in their care.

Community Practitioners' and Health Visitors' Association (CPHVA)
E: infocphva@unitetheunion.com
http://unitetheunion.org/cphva

European Food Safety Authority (EFSA)
www.efsa.europa.eu
Provides information on risk assessment regarding food and food safety and independent scientific advice and communication on existing and emerging risks.

Feedgood
Infant feeding information for families and health professionals in Scotland.
www.feedgood.scot

Food Standards Agency
(UK headquarters)
T: 020 7276 8829
E: helpline@foodstandards.gsi.gov.uk
www.food.gov.uk

GP Infant Feeding Network UK (GPIFN)
www.gpifn.org.uk

Institute of Health Visiting
T: 020 7265 7352

www.ihv.org.uk
Professional organisation for health visitors.

The International Baby Food Action Network
www.ibfan.org

La Leche League
T: 0845 456 1855 (General enquiries)
0845 120 2918 (24-hour helpline)
www.laleche.org.uk
Helps mothers to breastfeed through mother-to-mother support, encouragement, information and education.

Lactation Consultants of Great Britain (LCGB)
E: info@lcgb.org
www.lcgb.org

Midwives Information and Resource Service (MIDIRS)
T: 0800 581 009
www.midirs.org

The Multiple Births Foundation
T: 0203 313 3519
E: mbf@imperial.nhs.uk
www.multiplebirths.org.uk
Offers support to multiple-birth families, and education and advice to professionals about their special needs.

National Institute for Health and Care Excellence (NICE)
T: 0845 003 7780
www.nice.org.uk
For public health guidance on antenatal and postnatal care and nutrition.

NCT
T: 0300 33 00 770
www.nct.org.uk
For information to support parents on all aspects of antenatal and postnatal care.

NHS Choices
www.nhs.uk
Government-sponsored information website on all aspects of health.

NHS Health Scotland
T: 0131 536 5500
www.healthscotland.com

Public Health Agency (Northern Ireland)
T: 028 9031 1611
www.publichealth.hsci.net

Public Health England
T: 020 7654 8000
www.gov.uk/government/organisations/public-health-england

Public Health Wales
www.wales.nhs.uk/sitesplus/888/home

Royal College of Midwives
T: 020 7312 3535
www.rcm.org.uk

Royal College of Nursing
T: 020 7409 3333
www.rcn.org.uk

Royal College of Paediatrics and Child Health
T: 020 7092 6000
www.rcpch.ac.uk

Scientific Advisory Committee on Nutrition (SACN)
www.sacn.gov.uk

UNICEF UK Baby Friendly Initiative
T: 0844 801 2414
E: bfi@unicef.org.uk
www.babyfriendly.org.uk

United Kingdom Association for Milk Banking (UKAMB)
T: 0208 383 3559
E: info@ukamb.org
www.ukamb.org
A charity that supports human milk banking in the UK.

World Health Organization
www.who.int/health_topics/breastfeeding

Infant formula companies

Abbott

Infant milks produced:
- *PaediaSure Shake*

Abbott Nutrition
Abbott House
Vanwall Business Park
Vanwall Road
Maidenhead
Berkshire
SL6 4XE

T: 0800 252 882
www.abbottnutrition.co.uk
www.fussyeaters.co.uk

Aldi

Infant milks produced:
- *Mamia First Infant Milk*
- *Mamia Follow-on Milk*

Aldi Stores Ltd.
Holly Lane
Atherstone
Warwickshire
CV9 2SQ.

T: 0800 042 0800
www.aldi.co.uk
E: mamia@aldi.co.uk

Alpro

Infant milks produced
- *Alpro Soya Growing Up Drink*

T: 0800 0 188 180
E: info@alprohelpline.co.uk
www.alpro.com/uk

Aptamil
(Parent company Danone Nutricia)

Infant milks produced:
- *Aptamil 1 First Milk*
- *Aptamil Profutura 1 First Infant Milk*
- *Aptamil 2 Follow-on Milk*
- *Aptamil Proftura 2 Follow-on Milk*
- *Aptamil Anti-reflux*
- *Aptamil Comfort*
- *Aptamil 3 Growing-up Milk 1-2 Years*
- *Aptamil Profutura 3 Growing Up Milk*
- *Aptamil 4 Growing Up Milk 2-3 Years*
- *Aptamil Hungry Milk*
- *Aptamil Lactose Free*

Aptamil
Newmarket House
Newmarket Avenue
White Horse Business Park
Trowbridge
Wiltshire BA14 0XQ

T: 0800 996 1000
www.aptaclub.co.uk
www.aptamilprofessional.co.uk

Cow & Gate
(Parent company Danone Nutricia)

Infant milks produced:
- *Cow & Gate 1 First Infant Milk*
- *Cow & Gate 2 Follow-on Milk*
- *Cow & Gate Anti-reflux*
- *Cow & Gate Infant Milk for Hungrier Babies*
- *Cow & Gate 3 Growing Up Milk 1-2 Years*
- *Cow & Gate 4 Growing Up Milk 2-3 Years*
- *Cow & Gate Comfort*

Nutricia (Danone Nutricia Early Life Nutrition)
Newmarket House
Newmarket Avenue
White Horse Business Park
Trowbridge
Wiltshire BA14 0XQ
T: 0800 996 1234
www.eln.nutricia.co.uk

Hipp Organic

Infant milks produced:
- *Hipp Organic Combiotic First Infant Milk*
- *Hipp Organic Combiotic Hungry Infant Milk*
- *Hipp Combiotic Comfort*
- *Hipp Organic Combiotic Anti-reflux*
- *Hipp Organic Combiotic Follow-on Milk 2*
- *Hipp Organic Good Night Milk*

- *Hipp Organic Combiotic Growing Up Milk 3*
- *Hipp Combiotic Growing Up Milk 4*

Hipp Organic Ltd
The Stable Block
Hurst Grove
Sandford Lane
Hurst
Reading
Berkshire RG10 0SQ
T: 0845 050 1351
E: inforequest@HiPP.co.uk
www.HiPP.co.uk
www.HiPP4hcps.co.uk

Holle

Infant milks produced:
- *Holle Organic Infant Formula 1*
- *Holle Organic Infant Goat Milk Formula 1*
- *Holle Organic Infant Follow-on Formula 2*
- *Holle Organic Infant Goat Milk Formula 2*
- *Holle Organic Growing-up Milk 3*
- *Holle Organic Infant Goat Milk Follow-on Formula 3*

Holle Babyfood GmbH
Baselstrasse 11
4125 Riehen
Switzerland
T: +41 61 645 96 00
E: babyfood@holle.ch
www.holle.ch/english

Kabrita

Infant milks produced:
- *Kabrita Gold 1 infant milk*
- *Kabrita Gold 2 follow-on milk*
  Kabrita Gold 3 toddler milk

Hyproca Nutrition Europe B.V.
Dokter van Deenweg 150
Postbus 50078
8002 LB Zwolle
The Netherlands
T: +31 (0) 881163661

Kendal Nutricare

Infant milks produced:
- *Kendamil First Infant milk*
- *Kendamil Mehadrin First Infant Milk*
- *Kendamil Organic First Infant Milk*
- *Kendamil Follow-on Milk*
- *Kendamil Organic Follow-on Milk*
- *Kendamil Toddler Milk*
- *Kendamil Mehadrin Toddler Milk*
- *Kendamil Organic Toddler Milk*

Kendal Nutricare Ltd
Mint Bridge Road
Kendal
Cumbria
LA9 6NL
T: 01539 877100
E: Enquiries@KendalNutricare.com
www.kendalnutricare.com

Sainsbury's

Infant milks produced:
- *Sainsbury's Little Ones First Infant Milk*
- *Sainsbury's Little Ones Follow-on Milk*

Sainsbury's Supermarkets Ltd
33 Holborn
London
EC1N 2HT
T: 0800 636 262
E: customer.service@sainsburys.co.uk
www.sainsburys.co.uk

SMA Nutrition
(Parent company Nestlé)

Infant milks produced:
- *SMA Comfort*
- *SMA Extra Hungry*
- *SMA Organic First Infant Milk*
- *SMA Pro First Infant Milk*
- *SMA Organic Follow-on Milk*
- *SMA Pro Follow On Milk*
- *SMA HA*
- *SMA LF*
- *SMA Pro Anti-Reflux*
- *SMA Organic Growing up Milk*
- *SMA Pro Toddler Milk*
- *SMA Wysoy*

Nestlé Nutrition
1 City Place
Gatwick
RH6 0PA
T: 01828 580433

www.smahcp.co.uk
www.smababy.co.uk

NANNYcare

Infant milks produced:

- *NANNYcare First Infant Milk*
- *NANNYcare Follow On Milk*
- *NANNYcare Growing Up Milk*

NANNYcare Ltd
22-24 Kingsford Street
London
NW5 4JT

UK Helpline: 0800 328 5826
E: enquiry@nannycare.co.uk

Appendix 1
Background

A brief history of infant milks

Before the 20th century, infants not fed on human milk were unlikely to reach their first birthday. Many infants who were unable to be breastfed by their mothers were wet-nursed (given breastmilk by a woman other than the child's mother). Other less fortunate infants were 'dry-nursed'. Dry nursing involved feeding an infant on a home-prepared mixture based on a liquid, either water or milk, mixed with finely ground grains. However, the majority of infants died if they did not have access to breastmilk.

The first commercial infant formula was produced in 1867, devised by Justus von Liebig, a German chemist, and sold as Liebig's Perfect Infant Food. This consisted of wheat flour, cows' milk, malt flour and potassium bicarbonate. The product was initially sold in liquid form but soon became available as a powder with added pea flour and a lower milk content. The commercial success of this product quickly gave rise to competitors such as Mellin's Infant Food, Ridge's Food for Infants and Nestlé's Milk made from milk and cereal in Switzerland, and often credited as the first international formula milk brand. The term 'formula' is derived from Thomas Morgan Botch's approach to 'percentage feeding'. He coined the term when he was trying to devise the best mix of the various constituents that make up baby formula in the mid 19th century.

During the 19th and 20th centuries, nutrition scientists continued to analyse human milk and attempt to make infant formulas that more closely matched the composition of human milk. Maltose and dextrins were believed to be nutritionally important (even though these are not present in breastmilk), and in 1912 the Mead Johnson Company released a milk additive called Dextri-Maltose. This formula was only made available to mothers by doctors. In 1919, milk fats were replaced with a blend of animal and vegetable fats as part of the continued drive to simulate human milk more closely. This formula was called SMA, which stood for 'simulated milk adapted'.

In the late 1920s, Alfred Bosworth released Similac (for 'similar to lactation'), and Mead Johnson released Sobee. In 1941 National Dried Milk was introduced in the UK. This was a dried, full-fat, unmodified cows' milk powder fortified with vitamin D. The milk was introduced by the Government as part of the Welfare Food Service and was intended for families with babies or children who could not afford or otherwise obtain fresh milk during the period of milk rationing, but it continued to be used well into the 1970s. Commercial formulas did not begin to seriously compete with breastfeeding or home-made formula until the 1950s. Home-made formulas commonly used before this were based on diluted evaporated or sterilised milk and had the advantages of being readily available and inexpensive, although evaporated and sterilised milk are now recognised as being unsuitable for babies.

The reformulation of Similac in 1951, and the introduction (by Mead Johnson) of Enfamil in 1959, were accompanied by marketing campaigns and the provision of inexpensive formula to hospitals. By the early 1960s the use of commercial formulas was widespread.

By the mid-1960s most infant formulas were fortified with iron, differences in the whey:casein ratio of cows' milk and human milk were recognised, and most infant formula became whey-based. The renal solute load of infant formula was also considered in the 1960s and recommendations were made to reduce the potential renal solute load in an effort to reduce the prevalence of hypernatraemic dehydration. This condition had been associated with unmodified cows' milk formula with a high sodium content. The high phosphate content of formulas based on unmodified cows' milk caused problems of tetany and convulsions in some infants. In the UK, recommendations on infant feeding in the 1970s lowered the acceptable levels of sodium, phosphate and protein in infant formulas, and National Dried Milk, which was based on unmodified cows' milk, was withdrawn in 1976.

Since the early 1970s, industrial countries have witnessed an increase in breastfeeding among children from newborn to 6 months of age. This upward trend in breastfeeding has been accompanied by a deferment in the average age of introduction of other foods and cows' milk as the main drink, resulting in increased use of both breastfeeding and infant formula between the ages of 3-12 months. Later weaning and concerns over iron deficiency have also led to the development of other infant milk drinks for use into the second year of life. The last 25 years have also seen further changes in infant milk composition, with the addition of individual ingredients, which aim to make infant milk closer in composition to breastmilk. For example, taurine was first added in 1984, nucleotides in the late 1990s, and long chain polyunsaturated fatty acids and prebiotics in the early 2000s. However, despite advances in the composition of infant milks, breastmilk contains over 300 components, which contribute to the health and well being of infants, compared with only about 75 at most in typical infant formula. The cells that pass from the mother and the wide range of other immunomodulatory factors in breastmilk cannot be recreated, and it is also likely that there are other important components in breastmilk yet to be identified.

Further information on the history of infant milks can be found in *The politics of breastfeeding* by Gabrielle Palmer (Palmer, 2009).

Development of the regulation of infant milk composition

In 1974, the report *Present day practice in infant feeding* (Department of Health and Social Security, 1974) highlighted the decline in breastfeeding in the UK and the unsatisfactory composition of artificial milks then available. Following the publication in 1977 of a report on *The composition of mature human milk* (Department of Health and Social Security, 1977), which attempted to provide a basis for a compositional profile of human milk, the need for a standard for the composition of artificial milks was realised. Clear guidance on the composition of artificial feeds for the young infant were published by the Department of Health and Social Security in 1980 (Department of Health and Social Security, 1980), and in that report it was acknowledged that adequacy of artificial feeds should be assessed not only on nutrient content but also on the bioavailability of nutrients, nutrient balance and clinical and metabolic outcomes.

From 1989, legislation relating to infant milk composition has been made by the Council of Europe, and the first European Commission Directive on Infant Formulae and Follow-on Formulae was adopted in 1991. This specified the compositional and labelling requirements for milks for infants in good health during the first 4-6 months of life that all infant formulas sold in the European Union countries must comply with. Legislation was put into place in the UK in 2007, and there were some amendments to this, but from 2016 legislation on Foods for Special Groups comes into force, with delegated acts outlining the composition, labelling and marketing of infant formula, follow on formula and foods for special medical purpose. Directive EU 609/2013 came into force in the UK on July 20th 2016 as a Statutory Instrument attached to The Food Act, and highlights enforcement procedures and some basic principles, but much of the detail is in the delegated acts which do not come into force until 2020. For details of this new regulation see http://www.babymilkaction.org/archives/10328 More details of the new regulations will be included in future editions of this report.

In addition, the Codex Alimentarius of the United Nations Food and Agriculture Organization and the World Health Organization also provides guidance on the composition of infant formula and these standards are used widely internationally (Codex Alimentarius Committee, 2006). Because all Codex standards must be ‘consensus’ standards, with near unanimous consent, Codex faces difficult negotiations between countries and between competing interests before recommendations can be agreed. Codex has a committee which reviews Nutrition and Foods for Special Dietary Uses, and the process of agreeing standards can often be long, as compromise is preferred over voting, making meetings vulnerable to lobbying by commercial interests. Codex also produces international standards for food safety, including standards on microbiological specifications for infant formula (see www.codexalimentarius.org)

The International Code of Marketing of Breast-milk Substitutes

By the early 1970s, the majority of babies in many developed countries were not being breastfed and most infant milks used were commercially produced. The increased use of infant milks was attributed not only to improvements in their nutritional composition but also to vigorous promotion by the manufacturing industry. The WHO *International Code of Marketing of Breast-milk Substitutes* was adopted by a Resolution of the World Health Assembly in 1981 (WHO, 1981). The Code bans all promotion of breastmilk substitutes and sets out requirements for labelling and information on infant feeding. Also, any activity which undermines breastfeeding violates the aim and spirit of the Code. The Code and its subsequent World Health Assembly Resolutions are intended as a minimum requirement in all countries. The Code covers all products marketed in a way which suggests they should replace breastfeeding, including all types of formula milks, baby foods, teas and juices, and equipment such as bottles, teats/nipples and other related equipment. Organisations such as Baby Milk Action in the UK, which is part of the International Baby Food Action Network (IBFAN), review compliance with the WHO Code and highlight examples of non-compliance.

The UK was one of the strongest supporters of the International Code when it was adopted in 1981. Also, as a signatory to the 1990 Innocenti Declaration on the Protection, Support and Promotion of Breastfeeding, the UK Government committed itself to *“taking action to give effect to the principles and aim of all the articles of the International Code ... in their* *entirety ..."* and to enacting *"imaginative legislation protecting the breastfeeding rights of working women ... by the year 1995."*

At the 1994 World Health Assembly, UK support for the Code was reiterated once again and the Government 1995 White paper *The health of the nation*, called for an increase in breastfeeding rates (Department of Health, 1992). The Government officially supported the UK Baby Friendly Initiative in which the International Code is the pivotal recommendation. Despite this, in March 1995, the Infant Formula and Follow-on Formula Regulations were adopted as law in the UK, with this law falling short of the International Code in important respects. Most notably, it allows advertising of products through the healthcare system, in direct contravention of the WHO International Code.

Amongst the provisions of the 1995 legislation is a ban on the advertising and promotion of infant formula, but these measures are regarded as ineffectual by many breastfeeding advocacy groups and health professionals. Their view is that manufacturers have taken advantage of limitations in the scope of the regulations that have enabled them to advertise and promote follow-on formula in such a way that it is unclear whether the product being promoted is infant formula or follow-on formula. Current legislation (the Infant Formula and Follow-on Formula Regulations 2007) attempts to impose a few further limits on the advertising and promotion of infant milks, but has not prevented generic promotion of brand name, or the promotion of follow-up formula. We will report on new regulations coming in from July 2016 and the impact these may have on advertising and promotion in the next iteration of this report.

Infant feeding patterns in the UK

The most recently available national Infant Feeding Survey of parents across the UK (Health and Social Care Information Service, 2012) shows that, in 2010:

- About a fifth of mothers (19%) did not initiate breastfeeding at birth.
- 31% of parents introduced infant formula on the first day of life.
- 43% of mothers who used both breast and formula feeding used formula at all or almost all feeds from birth.
- By 1 week of age more than half of infants (52%) had had some infant formula, and by 6 weeks of age 73% of infants had been given infant formula.
- By 4-10 weeks, 33% of infants were entirely fed on infant formula and 26% were given formula and breastmilk.
- By 4-6 months of age, 60% of infants were entirely fed on infant formula.
- By 9 months, 95% of infants had had some infant milk.

The majority of infants in the UK are therefore likely to be given infant formula during the first six months of life, despite Department of Health recommendations that breastfeeding should be the source of nutrition during this period. The Infant Feeding Survey does not ask parents what type of milk they offer their infant during the first few weeks of life (stage 1 of the survey covers the period 4-10 weeks, but the majority of infants in the survey are 4-6 weeks of age) as there is an assumption that this will be an appropriate first milk. When mothers were asked when they first used follow-on formula, 16% of parents reported that they did so before 6 months of age. This is despite recommendations on follow-on formula packaging that follow-on formula is not appropriate for infants under 6 months of age, and advice from the majority of health professionals that a change to follow-on formula is not necessary at any stage. Only 68% of mothers said they knew the difference between follow-on formula and formula. Non-working women were more likely to use follow-on formula before 6 months of age.

Mothers who did use follow-on formula by 4-6 months said they did so on the advice of a health professional (17%) or because they thought it was better for the baby (18%) and 8% because they had seen information advertised. By the time their babies were 8-10 months of age, the majority of mothers were using follow-on formula.

Data from the *Diet and nutrition survey of infants and young children* (Department of Health and Food Standards Agency, 2013) suggests that 38% of children aged 12-18 months drank some kind of formula and 62% drank none. Eight per cent of those who gave formula only used ready-to-feed formula for children of this age. This survey reported that 18% of children aged 12-18 months were given growing-up milks, and the mean intake was 342ml/day. These milks were also used by 3% of families with children aged 10-11 months with a mean intake 397ml/day in this survey. Amongst 12-18 month olds, 8% were still receiving breastmilk with an estimated volume of 290ml/day, 1% were still given first infant formula, 1% hungry baby formula, 16% follow-on formula and 3% other milk products.

The infant milk market in the UK

The infant milk market in the UK is dominated by four major brands:

- Aptamil (Nutricia, owned by Danone)
- Cow & Gate (Nutricia, owned by Danone)
- SMA Nutrition (owned by Nestlé)
- Hipp Organic (owned by Hipp).

The Mintel Baby food and drink report (Mintel, April 2016) reported that sales of baby milk in the UK increased by £37million between 2014/2015 and 2015/2016. Danone increased sales by £39million whilst Nestlé (SMA) sales decreased by £5million. Danone have 82% of the market by sales and 79% by volume. Aptamil is the brand leader and earnt Danone £229million in 2015/16, accounting for 51% of all sales. Cow & Gate (also owned by Danone) had 31% of market share and SMA (Nestlé) 14%. The market share for other milks remains around 4%, with HiPP having 2% of the market.

Both Aptamil and Cow & Gate brands received substantial advertising support in 2015, which they use to support the brand across a range of products. The total above the line, online display and direct mail advertising expenditure on baby food and drink was £17.5million in the UK in 2015. Follow on milk has had the biggest boost in terms of marketing spend in recent years, increasing 39.5% between 2012-2015, with £16.4million spent on follow-on formula in 2015. Danone spent £5.7million advertising Aptamil follow-on milk and £3.7million on Cow & Gate follow on milk in 2015; SMA spent £3.4million advertising their follow-on milk. Companies spent about £21 for every baby born in the UK on marketing follow-on formula in 2015.

Advertising for Aptamil included TV support for its follow-on formula, emphasising how their products are ‘inspired by 30 years research on breastmilk’ and promoting its ‘Pronutra’ ingredients. Cow & Gate follow-on formula advertising using a more light hearted approach featuring the children’s song ‘Happy and You Know It’ but also references how it has been feeding babies for over 100 years and stating how ‘when happy on the inside, they’re happy on the outside.’

Factors influencing the purchase of infant milks was also considered, and the main factor determining parental choice of milk amongst their panel was ‘brand’. This is important as it is the support given to brands through advertising, through the promotion of milks to health professionals and using health professionals as part of the online marketing to health professionals and at conferences that promotes the brand integrity. The report highlights the importance of ‘brand loyalty’ in the market and parent’s being loath to swap brands that they think suit their child. Companies spend considerable funds on promoting brands to health professionals, and in supporting health professionals through invitations to conferences, study days, paying for travel and accommodation at conferences, lunches and trips abroad to help maintain professional loyalty to their brand as well. Other key factors that impact on purchasing choices includes price, age range featured on the pack, easy availability through supermarket and the perception that the product covers a babies nutritional needs. Less important but still highlighted as factors are convenient packaging, products being organic, containing specific ingredients such as prebiotics, offering health benefits or designed for babies with special requirements.

Mintel suggest that the rise in the use of infant milks despite a drop in the birth rate in recent years is related to parents looking for products that provide a shortcut to conveniently providing key nutrients for their children, and therefore the use of health claims for products is likely to significantly influence this. Infant milk usage is highest in the most affluent households, with 60% of households with an income >£50k/year buying infant milks compared to 47-51% of less affluent households. This number is however still significant and suggests an increase in the use of milks into the second and third year of life. In this report it is suggested that 65% of children in the second year of life, 44% of 2 year olds and 43% of 3 years olds are still given infant milks. Mintel put this increase of use of milks into toddlerhood down to strong advertising support for products.

This report reinforces the importance of advertising to companies to maintain their brand and market share and to promote new products and extend products as children age. The fact that brand is the most important factor for purchasers is seen as very positive in the commercial world, and highlights again the need to avoid the use of any materials produced by infant formula manufacturers by health care workers.

Two of the discount supermarket chains Aldi and Lidl started marketing infant milks in 2016, however in 2018, Lidl withdrew their infant milk products. In April 2018 Sainsbury’s started marketing their ‘Little Ones’ own brand of infant and follow-on formula milks. It will be interesting to see how these products impact on the market share of the main formula brands. Other infant milks such as Holle, NANNYcare, Kabrita and Kendamil formula have a negligible market share at the moment and are generally sold through health food shops, dedicated retailers or smaller retailers. Other milks from overseas may be available in UK retail outlets that cater for specific immigrant communities, and some shops may offer milks that are directly imported and which may not conform to EC regulations on infant formula and follow-on formula. Infant milks from around the world are also sold on websites such as ebay. Parents should be strongly discouraged from buying any milk that has not been recommended to them by a health professional.

The international infant milk market

The global infant milk market is currently worth around $47billion and is projected to increase to $50billion by 2020 (Euromonitor International, 2015). Infant milks are the fastest growing packaged food product in the world, with most of the growth in Asia. As in the UK, the international infant milk market is dominated by a small number of companies who market their products under a wide range of brand names. The USA market is dominated by Abbott and Mead Johnson, accounting for 80% of products sold, and more than half of infant milks sold in the USA are sold through supported government welfare programmes (Kent, 2006). The Western European market is approximately the same size as the USA market in volume terms, and the leading companies are Nestlé and Danone.

It is not easy to find information about where formula milks are made, as ingredients can be sourced from one country and processed elsewhere. It is thought that Ireland produces 15%-20% of infant formula milk globally and in 2010 the Irish Government announced that Danone was investing €50 million to expand the production of infant milk in Ireland by 300%, and that this would be exported to over 60 countries worldwide. Milks sold in the UK are also likely to be made in a number of other European countries, primarily France and Germany. Increasingly, companies are setting up infant formula production in parts of Eastern Europe and Asia and New Zealand manufactures milk for the Chinese and Asian sub-continent market.

More information on the global infant formula market can be found through the International Baby Food Action Network (www.ibfan.org).

European legislation on infant formula and follow-on formula to July 2016

Until July 2016, infant formula and follow-on formula available in the UK had to comply with all relevant food legislation and also with the requirements of European Commission Directive 2006/141/EC on Infant Formulae and Follow-on Formulae. The Directive required member states of the European Union to adopt and publish, by 31 December 2007 at the latest, laws and administrative provisions to implement the Directive at a national level. In England this Directive and Council Directive 92/52/EEC (regarding infant formula and follow-on formula intended for export to third countries) have been given effect by the Infant Formula and Follow-on Formula (England) Regulations 2007 and a subsequent amendment, which replace the Infant Formula and Follow-on Formula Regulations 1995. Similar regulations were in effect in Scotland, Wales and Northern Ireland. From July 2016 a new regulation encompassing all Foods for Special Groups EC 609/2013 came into force across the EU. This was partialy informed by the scientific opinion on the essential composition of infant and follow-on formulae (EFSA, 2014). The specific detail on composition, labelling and marketing is held in the delegated acts which accompany this directive, but these do not come into force until 2020. We report here on the rationale for the 2007 regulations and will update on the new regulations in the next update of this report as it remains unclear how the UK may determine and enforce regulations as it negotiates an exit from the EU.

The compositional standards established by Commission Directive 2006/141/EC were based on scientific reviews carried out by the Scientific Committee on Food (SCF) which from 2003 became part of the European Food Safety Authority (EFSA). The goal of setting minimum and maximum values of nutrients is to provide safe and nutritionally adequate infant formula products that meet the normal nutritional requirements of healthy babies. EFSA is an EC committee of independent scientists whose mandate is to answer scientific and technical questions concerning consumer health and food safety associated with the consumption of food products. The compositional revisions included in Directive 2006/141/EC are based on the SCF's 2003 report on the revision of essential requirements of infant and follow-on formula which took into account scientific and technical developments in infant feeding (Scientific Committee on Food, 2003). Their review adopted certain principles, including the principle that the composition of human milk from healthy, well nourished mothers is highly variable, as the content of many nutrients changes during lactation, or differs between women and throughout the day. Additionally, there are considerable differences in the bioavailability and metabolic effects of many specific nutrients in human milk and in infant formula. Conclusions on the suitability and safety of nutrient contents in infant formula cannot therefore be simply based on its similarity to human milk. The SCF suggests that a more useful approach to evaluate the adequacy of infant formula composition is the comparison of physiological (eg. growth patterns), biochemical (eg. plasma markers), and functional (eg. immune response) outcomes in infants fed formula with those in populations of healthy infants who have been exclusively breastfed for 4-6 months.

The European Commission Directive on Infant Formulae and Follow-on Formulae states the following (Food Standards Agency, 2007):

Minimum and maximum values for nutrients should:

- Be based on adequate scientific data that establishes needs for practically all infants in the target population and the absence of adverse effects or, in the absence of such data should:
  - be based on an established history of apparently safe use
  - take into account other factors such as bioavailability and losses during shelf-life
  - refer to total nutrient contents of IF (infant formula) and FOF (follow-on formula) as prepared ready for consumption according to the manufacturer's instructions.

The Directive itself aims to ensure that:

- The essential composition of infant formula and follow-on formula satisfy the nutritional requirements of infants in good health as established by generally accepted scientific data
- The labelling of infant formula and follow-on formula allows the proper use of such products and promotes and protects breastfeeding
- The rules on composition, labelling and advertising are in line with the principles and aims of the International Code of Marketing of Breast-milk Substitutes ('the Code')
- Information provided to carers about infant feeding does not counter the promotion of breastfeeding.

Other main provisions of the Directive are that:

- No product other than infant formula may be marketed or otherwise represented as suitable for satisfying by itself the nutritional requirements of normal, healthy infants during the first months of life until the introduction of complementary feeding
- Infant formula and follow-on formula shall not contain any substance in such quantity as to endanger the health of infants and young children
- There are detailed requirements for the essential composition of infant formula and follow-on formula
- There are limits on the level of any individual pesticide residue that may be present in infant formula and follow-on formula and specific upper limits for very toxic pesticides
- There are mandatory and non-mandatory particulars for the labelling of infant formula and follow-on formula
- Requirements are made for the labelling of infant formula and follow-on formula to apply to presentation and advertising
- There are restrictions on nutrition and health claims that can be made in relation to infant formula
- The labelling, presentation and advertising of infant formula and follow-on formula should avoid risk of confusion by the consumer between these two products
- There should be restrictions on the advertising of infant formula

Information should be provided on infant and young child feeding for use by families and those involved in the field of infant and young child nutrition.

Updated guidance on the risk assessment of substances present in food intended for infants below 16 weeks of age

In view of the potential greater sensitivity during the first weeks of life, The European Food Standards Agency (EFSA) has recently updated its guidance on the risk assessment of substances present in food intended for infants below 16 weeks of age. The new guidance, published in May 2017, represents a more robust approach that allows a case-by-case risk assessment based on evidence of:

– organ development in human infants including the gut, metabolism, the brain and brain barriers, the immune system, the endocrine and reproductive systems
– the toxicity of the substance from :

- tests in juvenile and adult animals
- tests in infant animals for effects not seen in juvenile/adult animals, or for effects potentially occurring at lower doses in infant animals.

In effect, in addition to testing programmes for the safety evaluation of foods used for the general population, an extended one generation reproductive toxicity study will be required for substances added intentionally to infant formula. EFSA also stressed the importance of human data.

Guidance notes have been produced by the Department of Health, which explain the existing regulations in more detail. These were updated in 2013 and remain in force until the new delegated acts come into play in 2020. See

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/204314/Infant_formula_guidance_2013_-_final_6_March.pdf

Marketing of infant and follow-on formula

It is currently unclear how changes to EU regulations in 2016 will impact on the marketing of infant and follow on formula. This section discusses the situation until July 2016 and we will report on changes when there is more clarity.

The Food Standards Agency (FSA) reviewed whether the controls brought in in 2007 on the way in which follow-on formula is presented and advertised have been effective in making clear to parents, parents-to-be and carers that advertisements for follow-on formula are meant only for babies over 6 months and are not perceived or confused as infant formula advertising, which is prohibited (Food Standards Agency, 2010). The review found that the controls are having the desired effect in the main, but some adverts are not always clearly understood as being for follow-on formula rather than infant formula. There was not sufficient evidence of confusion between infant formula and follow-on formula to justify a ban on the advertising of follow-on formula, but it was recommended that manufacturers should make changes to advertising, to make it clear that follow-on formula is intended for babies over 6 months. This includes clearly representing the age of babies in the adverts. The panel specifically recommended that:

"In order to increase the chances of achieving clarity, it is recommended that manufacturers make all the following changes to advertising:

- *Provide text relating to age suitability in a box, in bold or underlined*
- *Specify, unambiguously, the age of the child for whom the product is intended in the voiceover of television advertisements*
- *Ensure that the infants shown in follow-on formula advertising are unambiguously aged six months and over: for example by demonstrating features such as good head and arm control; sitting upright; having hair and teeth; showing emotional facial expression; being in an outdoor environment; self-feeding*
- *Increase the size and enhance the clarity of product images (ie. packshots)."*

A qualitative study undertaken in Australia (Berry et al, 2010), which investigated how women expecting a first baby perceived print advertisements for toddler milks, found that women clearly understood toddler milk advertisements to be promoting a range of products that included infant formula and follow-on formula. These adverts functioned as indirect advertising for infant formula and women accepted their claims quite uncritically. The FSA panel also acknowledged the brand extension that advertising of follow-on formula allowed and agreed that, whilst the current controls outlined by the Infant Formula and Follow-on Formula Regulations are fulfilling their objective to some degree, there remains confusion among some parents, carers and parents-to-be (Food Standards Agency, 2010).

Appendix 2
Monitoring the composition and safety of infant milks

PLEASE NOTE: This section requires updating but provides an overview of some of the ways that composition and safety have been monitored.

There are a number of pieces of EC legislation that aim to ensure that foodstuffs are safe for the consumer and free from microbiological contamination or hazardous substances. EC Regulation 2073/2005 on the microbiological criteria for foodstuffs supports EC food hygiene rules that have applied to all food businesses since January 2006. These regulations also apply to infant formula manufacture. Annex I of the regulations sets down detailed sampling plans for each of the microbiological criteria included. Annex II sets down specific requirements for shelf-life studies. The UK Food Standards Agency (FSA) stresses that the regulation is flexible in its approach, in that sampling and testing plans should be determined on the basis of risk (eg. size and type of business). Minimum requirements for microbiological testing are not specified and food business operators are not required to wait for test results before placing food on the market. Where microbiological testing does occur, food businesses may use their food safety management processes to establish appropriate sampling regimes.

The EC Regulation also stipulates that the safety of a product or batch of foodstuffs should be assessed throughout its shelf-life and process hygiene criteria should also show that the production processes are working properly throughout every stage of manufacturing and handling. Failure to comply with food safety criteria obliges the manufacturer to withdraw the product from the market. Failure to comply with process hygiene criteria should lead to a full review of current food safety management procedures. If *Enterobacteriaceae* are found in infant formula, further testing is required.

In the UK, enforcement of the regulations is the responsibility of either local authorities or the Port Health Authorities. Food business operators are required to provide evidence that the necessary food safety management procedures are in place to ensure that all criteria are met. Assessments by enforcement officers do not necessarily involve testing, but may do so where particular problems have been identified, or for inclusion in surveys (Food Standards Agency, 2008).

Copies of EC Regulation 2073/2005 can be found at eur-lex.europa.eu

The FSA's *General guidance for food business operators: EC regulation no. 2073/2005 on microbiological criteria for foodstuffs* can be found at http://www.food.gov.uk/multimedia/pdfs/ecregguidmicrobiolcriteria.pdf

European safety reviews of infant milk manufacturers

The European Commission Directorate General for Health and Consumers provides reports of missions carried out in member states relating to the manufacture of different food commodities (see http://ec.europa.eu/dgs/health_consumer/index_en.htm). A number of reports have been made relating to the official controls over the production and placing on the market of infant formula and follow-on formula in member states that produce milks for the UK market.

In 2007, the Directorate carried out a review of milk production in Ireland (EU Commission Health and Consumers Directorate General, 2007a), where there were five manufacturers of infant formula producing 15% of the world's total production, making Ireland the largest producer at that time and a significant exporter to the developing world. The review of how these products were monitored made the following observations:

- Only *two* samples of infant formula had been analysed for mineral content in 2006.
- Only six samples of milk had been monitored for pesticide residues in the last national monitoring review in 2004.
- There was a low level of compliance reported as regards labelling requirements, with only 4 out of 19 infant formulas and no follow-on formula complying with relevant labelling regulations.
- Two of the dairy science laboratories used for testing samples were not accredited.
- Methods for microbiological analyses of both infant formula and follow-on formula were not recognised by the official agency and did not use validated methods, and no official testing was carried out to verify manufacturers' results.
- Despite local authority audits of manufacturers being carried out since 2001, no local authority had visited any of the manufacturers to check controls on safety for infant formula and follow-on formula.
- In a few cases, general hygiene requirements were not met.

Similar studies were carried out in France (EU Commission Health and Consumers Directorate General, 2007b) and Poland in 2007 (EU Commission Health and Consumers Directorate General, 2007c), and in the UK (EU Commission Health and Consumers Directorate General, 2008) and Germany in 2008/2009 ((EU Commission Health and Consumers Directorate General, 2008a), and there appears to be an overall lack of use of approved safety procedures and regulations in some areas. The conclusion from the 2008 UK visit was:

*"The official controls over manufacturing and placing on the market of infant formulae, follow-on formulae and baby foods in the United Kingdom largely ensures that the relevant legislative requirements are complied with. **Some deficiencies** were noted with regard to the organisation, coordination and audits of official controls and **some shortcomings** were noted with regard to sampling and analysis of pesticides, contaminants and for microbiological contamination."* (Our bold) (EU Commission Health and Consumer Directorate General, 2008)

An overview report on inspections in Europe between 2007 and 2009 (DGSanco, 2011) gave the following summary:

“The Hazard Analysis Critical Control Points (HACCP) programmes were generally not designed to take into account the specific risks associated with the production of the specified foods and shortcomings were noted with regard to the food business operators (FBOs) obligations in relation to composition and labelling, as well as residues of pesticides and contaminants. In general official controls of the specified foods were not sufficient to ensure that the relevant specific legislative requirements regarding pesticides and labelling were complied with. A few cases were noted where official control was not sufficient to ensure compliance with European Union (EU) provisions concerning IF and FOF intended for export.”

Many people would be surprised to hear that there are any shortcomings at all in safety monitoring of infant milk products, particularly in light of the high-profile adulteration of infant milks in China in 2008 (see below). Whilst it is more likely that infants in poor countries will be at risk from contaminated milk products, it appears that there is insufficient independent and objective monitoring of manufacturing procedures even in the rich countries of Europe. This is particularly surprising as there is an assumption among parents that infant milk is a highly regulated product.

Lapses in production and labelling of infant milks

Infant milk production can be affected by human error in the same way as the manufacture of any other food product. Human error can lead to a number of safety lapses in food production, and there have been a number of cases of infant milk contamination worldwide, some of which are described here to illustrate the problems that can arise.

Product contamination with foreign objects, including broken glass and fragments of metal, have required product recalls. In 2006, both Nestlé and Mead Johnson recalled infant formula because of contamination with metal fragments. If ingested, these particles present a serious risk to a baby’s respiratory system and throat. In September 2010, Ross Abbott Nutrition recalled certain Similac brand infant formulas in the USA, Puerto Rico, Guam and some countries in the Caribbean following an internal quality review that detected the possibility of the presence of a small common beetle in the product.

Contamination with bacteria can also occur. In 2001, 400,000 tins of SMA Gold and White were recalled after a strain of the bacteria that causes botulism was traced to one of them after a 5 month old child fell ill in the UK.

Specific ingredients can also be added to excess, or left out. Carnation Follow-up Formula was recalled in 2001 as a result of excess magnesium (which can give rise to low blood pressure and an irregular heartbeat). In 2003 a soya protein based formula produced specifically for the Israeli kosher market and lacking vitamin B1 entered the marketplace, with infants suffering central nervous system damage. Several infants suffered irreparable damage and two died. In addition, 20 children exposed to the product in infancy showed abnormalities in language and mental development at around 3 years of age (Fattal-Valevski et al, 2009). Ross Products in the USA in 2006 recalled two products that were deficient in vitamin C (deficiency would result if consumed for 2-4 weeks), and in 2007 recalled products deficient in iron (anaemia would result if consumed for a month).

The 2008 Chinese infant milk scandal

Adulterated infant milk in the People's Republic of China in 2008 led to a reported 300,000 babies suffering kidney stones and kidney damage and six deaths, although the true numbers of infants affected are likely to be higher as the products had been available for many months before the scandal was reported. The formula milk was adulterated with melamine, which was added to milk to make it appear to have a higher protein content. In a separate incident four years earlier in China, watered-down milk had resulted in 13 infant deaths from malnutrition. Chinese authorities were still reporting some seizures of melamine-contaminated dairy product in some provinces in 2010 and traces have been found in products exported from China across the globe.

In 2010 melamine was reported in infant formula exported to Africa, sampled in Dar-es-Salaam, the centre of international trade in East Africa. Despite bans on exports from China to East Africa after the melamine scandal, 6% of all samples tested and 11% of international brand named products revealed melamine concentrations of up to 5.5mg/kg of milk powder – twice the tolerable daily intakes suggested (Schoder, 2010).

The need for independent, rigorous inspection and regulation of infant milks remains essential in all countries to ensure that vulnerable infants are protected from both deliberate and accidental contamination, and that these milks do not find their way into other markets where testing may not be routinely carried out.

Products can be unfit for purpose because of manufacturing problems. For example, in 2008, SMA Gold RTF liquid was recalled in the UK following curdling of the product.

Products wrongly labelled or with misprinted labels with ingredients not listed could lead to infant allergic reactions. In 2001, Mead Johnson's Nutramigen products labelled with incorrect preparation information were widely distributed in the Dominican Republic, Guam, Puerto Rico and the USA.

Whilst errors are fortunately rare, and companies act swiftly to recall products that are found to be contaminated or cause risk, the need for constant testing of products by independent bodies would seem essential as the consequences of irregularities can be life-threatening to infants.

References

Abrahamse E, Minejkas M, van Aken GA, et al (2012). Development of the digestive system – experimental challenges and approaches of infant lipid digestion. *Food Digestion*, 3, 63-77.

Advertising Standards Authority (2010). See: www.asa.org.uk

Advertising Standards Authority (2014). ASA adjudication on Nutricia Ltd. Accessed from: http://www.asa.org.uk/Rulings/Adjudications/2014/1/Nutricia-Ltd/SHP_ADJ_234819.aspx

Aggett P, Agostoni C, Axelsson I, et al (2002a). Iron metabolism and requirements in early childhood: do we know enough? A commentary by the ESPGHAN Committee on Nutrition. *Journal of Pediatric Gastroenterology and Nutrition*, 34, 337-345.

Aggett P, Agostoni C, Goulet O, et al (2002b). Antireflux or antiregurgitation milk products for infants and young children: a commentary by the ESPGHAN Committee on Nutrition. *Journal of Pediatric Gastroenterology and Nutrition*, 34, 496-498.

Agostoni C, Goulet O, Kolacek S, et al (2007). Fermented Infant Formulae Without Live Bacteria: Medical position paper by the ESPGHAN Committee on Nutrition. *Journal of Pediatric Gastroenterology and Nutrition*, 44, 392-397.

Agostoni C, Marangoni F, Bernardo L, et al (1999). Long-chain polyunsaturated fatty acids in human milk. *Acta Paediatrica*, 430, 68-71.

Agostoni C, Carratù B, Boniglia C, et al (2000). Free amino acid content in standard infant formulas: comparison with human milk. *Journal of the American College of Nutrition,* 19 (4), 434-438.

Agostoni C, Axelsson I, Goulet O, et al (2006). Soya protein infant formula and follow-on formula: a commentary by the ESPGHAN Committee on Nutrition. *Journal of Pediatric Gastroenterology and Nutrition*, 42, 352-361.

Aguilar-Toala JE, Garcia-Varela R, Garcia HS, Mata-Haro V et al (2018) Postbiotics:An evolcing terms within the functional foods field. *Trends in Food Sci and Chem,* **75**, 105-114.

Alexander D, Yan J, Bylsma L et al (2016). Growth of infants consuming whey-predominant term infant formulas with a protein content of 1.8 g/100 kcal: a multicenter pooled analysis of individual participant data. *American Journal of Clinical Nutrition,* doi:10.3945/ajcn.116.130633. Available at: http://ajcn.nutrition.org/content/early/2016/09/06/ajcn.116.130633.full.pdf+html. Accessed 08 May 2018.

American Academy of Allergy, Asthma and Immunology (2011). Infant formula of partially hydrolyzed whey is not the secret weapon for preventing childhood allergy and asthma. Available from: https://www.aaaai.org/global/latest-research-summaries/Current-JACI-Research/infant-formula-partially-hydrolyzed-whey.aspx

Arslanoglu S, Moro GE, Boehm G (2007). Early supplementation of prebiotic oligosaccharides protects formula-fed infants against infections during the first 6 months of life. *Journal of Nutrition*; 137: 2420-24.

Arslanoglu S, Moro GE, Schmitt J, et al (2008). Early dietary intervention with a mixture of prebiotic oligosaccharides reduces the incidence of allergic manifestations and infections during the first two years of life. *The Journal of Nutrition*, 138, 1091-1095.

Arslanoglu S, Moro GE, Boehm G, Wienz F et al (2012) Early neutral prebiotic oligosaccharide supplementation reduces the incidence of some early manifestations of allergic manifestations in the first 5 years of life. *J Biol Reg Homeost Agents*, **26** S:49-59.

Ballard O, Morrow AL (2013). Human milk composition: nutrients and bioactive factors. *Pediatric Clinics of North America*, 60, 49-74.

Baird J, Fisher D, Lucas P, et al (2005). Being big or growing fast: systematic review of size and growth in infancy and later obesity. *British Medical Journal*, 331, 929-931.

Bargellini A, Venturelli F, Casali E, Ferrari A, Marchesi I, Borella P (2018) Trace elemetns in starter infant formula: dietary intake and safety assessment. *Environ Sci Pollut Res*, **25**, 2035-20144

Benton D (2004). Role of parents in the determination of food preferences of children and the development of obesity. *International Journal of Obesity*, 28, 858-869.

Berry NJ, Jones S, Iverson D (2010). It's all formula to me: women's understanding of toddler milk ads. *Breastfeeding Review*, 18, 1, 21-30.

Berseth CL, Mimesser SH, Ziegler EE, et al (2009). Tolerance of a standard intact protein formula versus a partially hydrolysed formula in healthy term infants. *Nutrition Journal*, 8, 27.

Bettler J, Estorninos EM, Northington R, et al (2011). Effect of a partially hydrolysed whey protein formula with high SN-2 palmitate and reduced lactose on stool composition and consistency. *Acta Paediatrica,* 100, s463, 41.

Bettler J, Kullen M (2007). Infant formula enriched with alpha-lactalbumin has a prebiotic effect in healthy term infants. *Journal of Pediatric Gastroenterology and Nutrition*, 44, (suppl. 1), 1-11.

Billeaud C, Guillet J, Sandler B (1990). Gastric emptying in infants with or without gastro-oesophageal reflux according to the type of milk. *European Journal of Clinical Nutrition*, 44, 577-583.

Bolling K, Grant C, Hamlyn B, Thornton A (2007). *Infant Feeding Survey 2005.* Accessed from: http://www.ic.nhs.uk/webfiles/publications/ifs06/2005%20Infant%20Feeding%20Survey%20(final%20version).pdf

Bongers M, de Lorijn F, Reitsma J, et al (2007). The clinical effect of a new infant formula in term infants with constipation: a double-blind, randomized cross-over trial. *Nutrition Journal*, 6, 8.

Bowen W, Pearson S, Rosalen P, et al (1997). Assessing the cariogenic potential of some infant formulas, milk and sugar solution. *Journal of the American Dental Association*, 128, 865-871.

Boyle RJ, Ierodiakonou D, Khan T et al (2016) Hydrolysed formula and risk of allergic or autoimmune disease: systematic review and meta-analysis. *British Medical Journal*; **352**; i974

Braegger C, Chmielewska A, Decsi T, et al (2011). Supplementation of infant formula with probiotics and/or prebiotics: a systematic review and comment by the ESPGHAN Committee on Nutrition. *Journal of Pediatric Gastroenterology and Nutrition,* 52 (2), 238-250.

Brand-Miller J, Atkinson F, Rowan A (2013). Effect of added carbohydrates on glycemic and insulin responses to children's milk products. *Nutrients*, 5, 2-31.

British Dietetic Association (2010). *Practical Dietary Prevention Strategies for Infants at Risk of Developing Allergic Diseases.* Consensus Statement from the Food Allergy and Intolerance Specialist Group. London: British Dietetic Association.

Brunser O, Araya M, Espinoza J et al (1989). Effect of an acidified milk on diarrhoea and the carrier state in infants of low socio-economic stratum. *Acta Paediatrica Scandanavia,* 78, 259–264

Bruzzese E, Volpicelli M, Squeglia V et al (2009). A formula containing galacto- and fructo-oligosaccharides prevents intestinal and extra-intestinal infections: an observational study. *Clinical Nutrition;* 28, 2: 156-61.

Burrell SM, Exley C (2010). There is (still) too much aluminium in infant formulas. *BMC Pediatrics*, 10, 63.

Business Insights (2009). *The Infant Nutrition Market in the EU*. Business Insights Ltd.

Bussell R, Nichol R and Toumba K (2016). Fluoride levels in UK infant milks. *European Archives of Paediatric Dentistry,* 17, 177-185,

Butler G, Stergiardis S, Seal C, et al (2011). Fat composition of organic and conventional retail milk in northeast England. *Journal of Dairy Science*, 94, 24-36.

Butte NF, Wong WW, Hopkinson JM (2001). Energy requirements of lactating women derived from doubly labelled water and milk energy output. *Journal of Nutrition*, 131, 53-58.

Capeding R, Gepanyayao C, Calimon N, et al (2010). Lutein fortified infant formula fed to healthy term infants: evaluation of growth effects and safety. *Nutrition Journal*, 9, 22.

Carnielli V, Luijendijk I, Van Goudoever J, et al (1996). Structural position and amount of palmitic acid in infant formulas: effects on fat, fatty acid, and mineral balance. *Journal of Pediatric Gastroentrology and Nutrition*, 23, 553-560.

Carroll A, Garrison M, Christakis D (2002). A systematic review of non-pharmacological and non-surgical therapies for gastroesophageal reflux in infants. *Archives of Pediatrics and Adolescent Medicine,* 156, 109-113.

Carver J (2003). Advances in nutritional modifications of infant formulas. *American Journal of Clinical Nutrition*, 77 (6), 1550-1554S.

Chambers WA, Murphy D, Rodriguez W, Sun H (2013). Why any analysis of infant formula effects on infant visual acuity performed before the age of 7 years is not likely predictive. Published letter in response to article by Qawami et al, *Pediatrics;* 131, 1 e262-e272; 11 February 2013.

Chambers TL, Steel AE (1975). Concentrated milk feeds and their relation to hypernatraemic dehydration in infants. *Archives of Disease in Childhood*, 50, 610-615.

Chávez-Servín JL, Castellote AI, Rivero M, López-Sabater MC (2008). Analysis of vitamins A, E and C, iron and selenium contents in infant milk based powdered formula during full shelf-life. *Food Chemistry*, 107, 1187-1197.

Chief Medical Officer (2004). *CMO Update 37.* London: Department of Health.

Chuchu N, Patel B, Sebastien B, Exley C (2013). The aluminium content of infant formulas remains too high. *BMC Pediatrics*, 13, 162-167.

Chung CS, Yamini S, Trumbo P (2012). FDA's health claim revised: whey protein partially hydrolysed infant formula and atopic dermatitis. *Pediatrics,* 130, e408-e414.

Codex Alimentarius Committee (2006). *Joint FAO/WHO Food Standards Programme. Codex Committee on Nutrition and Food for Special Dietary Uses. 28th Session. Proposals for Sectors of Working Group on Food Additives*. CX/NFSDU/06/28/4-Ad.

Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (2003). *Phytoestrogens and Health*. Available at: http://cot.food.gov.uk/pdfs/phytoreport0503

Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (2006). *COT statement on uranium levels in water used to reconstitute infant formula.* Available at http://cot.food.gov.uk/pdfs/cotstatementuranium06.pdf

Corrêa NB, Péret Filho LA, Penna FJ, et al (2005). A randomized formula controlled trial of Bifidobacterium lactis and Streptococcus thermophilus for prevention of antibiotic-associated diarrhea in infants*. Journal of Clinical Gastroenterology*, 39 (5), 385-389.

Costalos C, Kapiki A, Apostolou M, Papathoma E (2008). The effect of a prebiotic supplemented formula on growth and stool microbiology of term infants. *Early Human Development*, 84, 45-49.

Davis A, Harris B, Lien E, et al (2008). α-lactalbumin-rich infant formula fed to healthy term infants in a multicentre study: plasma essential amino acids and gastrointestinal tolerance. *European Journal of Clinical Nutrition*, 62, 1294-1301.

Department of Health (1991). *Dietary Reference Values for Food Energy and Nutrients for the United Kingdom. Report on Health and Social Subjects 41.* London: The Stationery Office.

Department of Health (1992). *The Health of The Nation*. London: The Stationery Office.

Department of Health (2007). *Advice on Infant Milks Based on Goat's Milk*. Available at: http://www.dh.gov.uk/en/Healthcare/Maternity/Maternalandinfantnutrition/DH_4099143

Department of Health (2011). *Birth to Five*. London: Department of Health.

Department of Health (2012). Letter to General Practitioners from the Chief Medical Officer. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/134550/dh_132508.pdf.pdf

Department of Health (2013). *Preparation of infant formula.* Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/127411/update-from-the-Chief-Medical-Officer-and-Director-for-Public-Health-Nursing.pdf.pdf

Department of Health and Food Standards Agency (2012) *Guide to Bottle Feeding.* Available from http://www.nhs.uk/start4life/documents/pdfs/start4life_guide_to_bottle_feeding.pdf

Department of Health and Food Standards Agency (2013). Diet and Nutrition Survey of Infants and Young Children, 2011. Accessed from: http://webarchive.nationalarchives.gov.uk/20130402145952/http://transparency.dh.gov.uk/2013/03/13/dnsiyc-2011/

Department of Health and Social Security (1974). *Present Day Practice in Infant Feeding. Report on Health and Social Subjects 9.* London: HMSO.

Department of Health and Social Security (1977). *The Composition of Mature Human Milk. Report on Health and Social Subjects 12*. London: HMSO.

Department of Health and Social Security (1980). *Present Day Practice in Infant Feeding. Report on Health and Social Subjects 20.* London: HMSO.

Dewey KG, Dömellof M, Cohen RJ, et al (2002). Iron supplementation affects growth and morbidity of breast fed infants: results of a randomised trial in Sweden and Honduras. *Journal of Nutrition*, 132, 3249-3255.

DGSanco (2011). *Overview report of a series of missions carried out during 2007-2009 in order to evaluate the official controls over the production and placing on the market of infant formulae, follow-on formulae and baby foods, including the supply chain*. EC. Ref. Ares (2011) 952724 - 08/09/2011

Dömellof M, Lönnerdal H, Abrams AS, Hernell O (2002). Iron absorption in breast-fed infants: effects of age, iron status, iron supplements and complementary foods. *American Journal of Clinical Nutrition*, 76, 198-204.

EU Commission Health and Consumers Directorate General (2007a). *Final Report of a Mission Carried out in Ireland from 10 to 14 September 2007 in Order to Evaluate the Official Controls over the Production and Placing on the Market of Infant Formulae, Follow-on Formulae and Baby Foods, Including the Supply Chain*. Available at: http://ec.europa.eu/food/fvo/rep_details_en.cfm?rep_id=1977

EU Commission Health and Consumers Directorate General (2007b). *Final Report of a Mission Carried out in France from 19 to 27 November 2007 in Order to Evaluate the Official Controls over the Production and Placing on the Market of Infant Formulae, Follow-on Formulae and Baby Foods, Including the Supply Chain.* Available at: http://ec.europa.eu/food/fvo/rep_details_en.cfm?rep_id=1978

EU Commission Health and Consumers Directorate General (2007c). *Final Report of a Mission Carried out in Poland from 22 to 26 October 2007 in Order to Evaluate the Official Controls over the Production and Placing on the Market of Infant Formulae, Follow-on Formulae and Baby Foods, Including the Supply Chain.* Available at: http://ec.europa.eu/food/fvo/rep_details_en.cfm?rep_id=2012

EU Commission Health and Consumers Directorate General (2008). *Final Report of a Mission Carried out in the United Kingdom from 14 April to 23 April 2008 in Order to Evaluate the Official Controls over the Production and Placing on the Market of Infant Formulae, Follow-on Formulae and Baby Foods, Including the Supply Chain.* Available at: http://ec.europa.eu/food/fvo/rep_details_en.cfm?rep_id=2013

EU Commission Health and Consumers Directorate General (2008a). *Final Report of a Specific Audit Carried out in Germany from 02 December to 12 December 2008 in Order to Evaluate the Official Controls over the Production and Placing on the Market of Infant Formulae, Follow-on Formulae and*

Baby Foods, Including the Supply Chain. Available at*:* http://ec.europa.eu/food/fvo/rep_details_en.cfm?rep_id=2584

EU Commission Health and Consumers Directorate General (2013). *Regulation (EU) no 609/2013 of the European Parliament and of the Council of 12 June 2013 on food intended for infants and young children, food for special medical purposes, and total diet replacement for weight control.* Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0609&from=EN

Euromonitor Internationl (2015) *Market Overview: Identifying new trendsand opportunities in the global infant milk* market. Euromonitor International.

European Food Safety Authority (2004). *Opinion of the Scientific Panel on Biological Hazards (BIOHAZ) related to the microbiological risks in infant formulae and follow-on formulae.* Available at: http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1178620777466.htm

European Food Safety Authority (2005). Opinion of the Scientific Panel on Dietetic Products, Nutrition and Allergies on a request from the Commission related to the tolerable upper intake level of fluoride. *The EFSA Journal*, 210, 1-9.

European Food Safety Authority (2006). *Minutes' Statement of the Scientific Panel on Dietetic Products, Nutrition and Allergies, replying to applicant's comment on the Panel's Opinion relating to the evaluation of goats' milk protein as a protein source for infant formulae and follow-on formulae.* Available at: http://www.efsa.europa.eu/en/efsajournal/doc/30a.pdf

European Food Safety Authority (2008). Intake of aluminium from the diet. *The EFSA Journal*, 754, 1-34.

European Food Safety Authority (2012). *Scientific opinion on the suitability of goat milk protein as a source of protein in infant formulae and in follow-on formulae.* Available at: http://www.efsa.europa.eu/en/efsajournal/pub/2603.htm

European Food Safety Authority (2013). *Scientific opinion on nutrient requirements and dietary intakes of infants and young children in the European Union.* Available at http://www.efsa.europa.eu/en/efsajournal/pub/3408.htm

European Food Safety Authority (2014). Scientific opinion on the essential composition of infant and follow-on formulae. *EFSA Journal*, 12 (7), 3760. Available at http://www.efsa.europa.eu/en/efsajournal/doc/3760.pdf

European Food Safety Authority (2016). Scientific opinion on risks for human health related to the presence of 3- and 2-monochlropropanediol (MCPD), and their fatty acid esters, and glycidyl fatty acid esters in food. *EFSA Journal,* 14 (5), 4426. Available at https://www.efsa.europa.eu/en/efsajournal/pub/4426

European Food Safety Authority (2017). Scientific opinion on the safety and suitability for use by infants of follow-on formulae with a protein content of at least 1.6g/100kcal. EFSA Journal ,15, 5 4781. Available at: http://onlinelibrary.wiley.com/doi/10.2903/j.efsa.2017.4781/full

European Food Safety Authority (2017) DRAFT REGLATION COMMISSION REGULATION (EU) …/… amending Regulation (EC) 1881/2006 as regards maximum levels of glycidyl fatty acid esters in vegetable oils and fats, infant formula, follow-on formula and foods for special medical purposes intended for infants and young children. Available at:

https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-4129615_en

Fattal-Valevski A, Azouri-Fattal I, Greenstein Y, et al (2009). Delayed language development due to infantile thiamine deficiency. *Developmental Medicine and Child Neurology*, 51, 629-634.

Fewtrell M, Edmonds CJ, Isaacs E, et al (2011). Aluminium exposure from parenteral nutrition in preterm infants and later health outcomes during childhood and adolescence. *Proceedings of the Nutrition Society*, 79, 299-304.

Finglas PM, Rose MA, Pinchen HM, et al. (2015) M^c^Cance and Widdowson's The Composition of Foods, Seventh summary edition. Cambridge: Royal Society of Chemistry.

Fleddermann M, Demmelmair H, Grote V, Nikolic T, Trisic B (2014) Infant formula composition affects energetic efficiency for growth: The BeMIM study, a randomized controlled trial. *Clinical Nutrition*, 33, 588-595.

Food and Agriculture Organization/World Health Organization (1994). *Lipids in early development*. In: *Fats and Oils in Human Nutrition. Report of a Joint Expert Consultation.* Rome: FAO/WHO.

Food and Agriculture Organization/World Health Organization (2001). Report of a joint FAO/WHO expert consultation on evaluation of health and nutritional properties of probiotics in food including milk powder with live lactic acid bacteria.

Food Standards Agency (2005). *Guidance for Health Professionals on Safe Preparation, Storage and Handling of Powdered Infant Formula.* Available at: www.dh.gov.uk

Food Standards Agency (2007). *The Infant Formula and Follow-on Formula (England) Regulations (2007).* Accessed from: http://www.legislation.gov.uk/uksi/2007/3521/contents/made

Food Standards Agency (2008). *General Guidance for Food Business Operators. EC Regulation No. 2073/2005 on Microbiological Criteria for Foodstuffs.* Available at: http://www.food.gov.uk/multimedia/pdfs/ecregguidmicrobiolcriteria.pdf

Food Standards Agency (2009a). *Survey of Total and Inorganic Arsenic in Rice Drinks.* Accessed from: http://www.food.gov.uk/science/surveillance/fsisbranch2009/survey0209

Food Standards Agency (2009b). *Bacteriocidal Preparation of Powdered Infant Formula.* Available at: http://www.foodbase.org.uk//admintools/reportdocuments/395-1-697_b13010.pdf

Food Standards Agency (2010). *The Independent Review of the Controls on Infant Formula and Follow-on Formula.* London: Food Standards Agency.

Fonkalsrud E. (1996) Gastroesophageal reflux in childhood. *Current Problems in Surgery* 33, 1, 3-70.

Gibson G, Roberfroid M (1995). Dietary modulation of the human colonic microbiota: introducing the concept of prebiotics. *The Journal of Nutrition*, 125, 1401-1412.

Gil-Campos M, Ángel López M, Rodriguez-Benítez V, et al (2012). *Lactobacillus fermentum* CECT 5716 is safe and well tolerated in infants of 1-6 months of age: a randomized controlled trial. *Pharmacological Research,* 65, 231-238.

Goehring K, Marriage B, Oliver J et al (2016) Similar to Those Who Are Breastfed, Infants Fed a Formula Containing 2'-Fucosyllactose Have Lower Inflammatory Cytokines in a Randomized Controlled Trial.*The Journal of Nutrition,* Epub ahead of print October 26, 2016 as doi:10.3945/jn.116.236919.

Greer FR, Sicherer SH, Burks W (2008). Effects of early nutrition interventions on the development of atopic diseases in infants and children. The role of maternal dietary restrictions, breastfeeding, timing of introduction of complementary foods and hydrolysed formula. *Pediatrics*, 121, 183-191.

Grenby TH, Mistry M (2000). Properties of maltodextrins and glucose syrups in experiments in vitro and in the diets of laboratory animals, relating to dental health. *British Journal of Nutrition*, 84, 565-574.

Guarino A, Ashkenazi S, Gendrel D et al (2014) ESPGHAN and Nutrition/European Socisety for Pediatric Infectious Diseases: Evidence based guidelines for the management of acute gastroenteritis in children in Europe: Update 2014. *JPGN*, **59**, 1320 152.

Haenlein GFW (2004). Goat milk in human nutrition. *Small Ruminant Research*, 51, 155-163

Haroon Y, Shearer J, Rahim S, Gunn W, McEnery G and Barkhan P. The content of phylloquinone (vitamin K_1) in human milk, cows' milk and infant formula foods determined by high-performance liquid chromatography. *The Journal of Nutrition*, 112, 1105-1117.

Hawkes J, Gibson R, Robertson D, Makrides M (2006). Effect of dietary nucleotide supplementation on growth and immune function in term infants: a randomized controlled trial. *European Journal of Clinical Nutrition*, 60 (2), 254-264.

Health and Social Care Information Service (2012). *Infant Feeding Survey 2010*. Available at: http://www.ic.nhs.uk/statistics-and-data-collections/health-and-lifestyles-related-surveys/infant-feeding-survey/infant-feeding-survey-2010 [accessed November 2012]

Hegar B, Rantos R, Firmansyah A, et al (2008). Natural Evolution of Infantile Regurgitation Versus the Efficacy of Thickened Formula. *Journal of Pediatric Gastroenterology and Nutrition,* 47, 26-30.

Heine W, Klein P, Reeds P (1991). The importance of α-lactalbumin in infant nutrition. *Journal of Nutrition*, 121, 277-283.

Hester SN, Hustead DS, Mackey AD (2012) Is the macronutrient intake of formula-fed infants greater than breast-fed infants in early infancy? *Journal of Nutrition and Metabolism*: doi: 10.1155/2012/891201

Heyman B for the Committee on Nutrition of the American Academy of Pediatrics (2006). Lactose intolerance in infants, children and adolescents. *Pediatrics*, 118, 1279-1286.

Holmes-McNary M, Cheng W, Mar M, et al (1996). Choline and choline esters in human and rat milk and in infant formulas. *American Journal of Clinical Nutrition*, 64, 572-576.

Hormann E (2010). Reducing the risk for formula-fed infants: examining the guidelines. *Birth*, 37, 72-76.

Hörnell A, Lagström H, Lande B, Theosdottir I (2013). Protein intake from 0-18 years of age and its relation to health: a systematic literature review for the 5th Nordic Nutrition Recommendations. *Food and Nutrition Research.* 57.

Horvath A, Dziechciarz P and Szajewska H. (2008) The Effect of Thickened-Feed Interventions on Gastroesophageal Reflux in Infants: Systematic Review and Meta-analysis of Randomized, Controlled Trials. Pediatrics 122 6.

HØst A, Koletzko B, Dreborg S, et al (1999). Joint Statement of the European Society for Paediatric Allergology and Clinical Immunology (ESPACI) Committee on Hypoallergenic Formulas and the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) Committee on Nutrition. Dietary products used in infants for treatment and prevention of food allergy. *Archives of Disease in Childhood*, 81, 80-84.

Hurrell R, Juillerat M, Reddy M, et al (1992). Soya protein, phytate and iron absorption in humans. *American Journal of Clinical Nutrition*, 56, 573-578.

Iacono G, Merolla R, D'Amico D, Bonci E et al (2005) Gastrointestinal symptoms in infancy: A population based prospective study. *Digestive and Liver Disease,* **37**, 432-438.

Iannotti LL, Tielsch JM, Black MM, et al (2006). Iron supplementation in early childhood: health benefits and risks. *American Journal of Clinical Nutrition*, 84, 1261-1276.

Idjradinata P, Watkins WE, Pollitt E (1994). Adverse effect of iron supplementation on weight gain of iron-replete young children. *The Lancet*, 343, 1252-1254.

Ikem A, Nwankwoala A, Odueyungbo S, et al (2002). Levels of 26 elements in infant formula from USA, UK and Nigeria by microwave digestion and ICP–OES. *Food Chemistry*, 77, 439-447.

Indrio F, Di Mauro A, Trove L, Brindisi G (2015) Thickened partially hydrolysed milk formula added with *L. reuteri* decreases the number of regurgitation in infants and ameliorates the gastric motility. In: Selected Abstracts of the 1st Congress of joint European Neonatal Societies (jENS 2015); Budapest (Hungary); September 16-20, 2015; Session "Nutrition and gastroenterology". *Journal of Pediatric and Neonatal Individualized Medicine*. 4 2 :e040210. doi: 10.7363/040210. Available at: http://www.jpnim.com/index.php/jpnim/article/view/040210/280

Infante D, Segurra O, Le Luyer B (2011) Dietary treatment of colic caused by excess gas in infants: Biochemical evidence. *W J Gastro*, **17**, 2104-2108.

Jeffs SG (1989). Hazards of scoop measurements in infant feeding. *Journal of the Royal College of General Practitioners*, 39, 113.

Jensen RG, Hegarty, McMahon KE *(1978)* Lipids of human milks and infant formula: A review. *Am J Clin Nutr* 31 :990-1016, Jensen C, Heird W (2002). Lipids with an emphasis on long-chain polyunsaturated fatty acids. *Clinics in Perinatology*, 29, 261-281.

Jensen RG (1995). *Handbook of Milk Composition*. London: Academic Press Ltd.

Johnson MD, Kenney N, Stoica A, et al (2003). Cadmium mimics the *in vivo* effects of estrogen in the uterus and mammary gland. *Nature Medicine*, 9 (8), 1081-1084.

Kanabar D, Randhawa M, Clayton B (2001) Improvement of symptoms of colic following reduction of lactose load with lactase. *J H Nut Diet*, **14**, 359-369.

Kennedy K, Fewtrell M, Morley R, et al (1999). Double-blind, randomized trial of a synthetic triacylglycerol in formula-fed term infants: effects on stool biochemistry, stool characteristics, and bone mineralization. *American Journal of Clinical Nutrition*, 70, 920-927.

Kennedy K, Ross S, Isaacs EB, et al (2010). The 10-year follow-up of a randomised control trial of long-chain fatty acid supplementation in preterm infants: effects on growth and blood pressure. *Archives of Disease in Childhood*, 95, 588-595.

Kent G (2006). WIC's promotion of infant formula in the United States. *International Breastfeeding Journal*, 1, 8. Available from: www.internationalbreastfeedingjournal.com/content/1/1/8

Kent G (2012). Questionable impact of fatty acid supplementation of infant formula. Published letter in response to article by Qawami et al (2013), *Pediatrics;* 131: 1 e262-e272; 28 December 2012. (Letter sent on e-publication ahead of print publication.)

Kent G (2014). Regulating fatty acids in infant formula: critical assessment of U.S. policies and practices. *International Breastfeeding Journal,* 9, 2-12.

Kippler M, Hoque AM, Raqib R, et al (2010). Accumulation of cadmium in human placenta interacts with the transport of micronutrients to the fetus. *Toxicology Letters,* 192 (2), 162-168.

Koletzko B, Agostoni C, Carlson S, et al (2001). Long chain polyunsaturated fatty acids (LC-PUFA) and perinatal development. *Acta Paediatrica*, 90, 460-464.

Koletzko B, Baker S, Cleghorn G, et al (2005). Global standard for the composition of infant formula: Recommendations of an ESPGHAN coordinated International Expert Group. *Journal of Pediatric Gastroenterology*, 41, 584-599.

Koletzko B, Shamir R (2006). Commercial interest may be the greatest driver of what goes into infant formula. *British Medical Journal*, 332, 621-622.

Koletzko B, Koletzko S, Ruemmele F (2009). *Drivers of Innovation in Pediatric Nutrition*. Nestlé Nutrition Institute.

Koletzko B, Bhutta ZA, Cai W, et al (2012). Compositional requirements of follow-up formula for use in infancy: recommendations of an International Expert Group co-ordinated by the Early Nutrition Academy. *Annals of Nutrition and Metabolism*, DOI: 10.1159/000345906.

Koparal E, Ertugrul F, Oztekin K (2000) Fluoride levels in breast milk and infant foods. *Journal of Clinical Pediatric Dentistry,* 24, 299-302.

Kukuruzovic R, Brewster D (2002). Milk formulas in acute gastroenteritis and malnutrition: a randomised trial. *Journal of Paediatrics and Child Health*, 38, 571-577.

Kummeling I, Thijs C, Huber M et al. (2008) Consumption of organic foods and risk of atopic disease during the first 2 years of life in the Netherlands. *British Journal of Nutrition* 99 ,598-605

Kvistgaard AS (2012). *How infant formula with Lacprodan© Alpha proteins could provide the key to tackling the obesity crisis.* www.arlafoodsingredients.com

Lauritzen L, Hansen HS, Jorgensen MH, Michaelsen KF (2001). The essentiality of longchain n-3 fatty acids in relation to development and function of the brain and retina. *Progress in Lipid Research*, 40, 1-94.

Leach J, Baxter J, Molitor B, et al (1995). Total potentially available nucleosides of human milk by stage of lactation. *American Journal of Clinical Nutrition*, 61, 1224-1230.

Lee KS, Lee JH (2012). Clinical applications and limitations of a special formula for diarrhea in children. *Journal of the Korean Medical Association*, 55 (6), 551-561.

Lien E, Davis A, Euler A and the Multicenter Study Group (2004). Growth and safety in term infants fed reduced-protein formula with added bovine alpha-lactalbumin. *Journal of Pediatric Gastroenterology and Nutrition*, 38, 170-176.

Lind T, Seswandhana R, Persson LA, et al (2008). Iron supplementation of iron-replete Indonesian infants is associated with reduced weight-for-age. *Acta Paediatrica*, 97, 770-775.

Ljung K, Palm B, Grander M, Vahter M (2011). High concentrations of essential and toxic elements in infant formula and infant foods – a matter of concern. *Food Chemistry*, 127, 943-951.

Lodge CJ, Allen KJ, Lowe AJ, Dharmage SC (2013). Overview of evidence in prevention and aetiology of food allergy: a review of systematic reviews. *International Journal of Environmental Research and Public Health*, 10, 5781-5806.

Lönnerdal B, Hernell O (1994). Iron, zinc, copper and selenium status of breast-fed infants and infants fed trace element fortified milk based infant formula. *Acta Pediatrica*, 83, 367-373.

Lowe AJ, Hosking CS, Bennett CM, et al (2011). Effect of partially hydrolysed whey infant formula at weaning on risk of allergic disease in high risk children: a randomised control trial. *Journal of Allergy and Clinical Immunology*, 128, 360-365.

Lowe AJ, Dharmage SC, Allen KJ, et al (2013). The role of partially hydrolysed whey formula for the prevention of allergic disease: evidence and gaps. *Expert Review of Clinical Immunolog*y, 9, 31-41.

Lozoff B, Castillo, M, Clark K, Smith J (2011). Iron-fortified versus low-iron infant formula: developmental outcome at 10 years. *Archives of Pediatrics and Adolescent Medicine*. Published online November 7, 2011. doi:10.1001/archpediatrics.2011.197

LSRO (Life Sciences Research Office) (1998). *LSRO Report: Assessment of Nutrient Requirements for Infant Formulas.* Washington: Center for Food Safety and Applied Nutrition, Food and Drug Administration, Department of Health and Human Services.

Lucas A (1992). Randomised trial of RTF compared to powdered formula. *Archives of Disease in Childhood*, 67, 935-939.

Lucas A, Quinlan P, Abrams P, et al (1997). Randomised controlled trial of a synthetic triglyceride milk formula for preterm infants. *Archives of Disease in Childhood*: Fetal and Neonatal Edition, 77 (3), 78F-184F.

Lucas A, Stafford M, Morley R, et al (1999). Efficacy and safety of long-chain polyunsaturated fatty acid supplementation of infant-formula milk: a randomised trial. *The Lancet*, 354, 1948-1954.

Lucassen PL, Assendelft WJ, Gubbels JW, et al (1998). Effectiveness of treatments for infantile colic: systematic review. *British Medical Journal*, 316, 1563-1569.

MacLean W, Van Dael P, Clemens R, et al (2009). Upper levels of nutrients in infant formulas: comparison of analytical data with the revised Codex infant formula standard. *Journal of Food Composition and Analysis*, 23, 44-53.

Maldonado J, Cañabate F, Sempere L, et al (2012). Human milk probiotic *Lactobacillus fermentum* CECT5716 reduces the incidence of gastrointestinal and upper respiratory tract Infections in infants. *Journal of Pediatric Gastroenterology and Nutrition,* 54 (1), 55-61.

Majumdar I, Paul P, Talib VB, et al (2003). The effect of iron therapy on the growth of iron-replete and iron deplete children. *Journal of Tropical Pediatrics*, 49, 84-88.

Marriage B, Buck R, Goehring C et al (2015). Infants Fed Lower Calorie Formula With 2'FL Show Growth and 2'FL Uptake Like Breast-Fed Infants. *Journal of Pediatric Gastroenterology and Nutrition* 61 (6) 649-658.

McAndrew F, Thompson J, Fellows L, Large A, Speed M, Renfrew MJ (2012) *Infant Feeding Survey 2010.* Available at www.hscic.gov.uk.

Mendez M, Anthony M, Arab L (2002). Soya-based formulas and infant growth and development: a review. *The Journal of Nutrition*, 132, 2127-2130.

Mintel (2016). *Baby Foods, Drinks and Milk. UK.* London: Mintel Reports.

Mitchell M, Snyder E (1991). Dietary carnitine effects on carnitine concentrations in urine and milk in lactating women. *American Journal of Clinical Nutrition*, 54 (5), 814-820.

Morley R, Abbott R, Fairweather-Tait S, et al (1999). Iron fortified follow-on formula from 9 to 18 months improves iron status but not development or growth: a randomised trial. *Archives of Disease in Childhood*, 81, 247-252.

Monteiro PO, Victoria CG (2005). Rapid growth in infancy and childhood obesity in later life – a systematic review. *Obesity Reviews*, 6, 143-154.

Moro G, Arslanoglu B (2005). Reproducing the bifidogenic effect of human milk in formula-fed infants: why? and how? *Acta Paediatrica*, 94, suppl., 14-17.

Moro G, Arslanoglu B, Stahl B, et al (2006). A mixture of prebiotic oligosaccharides reduces the incidence of atopic dermatitis during the first six months of age. *Archives of Disease in Childhood*, 91, 814-819.

Moukarzel A, Abdelnour, H, Akatcherian, C (2007) Effects of a prethickened formula on esophageal pH and gastric emptying of infants with GER. *Journal of Clinical Gastroenterology*, 41, 823-829.

Moy R (2000). Iron fortification of infant formula. *Nutrition Research Reviews*, 13, 215-227.

Mullane NR, Drudy D, Whyte P, et al (2006). Enterobacter sakazakii: biological properties and significance in dried infant milk formula (IMF) powder. *International Journal of Dairy Technology*, 59, 102-111.

Muraro A, Dreborg S, Halken S, et al (2004a). Dietary prevention of allergic diseases in infants and small children. Part I: dietary prevention of allergic diseases in infants and small children. *Pediatric Allergy and Immunology*; 15, 103-110.

Muraro A, Dreborg S, Halken S, et al (2004b). Dietary prevention of allergic diseases in infants and small children. Part II: evaluation of methods in allergy prevention studies and sensitization markers. Definitions and diagnostic criteria of allergic diseases. *Pediatric Allergy and Immunology*, 15, 196-205.

Muraro A, Dreborg S, Halken S, et al (2004c). Dietary prevention of allergic diseases in infants and small children. Part III: critical review of published peer-reviewed observational and interventional studies and final recommendations. *Pediatric Allergy and Immunology*; 15: 291-307.

National Institute for Health and Clinical Excellence (2008). *Maternal and Child Nutrition. Public Health Guidance 11.* Available at: www.nice.org.uk/nicemedia/pdf/PH011quickrefguide.pdf

National Institute for Health and Care Excellence (2015). *Gastro-oesophageal Reflux Disease: Recognition, Diagnosis and Management in Children and Young People*. *NICE Guideline.* Available at: http://www.nice.org.uk/guidance/ng1/resources/gastrooesophageal-reflux-disease-recognition-diagnosis-and-management-in-children-and-young-people-51035086789

National Institute for Health and Care Excellence (2016). *Gastro-oesophageal Reflux Disease in Children and Young People*. *NICE Quality Standard 112. Avaialble at: https://www.nice.org.uk/guidance/qs112*

Nazarowec-White M, Farber J (1997). Enterobacter sakazakii: a review. *International Journal of Food Microbiology*, 34, 103-113.

Nestlé (2013). The first 1,000 days: Nestlé leadership in infant nutrition. Accessed from: http://www.nestle.com/asset-library/documents/investors/nis-2013-vevey/heiko-schipper-the-first-1000-days-nestle-leadership-in-infant-nutrition.pdf (accessed 7 November 2013).

NICE CK (2017) *NICE Clinical Knowledge Summaries: Infant colic*. Available at https://cks.nice.org.uk/colic-infantile

NHS (2011). *Guide to Bottle Feeding*. Available at: www.dh.gov.uk

NHS Choices (2017a) *Colic*. Available at https://www.nhs.uk/conditions/Colic/

NHS Choices (2017b) *Constipation.* Available at https://www.nhs.uk/conditions/constipation/treatment/#Babies

NHS Choices (2017c). Types of infant formula. Accessed from: https://www.nhs.uk/Conditions/pregnancy-and-baby/Pages/types-of-infant-formula.aspx#hypoallergenic

Osborn D, Sinn J (2006). Soya formula for prevention of allergy and intolerance in infants. *Cochrane Database of Systematic Reviews.* Issue 4. Art. No.: CD003741. DOI: 10.1002/14651858.CD003741.pub4

Osborn DA, Sinn JKH (2007). Probiotics in infants for prevention of allergic disease and food hypersensitivity. *Cochrane Database of Systematic Reviews.* Issue 4. Art. No.: CD006475. DOI: 10.1002/14651858.CD006475.pub2

Osborn K, Lyons M (2010). Is bottled water really unfit for making up formula? *Community Practitioner*, 83, 31-34.

Palmer G (2009). *The Politics of Breastfeeding: When Breasts are Bad for Business*. London: Pinter and Martin.

Pereira GR, Baker L, Egler J, et al (1990). Serum myoinositol concentrations in premature infants fed human milk, formula for infants, and parenteral nutrition. *American Journal of Clinical Nutrition*, 51 (4), 589-55.

Pereira MA, Jacobs D, van Horn L, et al (2002). Dairy consumption, obesity and the insulin resistance syndrome in young adults. *Journal of the American Medical Association,* 287, 2081-2089.

Petherick A (2010). Mother's milk: a rich opportunity. *Nature*, 468, S5-S7.

Poskitt E, Morgan J (2005). Infancy, childhood and adolescence. In: Geissler C and Powers H. *Human Nutrition*. Eleventh edition. London: Elsevier Churchill Livingstone.

Public Health England (2014). *The Composition of Foods*. 7th summary edition. London: Public Health England.

Qawasmi A, Landeros-Weisenberger A, Leckman J, Bloch M (2012). Meta-analysis of long-chain polyunsaturated fatty acid supplementation of formula and infant cognition. *Pediatrics*, 129 (6), 1141-1149.

Quinlan PT, Lockton S, Irwin J, et al (1995). The relationship between stool hardness and stool composition in breast-fed and formula-fed infants. *J Perinatal Gastro Nutrition*; 20: 81-90

Quinn EA (2014). Too much of a good thing: evolutionary perspective on infant formula fortification in the United States and its effects on infant health. *American Journal of Human Biology*, 26, 10-17.

Ramirez-Mayans J, Palacio del Carmen L, Cervantes-Bustamante R, et al (2003). Nutritional management of children with gastroesophageal reflux. A comparison of two different formulas. *International Pediatrics*, 18, 78-83.

Renfrew MJ, Ansell P, Macleod KL (2003). Formula feed preparation: helping reduce the risks; a systematic review. *Archives of Disease in Childhood*, 88, 855-858.

Renfrew MJ, Pokhrei S, Quigley M, et al (2012). *Preventing Disease and Saving Resources: The Potential Contribution of Breastfeeding Rates in the UK***.** London: UNICEF

Rijksinstituut voor Volksgezondheid en Milieu (National Institute for Health and Environment) (2016). Preliminary assessment of dietary exposure to 3-MCPD in the Netherlands. Available at http://www.rivm.nl/en/Documents_and_publications/Scientific/Reports/2016/april/Preliminary_assessment_of_dietary_exposure_to_3_MCPD_in_the_Netherlands

Rodríguez-Urrego J, Herrera-León S, Echeita-Sarriondia A, et al (2010). Nationwide outbreak of Salmonella serotype Kedougou associated with infant formula, Spain, 2008. *Eurosurveillance*, 15 (22), pii=19582.

Royal College of Midwives (2009). *Infant Feeding: A Resource for Health Care Professionals and Parents.* London: Royal College of Midwives.

Royal College of Nursing (2007). *Formula Feeds: RCN Guidance for Nurses Caring for Infants and Mothers.* London: Royal College of Nursing.

Rzehak P, Koletzko S, Koletzko B, et al, for the GINI Study Group (2011). Growth of infants fed formula rich in canola oil (low erucic acid rapeseed oil). *Clinical Nutrition*, 30 (3) 339-345.

Saavedra JM, Abi-Hanna A, Moore N, et al (2004). Long-term consumption of infant formulas containing live probiotic bacteria: tolerance and safety. *American Journal of Clinical Nutrition*, 79, 261-267.

Savage J, Fisher J, Birch L (2007). Parental influence on eating behaviour: conception to adolescence. *Journal of Law, Medicine and Ethics*, 35 (1), 22-34.

Savino F, Cresci F, Maccario S, et al (2003). Minor feeding problems during the first months of life: effect of a partially hydrolysed milk formula containing fructo- and galacto-oligosaccharides. *Acta Pediatrica*, 92, S441, 86-90.

Savino F, Palumeri E, Castagno E, et al (2006). Reduction of crying episodes owing to infantile colic: a randomized controlled study on the efficacy of a new infant formula. *European Journal of Clinical Nutrition,* 60, 1304-1310. Accessed from:
http://www.nature.com/ejcn/journal/v60/n11/full/1602457a.html - aff1

Schmelzle H, Wirth S, Skopnik H, et al (2003). Randomized double-blind study of the nutritional efficacy and bifidogenicity of a new infant formula containing partially hydrolyzed protein, a high [beta]-palmitic acid level, and nondigestible oligosaccharides. *Journal of Pediatric Gastroenterology and Nutrition*: 36, 343-35.

Schoder D (2010). Melamine milk powder and infant formula sold in East Africa. *Journal of Food Protection*, 73, 9, 1709-1714.

Scientific Advisory Committee on Nutrition (2007). *Subgroup on Maternal and Child Nutrition's (SMCN) response to the Infant Formula and Follow-on Formula Draft Regulations 2007.* Available at: http://www.sacn.gov.uk/pdfs/smcn_07_07.pdf

Scientific Advisory Committee on Nutrition (2008). *Consideration of the place of 'Good Night' milk products in the diet of infants aged 6 months and above.* Available at:
http://www.sacn.gov.uk/reports_position_statements/position_statements/sacn_statement_on_good_night_milks_-_november_2008.html

Scientific Advisory Committee on Nutrition (2011). *Dietary Reference Values for Energy*. Available at: https://www.gov.uk/government/publications/sacn-dietary-reference-values-for-energy

Scientific Committee on Food (1997). *Opinion on Certain Additives for Use in Foods for Infants and Young Children in Good Health and in Foods for Special Medical Purposes for Infants and Young Children (expressed on 21 March 1997 and amended on 13 June 1997)*
http://ec.europa.eu/food/fs/sc/oldcomm7/out06_en.html

Scientific Committee on Food (2001). Opinion of the scientific committee on food on 3-monochloro-propane-1,2-diol (3-MCPD). Updating the SCF opinion of 1991. Adopted on 30 May 2001. Brussels, Belgium: European Commission. Available at http://ec.europa.eu/food/fs/sc/scf/out91_en.pdf

Scientific Committee on Food (2003). *Report of the Scientific Committee on Food on the Revision of Essential Requirements of Infant Formulae and Follow-on Formulae.* Brussels: European Commission.

Sekine T, Endou H (2009). Children's toxicology from bench to bed – drug induced renal injury (3): Drug transporters and toxic nephropathy in childhood. *The Journal of Toxicological Science*, 34 (suppl 2), SP259-SP265.

Setchell K, Zimmer-Nechemias L, Cai J, Heubi J (1998). Isoflavone content of infant formulas and the metabolic fate of these phytoestrogens in early life. *American Journal of Clinical Nutrition*, 68, 1453S-1461S.

Shaw V (2015). *Clinical Paediatric Dietetics.* Fourth edition. Oxford: Wiley Blackwell Science.

Shulman RJ, Wong WW, Irving CS, et al (1983). Utilization of dietary cereal by young infants. *Journal of Pediatrics*, 103, 23-28.

Shulman R, Feste A, Ou C (1995). Absorption of lactose, glucose polymers or combination in premature infants. *Journal of Pediatrics*, 127, 626-631.

Simmer K, Patole S, Rao SC (2007). Longchain polyunsaturated fatty acid supplementation in infants born at term. *Cochrane Database of Systematic Reviews*, Issue 1. Art. No.: CD000376. DOI: 10.1002/14651858. CD000376.pub2.

Slurpsky CM, He X, Hernell O, Andersson Y et al (2017). Postprandial metabolic response of breastfed infants and infants fed lactose-free vs regular infant formula: A randomized control trial. Scientific Reports, 7:3640. DOI: 10.1038/s41598-017-03975-4.

Specker BL, Wey HE, Miller D (1987). Differences in fatty acid composition of human milk in vegetarian and nonvegetarian women: long-term effect of diet. *Journal of Pediatric Gastroenterology and Nutrition*, 6 (5), 764-768.

Staelens S, Van Den Driessche M, Barclay D et al (2008) Gastric emptying in healthy newborns fed an intact protein formula, a partially and an extensively hydrolysed formula. *Clinical Nutrition,* doi:10.1016/j.clnu.2007.12.009. Available at: https://www.researchgate.net/profile/Bart_Overmeire/publication/5570810_Gastric_emptying_in_healthy_newborns_fed_an_intact_protein_formula_a_partially_and_an_extensively_hydrolysed_formula/links/55cb6e2008aebc967dfe15d9.pdf

Swan GE, Powell NA, Knowles BL, Bush MT, Levy LB (2018). A definition of free sugars for the UK. Public Health Nutrition, online. Doi:10.1017/S1368998001800085X.

Szajewska H, Hoekstra JH, Sandhu B, The Working Group on Acute Diarrhoea of the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (2000). Management of acute gastroenteritis in Europe and the impact of the new recommendations: a multicenter study. *Journal of Pediatric Gastroenterology and Nutrition*, 30 (5), 522-527.

Szajewska H, Mrukowicz J (2001). Probiotics in the treatment and prevention of acute infectious diarrhea in infants and children: a systematic review of published randomized, double-blind, placebo-controlled trials. *Journal of Pediatric Gastroenterology and Nutrition*, 33 (suppl. 2), S17-S25.

Taitz LS, Scholey E (1989). Are babies more satisfied by casein based formula? *Archives of Disease in Childhood*, 64, 619-621.

Taveras EM, Rifas-Shiman SL, Belfort MB, et al (2009). Weight status in the first 6 months of life and obesity at 3 years of age. *Pediatrics*, 123, 1177-1183.

Teitelbaum J, Walker W (2002). Nutritional impact of pre-and probiotics as protective gastrointestinal organisms. *Annual Review of Nutrition,* 22**,** 107-138.

Thibault H, Aubert-Jacquin C, Goulet O (2004). Effects of long-term consumption of a fermented infant formula (with Bifidobacterium breve c50 and Streptococcus thermophilus 065) on acute diarrhea in healthy infants. *Journal of Pediatric Gastroenterology and Nutrition*, 39, 147-152.

Thorkelsson T, Mimouni F, Namgung R, et al (1994). Similar gastric emptying rates for casein- and whey-predominant formulas in preterm infants. *Pediatric Research*, 36, 329-333.

Tolia V, Lin C, Kuhns L (1992). Gastric emptying using three different formulas in infants with gastroesophageal reflux. *Journal of Pediatric Gastroenterology and Nutrition*, 15, 297-301.

Toporovski M, Neufeld C, Cuflat C, Magni A, Aleixo D, Okana R. (2013). A comparative study among two different AR formulas and a standard formula in infants with gastroesophageal reflux (GER). (Abstract presented at the 46th Annual meeting of the European Society for Pediatric Gastroenterology, Hepatology and Nutrition: London, May 8-11, 2013). Journal of Pediatric Gastroenterology and Nutrition. 56, Suppl 2, 330.

Trabulsi J, Capeding R, Lebumfacil J, et al (2011). Effect of an α-lactalbumin-enriched infant formula with lower protein on growth. *European Journal of Clinical Nutrition,* 65 (2), 167-174.

UBIC Consulting (2010). *Ingredients for the World Infant Formula Market*. Available from: www.ubic-consulting.com

Van Dael P, Barclay DV (2006). Geographical, seasonal and formula-specific variations in the selenium levels of infant formulae. *Food Chemistry*, 96, 512-518.

van de Heijning M, Berton A, Bouritius H and Goulet O (2014). GI Symptoms in Infants Are a Potential Target for Fermented Infant Milk Formulae: A Review. Nutrients 6 (9) 3942-3967.

Vandenplas Y, Hachimi-Idrissi S, Casteels A, Loeb H (1994). A clinical trial with an 'anti-regurgitation' formula. *European Journal of Pediatrics*, 153, 419-423.

Vandenplas Y, Veerman-Wauters G, De Greef E, et al (2011). Intestinal microbiota and health in childhood. *Bioscience Microflora,* 30 (4), 111-117.

Vandenplas Y, AlarconP, Fleischer D et al (2016) Should partial hydolysates be used as a starter infant formula? A Working Group Consensus. *Journal of Pediatric Gastroenterology and Nutrition*, 62, 22-35.

Vanderhoof JA, Moran JR, Harris CL, et al (2003). Efficacy of a pre-thickened infant formula: a multicenter, double-blind, randomized, placebo-controlled parallel group trial in 104 infants with symptomatic gastroesophageal reflux. *Clinical Pediatrics*, 42, 483-495.

von Berg A, Koletzko S, Grubl A, et al (2003). The effect of hydrolysed cow's milk formula for allergy prevention in the first year of life: the German Infant Nutritional Intervention Study, a randomized double-blind trial. *Journal of Allergy and Clinical Immunology,* 111, 533-540.

von Berg A, Filipiak-Pittroff B, Kramer U, Link E, et al (2008). Preventive effect of hydrolyzed infant formulas persists until age 6 years: long-term results from the German Infant Nutritional Intervention Study (GINI). *Journal of Allergy and Clinical Immunology*, 121, 1442-1447.

Walter T, Pino P, Pizarro F, Lozoff B (1998). Prevention of iron deficiency anemia: comparison of high- and low-iron formula in term healthy infants after six months of life. *Journal of Pediatrics*, 132, 635-640.

Weizman Z, Asli G, Alsheikh A (2005). Effect of a probiotic infant formula on infections in child care centres: comparison of two probiotic agents. *Pediatrics*, 115 (1), 5-9.

Wenzl TG, Schneider S, Scheele F, et al (2003). Effects of thickened feeding on gastroesophageal reflux in infants: a placebo-controlled crossover study using intraluminal impedance. *Pediatrics*, 111, e355-e359.

Westland S, Crawley H (2012). *Healthy and Sustainable Diets in the Early Years.* London: First Steps Nutrition Trust. Available at: http://www.firststepsnutrition.org/pdfs/HaSDEY_proof2.pdf

Westmark C (2014). Soya infant formula and seizures in children with autism: a retrospective study. PLoS ONE 9 (3): e80488. doi:10.1371/journal.pone.0080488

Willis J, Robinson J (1988). Enterobacter Sakazakii meningitis in neonates. *The Pediatric Infectious Disease Journal*, 7, 196-199.

Wojcik KY, Rechtman DJ, Lee ML, et al (2009). Macronutrient analysis of a nationwide sample of donor breastmilk. *Journal of the American Dietetic Association*, 109, 137-140.

World Health Organization (1981). *The International Code of Marketing of Breast-milk Substitutes.* Geneva: WHO.

World Health Organization (2003). *Global Strategy for Infant and Child Feeding*. Geneva: WHO.

World Health Organization (2007). *Safe Preparation, Storage and Handling of Powdered Infant Formula: Guidelines.* Geneva: WHO.

World Health Organization (2013). Information concerning the use and marketing of follow-up formula. Accessed from: http://www.who.int/nutrition/topics/WHO_brief_fufandcode_post_17July.pdf

Xinias I, Spiroglou K, Demertzidou V, et al (2003). An antiregurgitation milk formula in the management of infants with mild to moderate gastroesophageal reflux. *Current Therapeutic Research*, 6 (4), 270-278.

Yao M, Riley A, Trabulsi J, et al. (2010) Use of an electronic handheld diary to validate a new parent questionnaire assessing gastrointestinal tolerance in infants. *Journal of Pediatric Gastroenterology and Nutrition,* **50**, suppl 2:E208

Yau K, Huang C, Chen W, et al (2003). Effect of nucleotides on diarrhea and immune responses in healthy term infants in Taiwan. *Journal of Pediatric Gastroenterology and Nutrition*, 36, 37-43.

Yoshiota M, Fujita K, Sakata H, et al (1991). Development of the normal intestinal flora and its clinical significance in infants and children. *Bifidobacteria Microflora*, 10, 11-17.

Ziegler EE, Fomon SJ (1983) Lactose enhances mineral absorption in infancy. *Gastroenterol Nutr* **2**, 288–294

Zohoori FV, Moynihan PJ, Omid N, et al (2012). Impact of water fluoride concentration on the fluoride content of infant foods and drinks requiring preparation with liquids before feeding. *Community Dentistry and Oral Epidemiology*, 40, 432-440.

Index

Numbers refer to section or subsection numbers unless otherwise stated.

FIRST STEPS NUTRITION TRUST