Applied Horticultural Research Pty Ltd

Final Report for Horticulture Australia Ltd

Project AV09000 (completed June 6th 2011)
Identifying bioactive components and portion size in avocados for consumer health

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Horticulture Australia Ltd Final Report

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This project has been funded by HAL using the Avocado levy and matched funds from the Australian Government. The project firstly aimed to clarify the food labelling guidelines which were complex and under review and to establish a suitable portion size for avocados in a healthy, balanced diet. Additional nutrient data was needed to update the nutritional databases for Shepard and Hass avocados and to identify differences in nutrient content relative to season and district. In addition, some consumer focus groups were held to determine how to communicate the revised health information to consumers.

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TABLE OF CONTENTS

MEDIA SUMMARY

Regulatory review summary

Food Standards Australia New Zealand is developing a new food standard that may allow the use of more health claims for foods on packaging and in advertising. At present nutrient content and nutrient function claims for foods are generally permitted, but claims about health enhancement or reduction of risk of diseases are not permitted. It is unlikely that other claims about reduced risk of serious diseases (such cancer or cardiovascular disease) or prevention of macular degeneration could be made without substantial further research. The literature was searched for evidence that could support a health claim for avocados and it was concluded that there is not currently enough evidence to support a health claim specific to avocados.

Nutrient labelling and source claims

There are several nutrients that have potential for nutrient claims in avocados. These are: total phytosterols, monounsaturated and polyunsaturated fatty acids, folate, Niacin (Vitamin B3), and total dietary fibre.

The high phytosterol content of Hass and Shepard avocados is an important finding, with the potential to be used to promote avocados as healthy food which can help to reduce blood LDL cholesterol levels with the associated beneficial effects on cardiovascular health. High levels of monounsaturated fats were confirmed and this finding adds weight to the idea that avocados have significant potential benefits on cardiovascular health, similar to olive oil.

Avocados are an excellent source of dietary fibre, at a high enough level for a good source claim. Avocados should be actively promoted for their dietary fibre content. Avocados contain folate at a level high enough to support a good source nutrient claim.

Portion size modelling

Avocados are mainly purchased in the fresh state and it is likely to be the consumer who determines portion size depending on the way in which the food is going to be used. In this context nutritional information on 100g will remain useful, preferably supplemented with recipe and culinary suggestions. Replacing fruit or fat servings with avocados does have an impact on the total nutrient composition of the diet. The nutrients affected by replacing a fat serving were less significant than replacing a fruit serving and therefore it would be suggested that avocado be considered as a healthy fat alternative within the context of a healthy balanced diet.

Consumer focus group studies

Avocados were recognised as a food product of interest by all participants in the focus group sessions. Three key influences relating to convenience, food use and healthiness perceptions (nutrition messages) were identified as having an impact on the regular inclusion of avocados in the diet across all groups, although variations in emphasis was evident depending on the life stage and gender of the main grocery buyer.

Convenience was the primary reported influence on choice of food shopping venues in all groups. However the participants reported there was an acknowledged trade off with limiting shopping venues to large supermarkets. The taste preferences of spouses and children reportedly influenced the ways in which avocados were utilised in the home. Overall, avocados were reported to be used primarily as a snack or a fat replacement product. It was often used to replace margarine or butter on sandwiches and added to salads. The messages related to avocados were seen to be reassuring for the younger participants but were not seen to be particularly useful. Messages specifically referring to antioxidant and vitamins were often related to beauty products as opposed to foods and messages that were strongly associated with other product categories. The wording of the messages had a strong impact on the acceptance of the claim with scientific terms often rejected.

TECHNICAL SUMMARY

Regulatory review summary

Food Standards Australia New Zealand is developing a new food standard that may allow the use of more health claims for foods on packaging and in advertising. At present nutrient content and nutrient function claims for foods are generally permitted, but claims about health enhancement or reduction of risk of diseases are not permitted (with one exception about folate and birth defects). It is unlikely that the new standard will be in place before late 2011 at the earliest.

The following types of claims could be used immediately for Avocados:

- *Avocados form part of a healthy diet of fruits and vegetables.*
- *Avocados are a natural source of antioxidants.*
- *Avocados are a natural source of antioxidants that help protect the cells from oxidative damage.*
- *Avocado is a natural source of antioxidants vitamins A, C and E that help protect the cells from oxidative damage.*
- *A natural source of the antioxidants – to help keep your body healthy.*
- *Antioxidants in avocados help protect the body against free radical damage.*
- *Avocados are a source of vitamins B1, B2, B6, magnesium and copper.*
- *Avocados are a good source of vitamin C, vitamin E, niacin, pantothenic acid, folate and beta-carotene.*
- *Avocados are high in fibre.*
- *Avocados are low in salt.*
- *Avocados are cholesterol free.*

The following claim may be able to be used when the new Nutrition and Health Claims standard comes into force:

- *Eating a diet rich in fruits and vegetables as part of an overall healthy diet may reduce risk for stroke and perhaps other cardiovascular diseases.*

It is unlikely that other claims about reduced risk of serious diseases (such cancer or cardiovascular disease) or prevention of macular degeneration could be made without substantial further research.

Literature Review

In this review the literature was searched for evidence that could support a health claim for avocados. The outcome was that there is not currently enough evidence to support a health claim specific to avocados.

The primary components of avocados are the lipids and lipid soluble vitamins. A review of Australian and overseas nutrient composition databases revealed that avocados can range from 10-26% total fat content of which 5-17% is monounsaturated (primarily oleic acid). Avocados also contain 6-17.4 mg/100g Vitamin C, 1.3-2.66 mg/100g alpha-tocopherol (Vitamin E) and 20-81µg/100g beta-carotene (Vitamin A). The range of scientific literature relating to avocados is broad though for the purpose of this project the number of scientific publications was limited. Many published articles relating to avocados address the agricultural impact or disease impact of the fruit. Of the 488 publications obtained, 52 were further reviewed for relevance in their full text format.

Due to the limited numbers of studies related to avocados and health, further research is required to substantiate this relationship. A high quality, well controlled randomised controlled trial would be recommended though any relationship found should not be considered in isolation but rather in the context of the whole diet.

Nutrient labelling and source claims

There are several nutrients that have potential for nutrient claims in avocados. These are: total phytosterols, monounsaturated and polyunsaturated fatty acids, folate, Niacin (Vitamin B3), and total dietary fibre.

The high phytosterol content of Hass and Shepard avocados is an important finding, with the potential to be used to promote avocados as healthy food which can help to reduce blood LDL cholesterol levels with the associated beneficial effects on cardiovascular health. High levels of monounsaturated fats were confirmed and this finding adds weight to the idea that avocados have significant potential benefits on cardiovascular health, similar to olive oil.

Avocados are an excellent source of dietary fibre, at a high enough level for a good source claim. Avocados should be actively promoted for their dietary fibre content. Avocados are also a good source of folate, which is necessary for normal blood formation and is essential for normal cell growth and development, especially during pregnancy. The level of folate is high enough in all the samples measured to date for a good source nutrient claim.

The Niacin content in avocados was high enough across all the growing districts and cultivars sampled to make a source claim for this nutrient. The levels of vitamins E, C and beta carotene were not consistently high enough to justify source claims.

We suggest good source claims for total phytosterols, monounsaturated and polyunsaturated fatty acids, folate and total dietary fibre and a source claim for Niacin (Vitamin B3). Supporting data should be reviewed to ensure it meets the requirements of the new legislation relating to this area within FSANZ is finalised.

Portion size modelling

The outcome of the portions size modelling work used a serving size of 2 slices or 30g. Based on a reference energy value of around 250KJ this would enable a serving of avocado to equate as a serve of a fruit (267kJ) and a serve of fats/oils - equivalent in kilojoules to 1.5 teaspoons of oil.

The models in this project have shown that replacing fruit or fat servings with avocados does have an impact on the total nutrient composition of the diet. The nutrients affected by replacing a fat serving were less significant than replacing a fruit serving and therefore it is suggested that avocados be considered as a healthy fat alternative within the context of a healthy balanced diet.

The models created did incorporate avocado as a serving on a daily basis and were limited to the use of a serving size determined from authoritative sources (1/8 whole) rather than from separate modelling work as well.

Future work would recommend the serving size for avocados be modelled before it is incorporated into a healthy balanced diet and that a collection of options for the frequency of intake be considered. This would take into consideration the various cuisine patterns that use avocado as a spread, a dip, a key component in significant dishes, or a light meal or snack in itself. It would also be possible to link this with the diet models that have been developed using the reference serve size developed for the modelling exercise undertaken in this report.

Finally, with avocado purchased in the fresh unit state, it is likely to be the consumer who determines portion size depending on the way in which the food is going to be used. In this context nutritional information on 100g will remain useful, preferably supplemented with recipe and culinary suggestions.

Consumer focus group studies

Avocados were recognised as a food product of interest by all participants in the focus group sessions. Three key influences relating to convenience, food use and healthiness perceptions (nutrition messages) were identified as having an impact on the regular inclusion of avocados in the diet across all groups, although variations in emphasis was evident depending on the life stage and gender of the main grocery buyer.

Convenience was the primary reported influence on choice of food shopping venues in all groups. However the participants reported there was an acknowledged trade off with limiting shopping venues to large supermarkets. Some participants regularly sought out green grocers or local markets for the quality of the product. Price and quality were also reported to influence the frequency of purchases and hence frequency of consumption of the avocado. The impact of significant others on food selection was noted primarily through factors such as meeting flavour preferences and managing time constraints.

The taste preferences of spouses and children reportedly influenced the ways in which avocados were utilised in the home. Overall, avocados were reported to be used primarily as a snack or a fat replacement product. It was often used to replace margarine or butter on sandwiches and added to salads. Older females enjoyed using avocados in cooked dishes while some of the male participants expressed a distaste for hot avocado products. Storage of avocados during ripening and after cutting them open was also an area of concern commented upon within all groups.

The messages related to avocados were seen to be reassuring for the younger participants but were not seen to be particularly useful. Messages specifically referring to antioxidant and vitamins were often related to beauty products as opposed to foods and messages that were strongly associated with other product categories A disconnect was raised over claims relating to specific minerals for the female groups, while the males were not as concerned and felt listing minerals could be useful. The wording of the messages had a strong impact on the acceptance of the claim with scientific terms often rejected.

Areas that could be further pursued from a sales and marketing perspective may include:

- Taste testing promotions in supermarket chains to increase overall awareness and disseminate recipe ideas for the use of avocado
- Different varieties that are available seasonally may be linked in with recipe campaigns and used to link in new uses for avocado e.g. cold/fresh dishes in the hotter months and warm/creamy dishes in the cooler months.
- Packaging promotions where multiple avocados can be purchased together. The packaging/container could be used to educate consumers.

- Storage containers/techniques/implements to decrease the desire to eat the entire avocado in one sitting yet maintain quality of the fruit for use in the next sitting, potentially increasing the frequency of purchasing due to decreased concerns about food wastage.

INTRODUCTION

Avocados have long been seen by consumers as a nutrient rich food, particularly as they are a good source of heart healthy monounsaturated fats. Approximately 22% of the energy in avocado is found as fat, more than half of which is monounsaturated. Monounsaturated fats have been extensively studied for their cardiovascular health benefits, most notably positive effects on serum lipids when saturated fat intake is also reduced in the diet.

Further research reveals avocados contain a variety of bioactive chemicals which may be beneficial to human health. Avocado contains significant amounts of beta-phytosterol, phytosterols are plant analogues of cholesterol which act to inhibit intestinal absorption of cholesterol, thereby further enhancing the beneficial effects of avocado on the cardiovascular system.

Avocados also contain vitamins C and E as well as significant levels of the carotenoid lutein, each of which exert antioxidant actions in the body. Research by Lu et al (2005) reported that an acetone extract of avocado containing carotenoids and tocopherols inhibited the growth of prostate cancer cell lines in vitro. The paper suggests that because avocado contains a significant amount of monounsaturated fat the bioactive carotenoids are likely to be absorbed more easily into the blood stream rather than excreted from the body. Furthermore avocados are a good source of both soluble and insoluble fibre, contributing to feelings of satiety as well as gastrointestinal health.

The NUTAB 2006 guidelines for the nutrient composition of avocados contains data collected from 1983 – 1998. The varieties sampled were Fuerte and Hass. For the levels of proximate, vitamins and some fatty acids composite samples of 1kg of Fuerte and 1kg of Hass avocados from 5 outlets in Sydney were sampled. In 1997 this was repeated with 9 purchases of Hass avocados from 9 supermarkets in Melbourne and it was repeated again in 2000 again for Hass avocados. The analysis for trace elements and amino acids was collected from 2kg of the edible portion of Fuerte avocados from the Melbourne markets (NUTTAM 2006 online version, FSANZ). This information needed to be updated for new varieties and also for new supply chains.

This project aimed to collect new data on the levels of nutrients and bioactive compounds in Hass and Shepard avocados because this data was either limited or nonexistent in the current NUTAB 2006 guidelines. The new nutrient data collected from the project could also be used to better inform consumers regarding nutrient claims (nutrients with more than 10% RDI). For the bioactive compounds a review was done by the University of Wollongong's Smart Foods centre to identify bioactive compounds in avocados that could be important for human health. That review will include the finding from recently completed project AV07003: Determination of health-promoting bioactives in Australian avocados.

Another reason for this project was that Food Standards Australia New Zealand (FSANZ) is in the process of developing a policy (p293) for Nutrition, Health and Related Claims. It is intended that this policy will clarify the use of the guidelines for major health claims, such as "this product is high in X and could protect against Y". These claims cannot be made unless there is substantial scientific evidence to support the relationship, and high level claims must specifically be approved by FSANZ. However, nutrient content claims can readily be made on product labels, and can therefore be applied to packaged fresh fruit and vegetables if the data showing that the nutrient is above 10% of the recommended daily intake (RDI). For some crops this data is not available for others it is old or incomplete. Avocados fall in to the latter category.

Although FSANZ is responsible for defining food standards, enforcement of those standards is managed by other government departments such as State and Territory Health Departments, the New Zealand Food Safety Authority, and AQIS. There are important provisions in State and Territory Food Acts, the New Zealand Food Act 1981, and the Imported Food Control Act 1992 which provide various defences for failure to comply with food standards. The ACCC also helps to regulate food standards and labelling through the Trade Practices Act (1974).

Nutrient content claims are not commonly used for fresh produce. However, the current interest by consumers in phytonutrients and bioactive compounds means that it could be used and so it is important that the application of the Food Standards Code is clarified for the horticultural industry.

Reference:

Lu, Q-Y; Arteaga, J.R.; Zhang, Q.; Heurta, S.; Go, V.L.W. and Heber. D. (2005) Inhibition of prostrate cancer cell growth by an avocado extract: role of lipd-solube bioactive substances. Journal of Nutritional Biochemistry 16: 23 - 30.

Regulatory Review and Scientific Literature Review

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Background

Avocados have long been seen as a nutrient rich food, particularly as a good source of monounsaturated fatty acids. Common varieties in Australia for example are the Hass, Shepard and Fuerte varieties though other varieties grown in Australia include the Sharwil, Pinkeston, Wurtz, Bacon, Cocktail, Gwen, Hazzard and Reed varieties (Melbourne Market Authority). Avocados range in size and shape from the classic pear shape of the Fuerte through to a cucumber shaped cocktail avocado or more rounded Gwen avocado. Approximately one-fifth of the energy in avocado is provided as fat, more than half of which is monounsaturated, depending on the type. Monounsaturated fatty acids have generally been studied for their cardiovascular health benefits, most notably for their positive effects on serum lipids when saturated fat intake is also reduced in the diets.

Further research reveals avocados contain a variety of bioactive chemicals which may be beneficial to human health. Avocado contains significant amounts of beta-phytosterol and phytosterols, plant analogues of cholesterol, which act to inhibit intestinal absorption of cholesterol, thereby further enhancing the beneficial effects of avocado on the cardiovascular system.

Avocados also contain vitamins C and E as well as significant levels of the carotenoid lutein, each of which exert antioxidant actions in the body (Zabaras 2008). Furthermore, avocados are a good source of both soluble and insoluble fibre, contributing to feelings of satiety as well as gastrointestinal health.

An initial search of the scientific literature reveals much of the research surrounding avocado is dated. A review of this, along with the more recent scientific evidence on the nutrient content and health benefits of avocado would be warranted to further detail the health effects of bioactive compounds naturally present in avocado.

Rationale and objectives

1. Establish guidelines for the horticultural industry on the regulations governing nutrition claims for avocados.
2. Characterise the nutritional content of avocado and the extent of scientific research on potential health benefits.

Methods

Regulatory Review and Opportunities

Guidelines from following organisations were reviewed and in combination with the nutritive properties of avocados, opportunities for label claims were compiled.

- Food Standards Australia New Zealand
- Australian Competition & Consumer Commission (ACCC)
- Australian Food and Grocery Council (AFGC)

Literature Review and Recommendations

A review of food composition databases for the following countries was conducted to determine the existing composition information for Avocados and compliment the analysed data. Nutrient data was obtained for

- Australia
- New Zealand
- France
- Finland
- Denmark
- USA

A literature search of the CINAHL, Cochrane, Medline (1996-2010), PsychInfo (1987-2010) and Science Direct databases was conducted for the years 2000-2010. Using the search term avocado* alone, the following number of records were retrieved: CINAHL (78), Cochrane (1), Medline (330), PsychInfo (11) and Science Direct (5,094).

Using the search terms avocado*, persea Americana, limited to English language and humans. A total of 42 publications were obtained from CINAHL, 1 from Cochrane reviews, 130 from Medline, 11 from Psych Info and 308 from ScienceDirect. Of these 115 were duplicate publications. Abstracts from the remaining 488 publications were reviewed for relevance.

Studies were excluded if they did not address a specific health condition/risk (e.g. fruit-latex allergy, childbirth/abortion) or the nutrient content of avocados, were of an agricultural or purely botanical focus, focussed on an inedible component of the avocado (i.e. leaf or seed), did not address humans or animals for which results may relate to humans, were not English language, were not available in full text (i.e. conference abstract only) or were not available in their final published form (i.e. corrected proofs). The remaining 52 publications were obtained in full text and reviewed further. The majority of excluded studies included those about latex-fruit allergy, agricultural systems and avocado soybean unsaponifiables. Inedible parts of the avocado were considered a diuretic for kidney conditions and hypertension and for use in regulation of women’s menstrual cycles or as an abortifactant.

A summary of the research on key nutrient and bioactive components of avocado and their health benefits was compiled. This information was used to develop recommendations for AHR for the priority nutrients to analyse.

Regulatory Review

Summary of Regulatory review Findings

Food Standards Australia New Zealand is developing a new food standard that may allow the use of more health claims for foods on packaging and in advertising. At present nutrient content and nutrient function claims for foods are generally permitted, but claims about health enhancement or reduction of risk of diseases are not permitted (with one exception about folate and birth defects). It is unlikely that the new standard will be in place before late 2011 at the earliest.

The following types of claims could be used immediately for Avocados:

- *Avocados form part of a healthy diet of fruits and vegetables.*
- *Avocados are a natural source of antioxidants*
- *Avocados are a natural source of antioxidants that help protect the cells from oxidative damage*
- *Avocado is a natural source of antioxidants vitamins A, C and E that help protect the cells from oxidative damage*
- *A natural source of the antioxidants – to help keep your body healthy*
- *Antioxidants in avocados help protect the body against free radical damage*
- *Avocados are a source of vitamins B1, B2, B6, magnesium and copper*
- *Avocados are a good source of vitamin C, vitamin E, niacin, pantothenic acid, folate and beta-carotene*
- *Avocados are high in fibre*
- *Avocados are low in salt*
- *Avocados are cholesterol free*

The following claim may be able to be used when the new Nutrition and Health Claims standard comes into force:

- *Eating a diet rich in fruits and vegetables as part of an overall healthy diet may reduce risk for stroke and perhaps other cardiovascular diseases*

It is unlikely that other claims about reduced risk of serious diseases (such cancer or cardiovascular disease) or prevention of macular degeneration could be made without substantial further research.
Overview of Current Australian Regulations for Labelling and Advertising: Food Standards Australia New Zealand
Nutrition, health, and related claims for food (both on labels and in advertising) are regulated in Australia through an integrated regulatory system involving both National and State agencies as well as voluntary industry codes of practice. Food standards are developed by the bi-national statutory agency FSANZ (Australia New Zealand Food Authority 2002) and these standards are adopted by State governments who have the role of compliance enforcement.

Interpretive guides on the standards are also available from FSANZ (Food Standards Australia New Zealand 2008b). Among other things, these food standards cover:
general labelling provisions about the ingredients in foods – Standard 1.2.4
the elements in the mandatory nutrition information panel (NIP) that must appear on all packaged food as well as regulations on additional voluntary and claims about the presence or absence of nutrients – Standard 1.2.8

- the special labelling requirements for foods requiring pre-market approval (eg novel foods, foods with genetically modified ingredients, or irradiated foods) – Standards 1.5.1-3

- health claims for foods - Standard 1.1A.2

At present in Australia and New Zealand nutrient content claims are allowed (*e.g. 'this food is a source of vitamin C'*) provided the food provides at least 10% of recommended dietary intake (RDI) per serve for a 'source' claim, or 25% RDI per serve for a 'good source/high' claim. (*Note*: for labelling purposes FSANZ defines RDI values in Standard 1.1.1, which in some cases are different to those defined by the National Health and Medical Research Council. FSANZ is planning to commence a review of these claimable levels at the end of this year and it is possible that in the next few years the values for some nutrients, like folate, will be revised upwards, but for the moment all claims must conform to current regulations). Some general level health-maintenance claims (nutrient function claims that describe the normal role of nutrients in the maintenance of health) are also permitted.

The predecessor of FSANZ developed guidance material on what sort of nutrient function claims were acceptable, and developed a list of examples – e.g., ' *fibre helps eliminate waste products from the body'* (National Food Authority 1993). However, other types of health claims about the potential health benefits of foods are prohibited, with the sole exception of claims about the benefit of maternal consumption of folate, to reduce the risk of foetal neural tube defects. That claim is permitted for a defined range of foods listed in Standard 1.1A.2 – which includes avocado. To be eligible, a food must contain at least 40µg folate per serve and not more than 14g fat, 500mg sodium or 10g added sugar.

FSANZ is currently developing a new standard which will permit scientifically substantiated health claims for foods that meet certain nutrient profiling criteria. The new Nutrition, Health and Related Claims Standard will encompass two levels of health claims: general level health claims and high level health claims. The level of a claim will determine how the claim is regulated, including the evidence required for substantiation (Food Standards Australia New Zealand 2008a).

General Level Health Claims - do not reference a biomarker (eg, blood cholesterol or blood pressure) or a serious disease or condition and include content claims, function claims, enhanced function claims and risk reduction claims that reference a non-serious disease or non-serious condition. There are three types of general level claims:

a) Nutrient Function Claims – which describe the biological role of a food or energy or a nutrient [or a biologically active substance] in normal growth, development, maintenance and other like functions in the body (e.g. "*Iron helps transport oxygen around the body")*

b) Enhanced Function Claims - which describe the biological role of a food or energy or a nutrient [or a biologically active substance] beyond normal growth, development, maintenance and other like functions of the body (e.g., "*XX can help improve concentration")*

C) Risk Reduction Claims in relation to a non-serious disease or condition - which describe the biological role of a food or energy or a nutrient [or a biologically active substance] in significantly reducing the risk of developing a non-serious disease or condition (e.g., "*XX may help reduce the risk of acne")*

In the original proposed new framework, food companies would not need pre-approval to make general level claims but must use either a FSANZ model list of approved statements, or provide suitable scientific texts or dietary guidelines to support the claim, or must hold scientific evidence to substantiate such claims and produce this evidence, on request, for enforcement agencies.

The following sites provide guidance as to the sort of general level claims that are likely to be acceptable:

- Dietary Guidelines for Australian Adults
  National Health and Medical Research Council.
  http://www.nhmrc.gov.au/publications/synopses/dietsyn.htm
- Generic Health Claims
  Joint Health Claims Initiative (JHCI), United Kingdom
  http://www.jhci.org.uk/
- Health Claims in the Labelling and Marketing of Food Products, The Food Sector's Code of Practice
  Swedish Nutrition Foundation.
  http://www.snf.ideon.se/snf/en/rh/Healh_claims_FF.htm
- Health Claims that meet Significant Scientific Agreement (SSA)
  Food and Drug Administration, USA
  http://www.fda.gov/food/labelingnutrition/labelclaims/healthclaimsmeetingsignificantscientificagreementssa/default.htm
- Health Claims based on an Authoritative Statement of a Scientific Body
  Food and Drug Administration, USA
  http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/FoodLabelingNutrition/ucm056975

High level claims – are claims which reference a biomarker or a serious disease or condition and include biomarker maintenance claims, biomarker enhancement claims and risk reduction claims which reference a serious disease or condition

a) Biomarker Maintenance Claims – describe the biological role of a food or energy or a nutrient [or a biologically active substance] in maintaining a normal level of a recognized biomarker (e.g., *helps maintain normal blood cholesterol*)
b) Biomarker Enhancement Claims – describe the biological role of a food or energy or a nutrient [or a biologically active substance] in reducing or increasing the level of a recognized biomarker (e.g., *helps reduce cholesterol*)
c) Risk Reduction Claims which reference a serious disease or condition - describe the biological role of a food or energy or a nutrient [or a biologically active substance] in significantly reducing the risk of developing a serious disease or condition (e.g., *helps reduce the risk of cardiovascular disease*)

FSANZ commissioned a series of scientific reviews of the evidence for a number of proposed pre-approved health claims to include in the new standard (Food Standards Australia New Zealand 2007b). After these reviews, only eight have ultimately been accepted for inclusion in the new standard as high level claims, relating to the following food or nutrient-disease relationships:

- Sodium (with or without potassium) and hypertension;
- Fruit and vegetables and coronary heart disease;
- Saturated fat (with or without trans fat) and elevated serum cholesterol and heart disease;
- Calcium (with or without vitamin D) and osteoporosis;
- Folate and neural tube defects.

In the future, if the new Standard is approved, manufacturers would be able to make applications for approval of other claims, which will need to be scientifically substantiated. FSANZ has developed a substantiation framework, to be used by manufacturers wanting to apply for approval to use a health claim on a product (Food Standards Australia New Zealand 2008a).

The Final Assessment Report for Proposal P293, including draft Standard 1.2.7 – Nutrition, Health and Related Claims, was approved by the FSANZ Board in March 2008 and notified to the Australia and New Zealand Food Regulation Ministerial Council. The Council considered the draft and requested FSANZ undertake a review to consider a range of concerns about operation of the standard.

On 20 March 2009, FSANZ released a Consultation Paper which summarises proposed changes to address two of the key issues raised in the First Review Request: http://www.foodstandards.gov.au/standardsdevelopment/proposals/proposalp293nutritionhealthandrelatedclaims/index.cfm. The main proposed difference is for the regulation of general level health claims to be changed from industry self-substantiation, to an approach where such claims are only permitted if they refer to a food-health relationship listed in the Food Standard Code.

Since then the government has set up a broad-ranging review of food labelling law and policy in general, led by Dr Neil Blewett, which is due to report at the end of 2010. http://www.health.gov.au/internet/main/publishing.nsf/Content/review-food-labelling-law-&-policy Because of this, consideration of the proposed health claims standard has been put on hold until the findings of this review are considered, and it is therefore unlikely that health claims will be considered again by the Ministerial Council before March 2011.

The proposed new standard lists a number of ***proposed nutrient function claims*** (Table 12) that would be permissible, including the following that might be relevant to avocados:

Table 12: Proposed nutrient function claims

Property of food	General claim conditions	Specific descriptor	Specific descriptor conditions
Dietary fibre	Contributes to regular laxation	The food meets the general conditions for making a nutrition content claim about dietary fibre.	
Vitamin C	Enhances absorption of iron from food	The food meets the general conditions for making a nutrition content claim about vitamin C.	
	Necessary for normal structure and/or function of connective tissue	The food meets the general conditions for making a nutrition content claim about vitamin C.	
	Necessary for normal structure and function of blood vessels		
	Contributes to cell protection from the damage caused by free radicals		
	Necessary for normal neurological function		
	Contributes to normal growth and development		For children
Vitamin A	Necessary for normal vision	The food meets the general conditions for making a nutrition content claim about vitamin A	
	Necessary for normal structure and function of the skin and mucous membranes		
	Necessary for normal cell differentiation		
	Contributes to normal growth and development		For children
Folate	Necessary for blood formation	The food meets the general conditions for a nutrition content claim about folate.	
	Necessary for normal cell division		

	Necessary for normal growth and development		For children
Niacin	Necessary for normal neurological function Necessary for normal energy release from food Necessary for normal structure and function of skin and mucous membranes	The food meets the general conditions for making a nutrition content claim about niacin.	
	Contributes to normal growth and development		For children
Pantothenic acid	Necessary for normal fat metabolism	The food meets the general conditions for making a nutrition content claim about pantothenic acid.	
	Contributes to normal growth and development		For children
Thiamin	Necessary for normal carbohydrate metabolism Necessary for normal neurological and cardiac function	The food meets the general conditions for making a nutrition content claim about thiamin	
	Contributes to normal growth and development		For children
Riboflavin	Contributes to normal iron transport and metabolism Contributes to normal energy release from food Contributes to normal skin and mucous membrane structure and function	The food meets the general conditions for a nutrition content claim about riboflavin	
	Contributes to normal growth and development		For children
Vitamin B6	Necessary for normal protein metabolism Necessary for normal iron transport and metabolism	The food meets the general conditions for making a nutrition content claim about vitamin B6	
	Contributes to normal growth and development		For children
Vitamin E	Contributes to cell protection from free radical damage	The food meets the general conditions for making a nutrition content claim about vitamin E.	
	Contributes to normal growth and development		For children
Vitamin K	Necessary for normal blood coagulation Contributes to normal bone structure	The food meets the general conditions for making a nutrition content claim about vitamin K	
	Contributes to normal growth and development		For children
Copper	Contributes to normal connective tissue structure Contributes to normal iron transport and metabolism Contributes to cell protection from free radical damage Necessary for normal energy production Necessary for normal neurological function Necessary for normal immune system function Necessary for normal skin and hair colouration	The food meets the general conditions for making a nutrition content claim about copper.	
	Contributes to normal growth and development		For children
Magnesium	Contributes to normal energy metabolism Necessary for normal electrolyte balance Necessary for normal nerve and	The food meets the general conditions for making a nutrition content claim about magnesium.	

	muscle function		
	Necessary for teeth and bone structure		
	Contributes to normal growth and development		For children
Potassium	Necessary for normal water and electrolyte balance	The food must contain a minimum potassium level of 200 mg/serving.	
	Contributes to normal growth and development		For children

It also list the following ***proposed pre-approved high level health claims:***

Table 13: Proposed pre-approved high level health claims

Property of food	General claim conditions	Specific descriptor	Specific descriptor conditions
Folic acid	Reduced risk of foetal neural tube defects	(a) the food contains no less than 40 μg folic acid per serving; and	(a) the population group is women of child bearing age; and (b) a varied diet including food sources of folate and a recommendation that women consume at least 400 μg of folic acid per day, at least the month before and three months after conception.
Increased intake of fruit and vegetables	Reduced risk of coronary heart disease	(a) claims are not permitted on – (i) fruit juice or vegetable juice standardised under Standard 2.6.1; or (ii) non alcoholic beverages and brewed soft drinks standardised under Standard 2.6.2; and (b) the food contains no less than 90% fruit or vegetable by weight.	Healthy diet with an increased intake of both fruit and vegetables and consisting of a variety of foods.
A high intake of fruit and vegetables	Reduced risk of coronary heart disease	(a) claims are not permitted on – (i) fruit juice or vegetable juice standardised under Standard 2.6.1; or (ii) non alcoholic beverages and brewed soft drinks standardised under Standard 2.6.2; and (b) the food contains no less than 90% fruit or vegetable by weight.	Healthy diet high in both fruit and vegetables and consisting of a variety of foods.
Fruits and vegetables	Contributes to heart health	(a) the food is not – (i) fruit juice or vegetable juice as standardised by Standard 2.6.1; or (ii) a food standardised by Standard 2.6.2; and (b) the food contains no less than 90% fruit or vegetable by weight.	(a) Healthy diet with an increased intake of both fruit and vegetables and consisting of a variety of foods *or* (b) Healthy diet with a high intake of both fruit and vegetables and consisting of a variety of foods.

Communication of Health Messages to Consumers

Food labels are an important tool to assist consumers in making healthy food choices. In addition to mandatory nutritional labelling information, manufacturers have a variety of options on food packages to communicate the nutrition and health benefits of their products (Agarwal, Hordvik *et al.* 2006). However, consumers often express concern that health claims are just another sales tool, and the use of poorly substantiated claims could increase the current levels of consumer scepticism about all attempts to communicate the health benefits of food (Williams 2005). Recent trends in the USA and the EU indicate that in the future regulators may require further research to test how consumers are likely to interpret and use any health claim.

Nutrient profiling

Nutrient profiling of foods is the science of categorizing foods based on their nutrient composition. For regulatory agencies, nutrient profiles can be the basis for disallowing nutrition or health claims and for regulating advertising to children. The EU and Australia/New Zealand have adopted nutrient profiling as the basis for regulating which foods will be permitted to carry health claims. The Australian approach proposes a mixed scoring system of disqualifying nutrients (energy, saturated fat, sodium, sugar) balanced with positive scores for protein, fibre, fruit and vegetable content (Food Standards Australia New Zealand 2008a). In general, plain fruits and vegetables will have little difficulty meeting the nutrient profiling criteria.

Australian Competition & Consumer Commission (ACCC)

The ACCC has responsibility for enforcement of the Trades Practices Act, which generally prohibits any form of false or misleading claims in relation to all products on sale or in advertising, including food. The ACCC has developed guidelines related to a number of issues concerning food in their publication *Food descriptors guideline to the Trade Practices Act* (Australian Competition and Consumer Commission 2006). However, the ACCC takes a wide view of evidence as to whether a claim on labels or in advertising is misleading, and impressions provided by graphics and design can be taken into account, not just the accuracy of specific text. The ACCC does not necessarily accept guidelines from FSANZ when deciding what are false or misleading representations. For example, previously FSANZ had allowed claims of ‘fat free’ on products that contained minimal levels of fat (<0.15%). The ACCC has taken a more rigorous interpretation, and decided that unless a product contains zero fat, claims of ‘fat free’ would be false and misleading.

Australian Food and Grocery Council (AFGC)

The AFGC has produced a voluntary code of practice on the provision of information on food products (Australian Food and Grocery Council 1995). This incorporates a code of practice on nutrient claims that was earlier developed by the National Food Authority, which sets the levels of nutrients required in foods to be able to make claims about high, low, reduced or increased levels of nutrients, or comparisons between products (National Food Authority 1995). In general products need to have a difference of at least 25% from comparison products to be able to make claims of nutritional superiority.

The fact that this guide is only voluntary has led to a considerable amount of non-compliance – particularly for claims about “% fat free”. As a result, it is proposed that all claims for nutrient content will be included in black letter law of the new food standards on nutrition, health and related claims.

Comment on Current Claims in the Market

Despite the current prohibition on health claims, there are a number of claims on products at present that appear to be non-compliant with current regulations. The prevalence of health claims on labels, in magazines and on the internet, and the level of compliance of these claims with existing regulations, has been studied recently in a series of studies from the Smart Foods Centre (Dragicevich, Williams *et al.* 2006; Williams, Ridges *et al.* 2006; Williams, Tapsell *et al.* 2007). These data show that many of the claims in the Australia food market at present are high level claims or therapeutic claims which are not legally permitted by current food standards. In some cases this may be due to lack of awareness of the regulations, or in some cases the claims are carefully worded to be a *Nutrient Function Claim* (which is permitted) rather than a *Health Claim*.

Claims about antioxidants are not regulated within current Food Standards or the voluntary Code of Practice on Nutrient Claims (because “antioxidant” is not a specific nutrient), but they would fall under the category of claims about “bioactive substances” that will be referred to in Clause 11 of the proposed new standard on health claims. In this standard it is proposed that manufacturers would need to define for themselves the daily reference quantity of the substance that is recommended, and then products would need to contain at least 10% of that level per serve to justify a claim.

Table 14, below shows how antioxidant ingredients are being claimed in the Nutrition Information Panel on a variety of packaged food products in the market today.

Table 14: NIP antioxidant claims in the market today

Brand	Product	Entry in NIP	Quantity and Units
Lipton	Iced Tea	Flavonoid antioxidants	26mg/100mL
Pokka	Iced Tea	Catechins (antioxidants)	10mg/mL
Leggos	Tomato Paste	Lycopene	43mg/100g
Twinings	Tea	Flavonoid antioxidants	25-60mg/100mL
Ocean Spray	Cranberry Juice	Phenolic antioxidants	60mg/100mL
Nestle	Noir Chocolate	Total polyphenols (epicatechin equivalents)	Min 1000mg/100g
Nestle	Nescafe	Natural coffee polyphenols and melanoidin antioxidants	210mg/100mL
Uncle Toby’s	Plus Antioxidant Lift (cereal)	Vitamin A Vitamin E	200µg/100g (25% RDI) 2.5mg/100g (25% RDI)
Woolworths	Dark berry blend muesli	Antioxidant	1190TE* (*Trolox equivalent)

Other claims in the market

There are many other nutrient and health claims currently in the market. Table 15 gives some examples of different types of health claims on the market that are permissible and those that breach current regulations (Williams, Tapsell *et al.* 2007).

Table 15: Examples of different types of health claims on the market

Permissible	Not permissible
Assists in maintaining digestive health	Beta-glucan from oats can help the body control cholesterol levels
With calcium for strong bones and teeth	A diet rich in phytoestrogens may decrease the risk of breast cancer
Zinc is an important mineral that helps support kid's healthy growth	Can help with weight loss by keeping you fuller for longer
Provides sustained energy release	A low GI diet can help diabetics manage their blood glucose levels

Enforcement of Food Standards

Enforcement of the food regulations is the responsibility of the Health Departments in individual States. Generally the level of auditing of compliance is variable, and labelling breaches are not given a high priority for action, compared to food safety issues. A recent survey on the labelling of 7850 products in 47 different food categories found that more than 5% of health claims were not complying with the current regulations and that the standards were not being fully enforced (Williams, Ridges *et al.* 2006). However, if consumers or competitors notify the departments of apparent breaches of standards, they will usually follow up these cases for action.

Opportunities for Claims

Nutrient Claims

The current Food Standards Code summarises the regulations on nutrient claims in Standards 1.2.8 (FSANZ 2002) with explanatory guidance about this in the Users Guide (Food Standards Australia New Zealand 2008c). The definition of a **nutrition claim** is:

a representation that states, suggests, or implies that a food has a nutritional property whether general or specific and whether expressed affirmatively or negatively, and includes a reference to:

energy, or

salt, sodium or potassium, or

amino acids, carbohydrate, cholesterol, fat, fatty acids, fibre, protein, starch, or sugars, o

vitamins or minerals, or

any other nutrient, or

a biologically active substance.

A nutrient claim (and values declared in the Nutrition Information Panel) must be based on the "average" level of the component in that product. This can be determined in a variety of ways:

a) Laboratory analysis

b) Food composition tables or databases, or *c) Calculation from the actual ingredients used in a product (eg a recipe)*

In the case of fresh produce like Avocados this means the choice is between analysis of products or published data. Detailed discussion of these options is provided in the Users Guide to Standard 1.2.8 (Food Standards Australia New Zealand 2008c) .

At present, Avocados Australia has a website that presents nutrient information based on US analytical data, with claims per 190g serve.
http://www.avocado.org.au/nutrition/nutritional_info_panel.aspx
However, these values are different to the Australian analytical data used by FSANZ and, given the likely variation in nutrient content by variety, season and growing region, it would probably be unwise to rely on overseas published data alone, especially if nutrient function or health claims were to be made.

Of the nutrients found in avocados, the following are likely to be worth consideration for nutrient claims. However claims can only be made if a serve contains at least 10% of the RDI in Standard 1.1.1 (Table 16) - and it is up to the marketer to define and declare what is a serve size, and to have good data on the nutrient content.

It is likely that other nutrients (such a phosphorus, zinc or calcium) would not be present in the levels needed to make a claim.

Table 16: RDI values from standard 1.1.1

Vitamin	RDI
Vitamin B1 (thiamin)	1.1mg
Vitamin B2 (riboflavin)	1.7mg
Vitamin B3 (niacin)	10mg
Vitamin B6 (pyridoxine0	1.6mg
Vitamin C	40mg
Vitamin A	750µg retinol equivalents (= 4500 µg beta carotene)
Folate	200 µg
Pantothenic acid	5mg
Vitamin E	10mg
Vitamin K	80 µg
Magnesium	320mg
Copper	3mg

Antioxidants

- *Avocados are a natural source of antioxidants*

Aside from specific vitamin and mineral claims, a number of products in the market are now making general antioxidant claims (eg, "*rich in antioxidants*". Such claims are not regulated within current Food Standards or the voluntary Code of Practice on Nutrient Claims, but they would fall under the category of claims about "bioactive substances" that will be referred to in the proposed new standard on health claims. In this standard it is proposed that manufacturers would need to define for themselves which components are antioxidants and the daily reference quantity of each substance that is recommended, and then products would need to contain at least 10% of that level per serve to justify a claim. If claims were to be made that a foods was a source of bioactive substances such as lutein and/or zeaxanthin then the marketer would need to be able to have scientific evidence for a recommended daily intake.

Some of the more traditional nutrients in avocados also have antioxidant properties (vitamin A, E and C), and this too could be used to substantiate the antioxidant properties of avocados. Alternatively data on the analysed total antioxidant capacity of avocados could be relied upon (e.g. (Pellegrini, Serafini *et al.* 2003)), although it would be better to use more specific analytical data on particular bioactive substances – such as the carotenoids lutein and zeaxanthin - if possible (see 1.2 for examples of antioxidant claims in the Australian market).

Potential Health Claims

The following comments summarise the status of some potential types of claims that might be made for avocado, although many claims would need to be able to be substantiated with nutritional analysis information.

Folate

One of the pre-approved FSANZ nutrient function claims is that “folate is necessary for normal blood formation”, and under avocados could use this now, provided the folate level was declared in the NIP and contained more than 20 µg/serve (10% RDI in Food Standards Code).
Both content and nutrient function claims could be made:

- *A source of folate*
- *Folate is necessary for normal blood formation*
- *Folate is a B group vitamin that is essential for normal cell growth and development*

Furthermore, under Standard 1.1A.2 of the Food Standards Code, avocado is already listed as a food that would be permitted to make a high level claim for the role of folate in the reducing the risk of neural tube defects, although this may not necessarily be an appealing message to put on a product targeted at a wide population.

Dietary guideline claims

- *Avocados form part of a healthy diet of fruits and vegetables. Eating a diet rich in fruits and vegetables as part of an overall healthy diet may reduce risk for stroke and perhaps other cardiovascular diseases*

The first sentence is fine; it is consistent with Dietary Guidelines for Australians (National Health and Medical Research Council 2003) and is permitted now as normal nutritional advice of a general nature.

The second sentence contravenes current regulations, even though it is a well established fact. However it is one of the claims that has been pre-approved for use in the proposed new health claims standards and could be used once the new standard came into force.

Antioxidant Function Claims

- *Avocados are a natural source of antioxidants which may reduce the risk of cancer*

Any claim about reducing the risk of a serious disease (like cancer or cardiovascular disease) is currently prohibited and would require pre-approval by FSANZ when the new standard comes into law. It is unlikely that there is sufficient clinical evidence yet to substantiate this specific claim adequately. Claims about antioxidants and their normal function in the body would be permissible, provided there was analytical data to demonstrate a reasonable amount present in a single serve. Such claims could be worded as Nutrient Function Claims as follows:

- *Avocados are a natural source of antioxidants vitamins A, C and E that help protect the cells from oxidative damage*
- *A natural source of the antioxidants – to help keep your body healthy*
- *Antioxidants in avocado help protect the body against free radical damage.*

General health benefit claim

- *Avocados are a source of vitamins A, C, E, carotenoids, lutein and zeaxanthin, which have many health benefits*

These types of Nutrient Content Claims are normally permissible, provided they are substantiated. The proposed standards for nutrient claims in P293 are slightly different to the current voluntary standards and it would be prudent to ensure these standards are met before making such nutrient claims.

Comparative Claims

- *Avocado has five times as much beta-carotene as lettuce*
- *Avocados are higher in total antioxidants than tomatoes or apples*

Comparative claims such as this are currently covered under the voluntary Code of Practice on Nutrient Claims (National Food Authority 1995). Normally there needs to be at least a 25% difference before a claim can be made *and* claims are meant to be restricted to comparisons between foods in the same food group. Thus a comparison between a vegetables and meat or dairy foods would normally be discouraged. As with all nutrient content claims, comparisons should take into account the amount per serve, not just the amount per 100g.

Other Claims

There are a number of possible nutrients or nutrient function claims that could be relevant to avocado within current regulations, for example:

- *All the goodness of one serve of vegetables*
- *All natural*

Furthermore, although most vegetables are naturally low in salt and cholesterol, such claims are compelling for consumers and there is no reason not to highlight the fact with claims such as:

- *Low in salt*
- *Cholesterol free*

Final Note

This review has not assessed whether any of these potential claims have sufficient scientific substantiation to support the claim. In the case of function and health claims this would involve a substantial body of work to search for and summarise all the relevant scientific studies. It is no longer sufficient to rely on single studies to support such claims; a food company has to demonstrate they have followed the FSANZ substantiation guidelines, which require a defined literature search strategy, evaluation of the quality of each study, and an overall assessment of the balance of evidence, with particular emphasis placed on human clinical trials. Information relating to the scientific substantiation may be found in the next section of this report.

SCIENTIFIC REVIEW

Scientific Review Summary and Recommendations

The primary components of avocados are the lipids and lipid soluble vitamins. A review of Australian and overseas nutrient composition databases revealed that avocados can range from 10-26% total fat content of which 5-17% is monounsaturated (primarily oleic acid). Avocados also contain 6-17.4mg/100g Vitamin C, 1.3-2.66mg/100g alpha-tocopherol (Vitamin E) and 20-81µg/100g beta-carotene (Vitamin A). The range of scientific literature relating to avocados is broad though for the purpose of this project the number of scientific publications were limited. Many published articles relating to avocados address the agricultural impact or disease impact of the fruit. Of the 488 publications obtained, 52 were further reviewed for relevance in their full text format. Of these the primary role of avocados in health related to:

- Cancer
- Cardiovascular health
- Glucose diffusion/hyperglycaemia
- Wound healing.

The studies generally related to the role of avocados as a whole fruit, with very few of the studies focusing on single, isolated nutrients/phytochemicals.
The role of phytochemicals in avocados has been tested on a range of cancer cells lines with both positive and negative effects. Lutein (carotenoid) was found to have minimal impact in one study while having a synergistic effect in another. Tocopherols and other carotenoids, similarly were found to have effects in inhibiting the proliferation of cancer cells lines but the specific compounds were not isolated to determine if there was a heightened effect on their own. Other components of avocados including alkanols have also been identified though many were isolated from unripe avocados and the component extracted not specified in the study. The majority of the cancer studies were in vitro.

In the area of cardiovascular health, avocados were implemented in a range of diets in human subjects. A large number of these studies originated in Mexico though some Australian studies were also obtained. The focus of all of the studies was the high monounsaturated fat content of the avocado and most asked their participants to consume it in daily quantities of 200-300g. Depending on the study quality, the results were mixed. Decreases in total cholesterol levels were varied between the studies though overall LDL cholesterol and HDL cholesterol was generally found to decrease. One of the studies reviewed addressed the oleic acid composition of the plasma as a marker of compliance, noting increases to be found in the avocado focussed intervention group. The Australian study was the only one to find a decrease in total cholesterol and an increase in HDL cholesterol though no differences were found for LDL cholesterol levels. Many of the studies were very small in their size, limiting the power of the results. Some studies may have been poorly controlled with large differences in results attributable to the fat source e.g. animal fat.

Only two studies were identified relating to glucose diffusion/hyperglycaemia. The first, an in vitro study found avocados to be a potential glucose diffusion inhibitor while the second, a human study found a decrease in glycaemic control on a high monounsaturated fat diet of which 30g fat was displaced with avocado. One study was identified for wound healing and was conducted with rats. An avocado extract both oral and topical was found to significantly increase the speed of wound healing after 14 days. The authors related this to a pro-inflammatory response initiate by the avocado.

Due to the limited numbers of studies related to avocados and health, further research is required to substantiate this relationship. A high quality, well controlled randomised controlled trial would be recommended though any relationship found should not be considered in isolation but rather in the context of the whole diet.

Nutrient content of Avocados (Published data)

The avocado pear or *Persea americana* is one of the few food items grouped into the fruit category containing fatty acids. Originating from the Lauraceae family (Orhan and Sener 2002) of flowering plants, the nutrient content, as indicated above in Table 6, can vary widely between different types of avocado and between different countries. Approximately 70 different species of Avocado exist in North, Central and South America with another 80 species in East and Southeast Asia (Ding, Chin *et al.* 2007). The nutritional content of avocados in Australia and overseas has been presented below in Table 17. Gaps in the data indicate that the nutrient was not analysed for the particular data set.

Table 17: Nutrient composition of avocados from selected countries

Nutrient (per 100g)	Measure	Australia(Food Standards Australia New Zealand 2007a)				NZ(Crop and Food Research 2008)	France(AFSSA 2008)	Finland(FINELI 2010)	Denmark(National Food Institute - Technical University of Denmark 2009)	USA(U.S Department of Agriculture Nutrient Data Laboratory 2008)		
		Shepard		Haas	Fuerte	Haas	Flesh (NS)	Flesh (NS)	Flesh (NS)	All types	Florida	California
Energy	kJ	862	855	993	1010	564	776	765	670	501		697
Moisture	g	71.0	70.9	71.2	63	76.1		68.0	73.23	78.81		72.33
Nitrogen	g	0.33	0.33	0.32				0.3				
Protein	g	2.0	2.0	2.0	1.8	1.9	2.6	1.9	2.0	2.23		1.96
Fat	g	21.4	21.2	25.4	25.6	13.9	19.4	15.7	14.66	10.06		15.41
Ash	g	1.4	1.5	1.1				2.8	1.58	1.08		1.66
Fructose	g	0.1	0.1	0.1			0.1	0.2	0.12	0.25		0.08
Glucose	g	0.3	0.3	0.1			0.4	0.1	0.37	2.17		0.08
Sucrose	g	0.1	0.1	0.0			<0.1		0.06	0.00		0.06
Maltose	g	0.0	0.0	0.0			0.0	0.0	0.00	0.00		0.00
Lactose	g	0.0	0.0	0.0			0.0	0.0	0.00	0.00		0.00
Galactose							0.1		0.10			0.08
Sugars, total	g	0.5	0.6	0.2	0.6	0.66	0.7	0.40	0.66	2.42		0.30
Starch	g	0.0	0.0	0.0	0.1	0.11	0.1	0.05	0.11			0.11
Available Carbohydrate	g	0.5	0.6	0.2	0.7	0.8	0.8	11.7	8.53	7.82		8.64
Total Dietary Fibre	g	2.8	2.8	1.6	4.4	5.6	6.7	5.2	6.7	5.6		6.8
Insoluble fibre							2.0					
Soluble fibre							1.6					
Calcium	mg	14	12	29		10.7	15.0	12.1	12	10		13
Chromium	µg	0.3						0.7				
Copper	mg	0.271	0.271			0.28		0.19	0.19			
Fluoride	µg	120.94	121.25						7.0	0.311		0.170

Iodine	µg	0.0	0.0		0.1	1.2	1.4				
Iron	mg	0.6	0.7	0.6		0.77	0.5	0.4	0.55	0.17	0.61
Magnesium	mg	27	27	22		27.1	29.0	25.0	29	24	29
Manganese	mg	0.232	0.233			0.235		0.142	0.142	0.095	0.149
Molybdenum	µg	0.5									
Nickel	µg	104						59.7			
Phosphorus	mg	48	48			43.3	31.0	46.5	52	40	54
Potassium	mg	509	520	460		420	400	450	485	351	507
Selenium	µg	0.0	0.0			0.4	0.4	0.8	0.4		0.4
Sodium	mg	4	4	2	21	0.95	6.0	6.0	7	2	8
Zinc	mg	0.6	0.6	0.5		0.487	0.0	0.64	0.64	0.40	0.68
Thiamin	mg	0.08	0.08	0.07		0.067	0.07	0.1	0.067	0.021	0.075
Riboflavin	mg	0.14	0.14	0.15		0.137	0.16	0.18	0.130	0.053	0.143
Niacin	mg	2.0	2.2	1.5		1.37	1.1	1.1	1.738	0.672	1.912
Niacin derived from Tryptophan or Protein	mg	0.5	0.3	0.4				0.35			
Niacin Equivalents	mg	2.4	2.5	1.9			1.5	1.35			
Vitamin B6	mg	0.11	0.11			0.364		0.36	0.257		
Biotin	µg	4.9	5.0					3.6		0.078	0.287
Folate	µg	59	59			79.3	11.0	93.0	81	35	89
Choline	mg								14.2		
Dietary Folate Equivalents	µg	59	59								
Pantothenic Acid	mg	0.86	0.87			1.23		1.1	1.389	0.931	1.463
Vitamin C	mg	11	13	6		11.3		6.0	10.0	17.4	8.8
Alpha Carotene	µg	169	165	360			10.2		24	27	24
Beta Carotene	µg	27	29	20		81			62	53	63
Cryptoxanthin	µg	117	103	290					28	36	27
Beta Carotene equivalents	µg	170	163	345				16			
Carotenoids, total	µg						406.5				
Retinol Equivalents	µg	28	27	58			5.2	8.33	7	7	7
Alpha Tocopherol	mg	1.9	1.9				2.1	1.3	2.07	2.66	1.97
Vitamin E	mg	1.9	2.0			1.34		1.3			
Vitamin K	µg						20.0	8.0	21.1		21.0
C8:0	g	0.00	0.0	0.0				0.0	0.001		0.001
C16:0	g	4.82	5.07	4.61				1.85	2.075	1.905	2.075
C18:0	g	0.00	0.0	0.0				0.0	0.049	0.055	0.049
Total Saturated Fatty Acids	g	4.8	5.1	4.6	4.1	1.83	2.7	1.8	2.126	1.960	2.126
C16:1	g	2.05	2.23	1.7				0.525	0.698	0.825	0.698
C17:1	g	0.00	0.0	0.0					0.010		0.010
C18:1	g	10.76	9.94	15.3				11.3	9.066	4.689	9.066
C20:1									0.025		0.025

C22:1									0.000		0.000
Total Monounsaturated Fatty Acids	g	12.8	12.2	17.0	16.1	9.83	12.6	11.8	9.799	5.513	9.799
C18:2 (undifferentiated)	g	2.66	2.84	2.43			1.146	1.29	0.125	1.580	1.674
C18:3 (undifferentiated)	g	0.00	0.0	0.0			0.124	0.06	0.015	0.096	0.125
C20:3									0.016		0.016
C20:4								0.016	0.000		0.000
Omega-3					0.1			0.06			
Omega-6					0.0			1.31			
Total Polyunsaturated Fatty Acids	g	2.7	2.8	2.4	3.3	1.48	1.6	1.4	1.816	1.676	1.816
Sterols	mg						75.3				
Stigmasterol	mg								2		2
Campesterol	mg								5		5
Beta-sitosterol	mg								76		76
Cholesterol	mg	0	0.0	0.0	0.0	0.0		0.0	0.000		0.000
Alanine	mg	92		90				120	109	121	106
Arginine	mg	87		86				64	88	99	87
Aspartic Acid	mg	154		151				430	236	264	232
Cystine + Cysteine	mg	37		36					27	31	27
Glutamic Acid	mg	204		200				230	287	321	282
Glycine	mg	84		83				76	104	116	102
Histidine	mg	39		39				33	49	55	48
Isoleucine	mg	71		70				64	84	94	83
Leucine	mg	121		119				100	143	160	141
Lysine	mg	103		101				94	132	147	129
Methionine	mg	28		27				30	38	42	37
Phenylalanine	mg	73		71				67	232	260	228
Proline	mg	74		73				73	98	110	96
Serine	mg	96		94				79	114	128	112
Threonine	mg	77		76				55	73	82	72
Tryptophan	mg	26		26				21	25	28	25
Tyrosine	mg	195		191				43	49	54	48
Valine	mg	100		99				88	107	120	105
Organic acids, total						0.3					
Citric Acid	g	0.1	0.1	0.1							
Lactic Acid	g	0.0	0.0	0.0							
Malic Acid	g	0.3	0.4	0.2							
Oxalic Acid	g	0.0	0.0	0.0							
Quinic Acid	g	0.0	0.0	0.0							

NB: Values shown are as they appear in the database from which they originate. Australian data, though from a 2006 database has originated primarily from analytical work of the 1980s. Abbreviations: NS- Not specified.

Most notably, the avocado is known for its monounsaturated fatty acid content, vitamin E, niacin, retinol equivalents (Vitamin A) and folate. It also contains notable levels of thiamin, riboflavin and magnesium. It also has antioxidant properties which will be explore further in the following section. The variability of the nutrient content of avocados is similar to any other plant-based food item. The nutrient content is largely influenced by the climate, soil conditions, season of harvest and ripeness at harvest. Each of these factors can have significant impact on the overall composition. Selenium for example is largely obtained from the soil. Selenium rich soils will result in a high composition of this nutrient within the flesh of the avocado. Other nutrients such as the fat, protein and carbohydrate content are more strongly affected by the type of Avocado selected. Common types of avocado include Fuerte, Hass, Gwen, Bacon, Lamb Hass, Pinkerton, Reed and Zutano varieties (Ding, Chin *et al.* 2007).

The literature also revealed a number of studies in which the nutrient composition of avocados was listed.

Vitamin and mineral composition

As avocados age and fruit becomes overly ripe, the composition different minerals may be affected. In particular, calcium may be affected with an inverse relationship. Riper fruit may result in calcium deficiency of the reproductive tissue (fruit) of the plant (Grattan and Grieve 1998). Other less commonly reported minerals may also be found in the avocado fruit. HPLC analysis revealed concentrations of Ubiquinol-10 of 3.14 ±0.40µg/g, Ubiquinone-10 6.34±0.49µg/g and Coenzyme Q10 9.48±0.84µg/g (Kubo, Fujii *et al.* 2008). Ubiquinol is known for its antioxidant capacity within the body and of similar strength to alpha-tocopherol, while Coenzyme Q10 is a product of Uniquinone-10 and involved in the mitochondrial pathways and electron transport functions of the body (Frei, Kim *et al.* 1990).

Antioxidant composition

The overlap between vitamins, minerals and their function (antioxidant) makes some bioactive compounds difficult to classify. Perez-Galvez et al. (2005) describe the bioavailability of carotenoids in their review of chemical behaviour. They note that lipophilic nature of carotenoids may enhance their biological absorption. Within the body, carotenoids are generally found in the liver though may also be found in other tissues including the colon, prostate and skin. The xanthophyll type of carotenoid in particular has the ability to become esterified in the presence of particular fatty acids increasing the requirement of bile salts and intestinal enzymes to digest the nutrient. The process of esterification is thought to relate to ripening of the fruit (Pérez-Gálvez and Mínguez-Mosquera 2005). Lutein has been identified a primary carotenoid. Other carotenoids of interest, though contained in smaller amounts) are the oxygenated and non-oxygenated violaxanthin isomers, antheraxanthin, alpha-carotene and beta-carotene carotenoids (Zabaras 2008). Alpha-tocopherol followed by gamma and delta-tocopherol have been identified as the primary forms of vitamin E though the gamma and delta forms have been found in significantly smaller proportions. Avocados have also been noted to contain the polyphenol ellagic acid which is similarly found in grapes and strawberries (highest composition) and a novel flavonoid, persenone A, found primarily in avocados though also in similar amounts in tomatoes (Aggarwal and Shishodia 2006). This flavonoid has an inhibitory role in the process of inflammation (Kim, Murakami *et al.* 2000). Table 18 below outlines some antioxidants that have been analysed in avocados.

Table 18: Antioxidant content of avocados from the scientific literature

Study	Method of analysis	Avocado type	Content
Strangeland et al (2009) (Stangeland, Remberg *et al.* 2009)	FRAP assay	Mill	Antioxidant activity 0.34±0.10mmol/100g (0.22-0.51mmol/100g) fresh weight or 0.31mmol/serving size (90g)

Gomez-Lopez (2002) (Gómez-López 2002)	Spectrophotometer	Mill-Booth 1 Mill-Julio Millan	Polyphenol oxidase specific activity/my protein: 4-methyl catechol 9.72±0.23, Catechol 9.15±0.20, Pyrogallol 6.87±1.39, DL-DOPA 5.84±0.10, Chlorogenic acid 0.92±0.28, Caffeic acid 0.25±0.03, Protocatechuic acid not detected. Polyphenol oxidase specific activity: 4-methyl catechol 52±1.18, Catechol 40.3±0.75, Pyrogallol 22.4±1.39, DL-DOPA 28.6±0.11, Chlorogenic acid 10.73±1.67, Caffeic acid 2.12±0.27, Protocatechuic acid 0.56±0.10.
Homnava et al. (1990) (Homnava, Rogers *et al.* 1990)	HPLC	Florida variety 1 (sample 1) (sample 2) Florida variety 2 (sample 1) (sample 2)	Cryptoxanthin 16±0.3µg/100g, alpha-carotene 41±2.5µg/100g, beta-carotene 68±8.0µg/100g, total retinol equivalents 16/100g Cryptoxanthin 27±1.2µg/100g, alpha-carotene 16±4.0µg/100g, beta-carotene 38±2.6µg/100g, total retinol equivalents 10/100g Cryptoxanthin 78±5.8µg/100g, alpha-carotene 20±17.5µg/100g, beta-carotene 63±7.1µg/100g, total retinol equivalents 19/100g Cryptoxanthin 22±1.7µg/100g, alpha-carotene 36±5.4µg/100g, beta-carotene 42±4.0µg/100g, total retinol equivalents 12/100g
Lu et al (2005) (Lu, Arteaga *et al.* 2005)	HPLC	Hass	293±55µg/100g (213-361) lutein, 11±3µg/100g (8-18) zeaxanthin, 25±4µg/100g (21-32) beta-cryptoxanthin, 25±5µg/100g (19-30) alpha-carotene, 60±11µg/100g (48-81) beta-carotene, 334±204µg/100g (117-746) gamma-tocopherol, 2871±301µg/100g (2537-3278) alpha-tocopherol.
Zarbaras (2008) (Zabaras 2008)	HPLC	Hass	Alpha-tocopherol 1197-2151 µg/100g, gamma-tocopherol 118-232 µg/100g, delta-tocopherol 83-260 µg/100g, lutein (all-trans) 160-273 µg/100g, Violaxanthin (al-trans) 25-58µg/100g, Violaxanthin (cis-) 18-42µg/100g), antheraxanthin (all-trans) 18-48µg/100g), alpha-carotene 6-13 µg/100g, beta-carotene 15-52µg/100g.

Fatty acid composition

Avocados were selected as the food item of choice for many early fatty acid biosynthesis studies in plants. They have also been noted to also contain high levels of polar lipids, phenols and pigments which make traditional methods of analysis, using spectrophotometry, challenging due to the inhibition of the required enzymes (Salas, Sánchez *et al.* 2000). Avocados are known for their high concentrations of oleate and relatively low saturated fatty acid content (Salas, Sánchez *et al.* 2000), Table 19. They are also known for their high lipid content, with approximately one quarter of the fruit consisting of this nutrient alone (Zabaras 2008).

Table 19: Fatty acid composition of avocados from the scientific literature

Study	Method of analysis	Avocado type	Content
Carranzea-Madrigal et al (1997) (Carranza-Madrigal, Herrera-Abarca *et al.* 1997)	Gas Chromatography	Hass	Myristic acid (14;0) 0.24%, Palmitic acid (16:0) 17.68%, Palmitoleic acid (16:1) 7.23%, Oleic acid (18:1) 61.62%, Stearic acid (18:0) 1.10%, Linoleic acid 12.09% (18:2)
Salas et al (2000) (Salas, Sánchez *et al.* 2000)	Literature	Not specified	16:0 9-13%, 16:1 2.8-4.0%, 18:0 0.4-1.0%, 18:1 69-74%, 18:2 10-14%, 18:3 (Linolenic acid) 1-2%, 20:0 (Arachidic acid) <0.1%.
Lisa et al (2008) (Lísa and Holcapek 2008)	HPLC, APCI-MS	Not specified	16:1 16.52%, 17:1 (Margaroleic acid) 0.01%, 17:0 (Margaric acid) 0.01%, 18:3 1.32%, 18:2 13.48%, 18:1 60.98%, 18:0 0.46%, 20:1 (Gadoleic acid) 0.20%, 20:0 0.07%, 22:0 (Behenic acid) 0.06%, 24:0 (Nervonic acid) 0.10%, 25:0 0.02%, 26:0 (Cerotic acid) 0.02%), Total SFA 17.49%, Total MUFA 67.71%, Total PUFA 14.80%.
Pacetti et al (2007) (Pacetti, Boselli *et al.* 2007)	LC-MS	Hass	(Total lipids) 16:0 17.4±0.3%, 16:1 6.3±0.0%, 18:0 0.5±0.0%, 18:1 65.8±0.3%, 18:2 9.3±0.0%, 18:3 0.5±0.0%, 20:1 0.2±0.0%
Colquhoun et al (1992) (Colquhoun, Moores *et al.* 1992)	Gas chromatography	Sharwill	C14:0 0.8%, C16:0 18.3%, C18:0 <0.1%, Total SFA 19.1%, C16:1 9.3%, C18:1 53.7%, Total MUFA 63.0%, C18:2 15.5%, C18:3 1.8%, Total PUFA 17.3%
		Hass	C14:0 <0.1%, C16:0 15.6%, C18:0 <0.1%, Total SFA 15.6%, C16:1 11.0%, C18:1 54.2%, Total MUFA 65.2%, C18:2 16.4%, C18:3 2.3%, Total PUFA 18.7%
Pieterse et al (2005) (Pieterse, Jerling *et al.* 2005)	Gas chromatography	Not specified	Total fat 17.76g/100g, MUFA 9.90g/100g, C16:1 16.65%, C18:1 47.48%, PUFA 2.56g/100g, C18:2 14.64%, C18:3 1.29%, SFA 4.25g/100g, C16:0 16.79%, C18:0 0.63%

Abbreviations: SFA: Saturated fatty acids, MUFA: Monounsaturated fatty acids, PUFA-Polyunsaturated fatty acids

Other components

The isoflavones daidzein and genistein have also been detected in avocados though this identification was limited to paper-based chromatography methods (Mackova, Koblovska *et al.* 2006). Isoflavones have been studied for their oestrogenic activity; though have been noted to be found in small concentrations in a number of plant species. Avocados have been found to contain high concentrations of dopamine. Dopamine is a known neurotransmitter in mammals (Kulma and Szopa 2007). During the ripening process, the polysaccharides (carbohydrates) in avocados undergo a depolymerisation process. During this process the pectin and hemicellulose specially are effected (Goulao and Oliveira 2008). Table 20, below, lists some other components of Avocado that have been detected.

Table 20: Content of other bioactives of avocados from the scientific literature

Study	Method of analysis	Avocado type	Content
Kulma et al (2007) (Kulma and Szopa 2007)	Not specified	Fuerte	Dopamine 4µg/g, Norepinephrine <3.5µg/g (neurotransmitter)
Kuhnle et al (2009) (Kuhnle, Dell'Aquila *et al.* 2009)	LC-MS	Not specified	Phytoestrogens 43µg/100g, Isoflavones 9µg/100g, Lignans 34µg/100g, Daidzein <1µg/100g, Genistein <1µg/100g, Glycitein 6µg/100g, Biochanin A <1µg/100g, Formononetin <1µg/100g, Secoisolariresinol 24µg/100g, Matairesinol 8µg/100g
Honow (2002) (Hönow and Hesse 2002)	HPLC-ER	Not specified	Measured: Total and soluble oxalate content 1.3mg/100g (0.4-2.1mg/100g). Literature: 8.6mg/100g
Colquhoun et al (1992) (Colquhoun, Moores *et al.* 1992)	Literature	Not specified	Phytosterols: beta-sitosterol 89.0%, campesterol 6.9%, delta-7-avenasterol 0.3%
Zabaras (2008) (Zabaras 2008)	HPLC	Hass	Chlorophyll a 1073-1465 µg/100g, chlorophyll b 1231-2215µg/100g.

Avocados and health: Review of the Literature

Avocados have been linked to a number of health benefits due to their high monounsaturated fat content, polyunsaturated fat content and phytochemical composition (Ding, Han *et al.* 2009). The primary health benefits that arose through this literature search were the relationship of avocados with cancer, cardiovascular health, diabetes management and wound healing. The antioxidant properties of the fruit were the primary constituents that provided the links with cancer, whilst the low levels of sodium, absence of cholesterol and relative levels of energy and carbohydrates further and lipid composition support the cardiovascular health benefits. The macronutrient composition also supported the diabetes relationship, while the general antioxidant properties were again linked with wound healing. Despite these links, the literature supporting avocados is very limited for all health benefits and requires further research to improve the strength of these relationships.

Avocados and cancer

The cancer cell model has been used in number of animal and cellular studies with avocado extract. The identified studies utilised human oral, prostate, lung, mammary, colon, kidney and pancreatic cell lines to test the antioxidant properties of various phytochemicals found within the fruit. Some compounds have known nutritive properties while others are novel isolates. The high levels of phytochemicals contained in the avocado have been considered to have chemo-protective activity as considered in the majority of the cancer studies retrieved. The studies primarily utilise fresh ripe avocado with crude extracts, though some studies introduce the use of unripe avocado and/or the use of purified extracts.

Extracts of the flesh of Hass avocados have been shown to reduce apoptosis in human cancer cell lines in normal tissues but not in other human oral cell lines (Ding, Han *et al.* 2009). Apoptosis is the process of programmed cell death which is amplified in the presence of cancer. The extract studied, a chloroform based extract of phytochemicals (D003, types not specified), was able to inhibit and induce apoptosis in malignant (cancerous) and premalignant (pre-cancerous) cell growth in human oral cells. This inhibition of the cell death created an increase in the generation of high levels of potentially damaging molecules, reactive oxygen species (ROS) which are already increased with a cancer model, while having no effect on the normal oral cell lines (Ding, Han *et al.* 2009). In further work this research team addressed the mechanisms that were disrupting the cellular balance and resulting in apoptosis in a cancer cell model. Higher concentrations of the phytochemical extract (30-100µg/mL D003) were used due to the previous resistance of the normal cell lines to induced apoptosis. Despite the higher concentration of the extract, there was still limited impact on the normal cell lines which was suggested to be the result of lower ROS generation in healthy oral cell lines. The cancer cell lines, however, were seen to trigger both intrinsic and extrinsic apoptitic pathways (Ding, Han *et al.* 2009). When injected with premalignant genes, the healthy cell lines saw an increase in the ROS generation and also, as a result, the reactivity to the D003. This outcome proposes that higher ROS levels in cancerous cell lines increase the sensitivity to apopotosis resulting from the D003 extract (Ding, Han *et al.* 2009), suggesting that phytochemicals in avocado may encourage cell death of pre-cancerous and cancerous oral cell lines.

Utilising the phytochemical groups of carotenoids and tocopherols, an American research team also addressed their role on cancer cell lines. A concentrated extract of **Hass avocado** was used to test the effects (Lu, Arteaga *et al.* 2005) (levels not found naturally). This extract was added in differing concentrations to human prostate cancer cell lines and originated from a 42.7g homogenate of avocado, 7.2g of residue was created by acetone extraction. The extract significantly inhibited proliferation of the cancer cell lines in a dose dependant manner. As a follow on to this finding, the team specifically focussed their activities on a type of carotenoid, lutein, which was isolated as a puree. Contrary to hypotheses, lutein only produced minimal effects at 8µmol/L on the cancer cell lines. The greatest concentration of the total extract tested was 500µg/mL which was calculated to contain only 0.015µmol/L of lutein. It was concluded that it is likely that other bioactives, other than lutein, in the avocado that may be contributing to the inhibited proliferation of the prostate cancer cell lines, though no further testing was conducted.

While some studies report fresh avocados to have *weak* anti-cancer activity (Murakami, Jiwajinda *et al.* 1995), others (with similar study designs) have reported fresh ripe avocados to have *strong* anti-cancer activity (Koshimizu, Ohigashi *et al.* 1988). This difference in results may be the result of different type of avocado being used with different bioactive concentrations. A review conducted by Ding et al (Ding, Chin *et al.* 2007), however, outlined the impact of the alkanols on cancer cell lines in unripe avocado with little difference in effect. The alkanol compounds have also been related to liver suppressive effects within the body. Further studies have utilised dried ripe and unripe Miller avocado on human cancer call lines. The cell lines selected were lung carcinoma, mammary adenocarcinoma, colon adenocarcinoma, kidney carcinoma, pancreatic carcinoma and prostate carcinoma. The powdered avocado flesh had activity against all six cell lines with a specific selectivity for the prostate adenocarcinoma (Oberlies, Rogers *et al.* 1998). The original powder was obtained from a 954g unripe fruit and a 270g portion of a ripe fruit. Considering the amount required for the cell line studies alone, it is unlikely that a strong effect would be observed in human clinical studies.

The mechanism of action for avocados on cancer cell lines has primarily been of an antioxidant or free radical scavenging nature. Inhibitors for the generation of the Nitric oxide (NO) compound have also been isolated from Mill avocados. Inhibition of NO has been noted for its preventative relationship with carcinogensis. The generation of NO is considered to provide these effects in inflammatory cells. Two more specific inhibitors of NO generation were isolated and inhibitory activity tested on human promyelocytic cells. All compounds were found to suppress the tumour promoter generation. The compounds were only found to suppress the activity rather than to act as free radical scavengers (Kim, Murakami *et al.* 2000).

As also noted by Zabaros (2008) the majority of work in avocado cancer research has been conducted by overseas research teams though two of the above studies did use the Hass avocado variety which is also available in Australia. The study ulitised the Hass avocado and obtained antioxidant extract which was analysed by HPLC for its lipophilic components –carotenoids, tocopherols and chlorophylls. Gastric adenocarcinoma, colon adenocarcinoma and leukaemia cancer cells were cultured, incubated and each treated with the three extracts in varying concentrations. After further incubation, the extracts were all shown to suppress proliferation in a dose dependant manner. A purified solid phase extracted fraction was found to have the greatest effect than compared with the individual extracts or the crude extract itself. Pure components of the individual extracts were also tested in doses much greater than those found naturally in avocado and no effect was seen suggesting a synergistic effect. The team also tested the antioxidant activity of the extracts and it was found that those from a solid phase extraction possessed lesser antioxidant activity than compared with the crude extracts. These were further analysed and found to contain little caroteinoid, no tocopherol and limited chlorophyll, suggesting the activity is coming from these sources. This also suggested that other components other than the named antioxidants were having the effects on the cancer cells. Persin (a toxic component of leaves) was hypothesised to potentially be having the effect though was not isolated for further study. This study suggests that in their natural form, the bioactive components of avocado may not have the same strength of effect as they do in their purified form under laboratory conditions.

The literature for the relationship between avocados and cancer is limited. The majority of the studies utilise human cell lines though very few use the same origin of cell line for direct comparison. A general phytochemical extract with a free radical mechanistic action is often observed, though specific bioactive groups such as carotenoids or tocopherols are also addressed and extracted. When isolating single compounds from these groups e.g. lutein, the effect is reduced, though when a purified form as opposed to a crude form of the extract is utilised the effect is strengthened. Only one study focussing on inhibition of NO as an anti-cancer mechanism was identified, though the bioactive component of action was not identified. In general a synergistic effect of bioactives is postulated for the relationship between avocados and cancer though further research into specific compound groups is warranted.

Avocados and cardiovascular health

Cardiovascular health has long been an area of interest for research teams addressing the importance of avocados. The relationship has emerged from the high monounsaturated fat content of the fruit. The monounsaturated fat content is commonly utilised in human studies to displace the saturated fat intake, in turn improving cardiovascular health due to the positive impact on blood lipids. The high oleic acid content of avocados has been linked with advantageous impacts on atherome plaque formation (Carranza-Madrigal, Herrera-Abarca *et al.* 1997) though the vascular responses identified with avocado consumption have also been suggested to relate to increased renal arachidonic acid (Banos, Perez-Torres *et al.* 2008).

A crossover study conducted in Mexico examined the impact of the oleic acid content of avocados in a vegetarian diet on serum lipids compared with a traditional vegetarian diet (Carranza-Madrigal, Herrera-Abarca *et al.* 1997). Thirteen hypercholesterolaemic, overweight (mean BMI 28.7 +/- 5.7kg/m^2) men and women with a mean age of 55.8 years, a total cholesterol level of >6.2mmol/L and LDL cholesterol level >4.13mmol/L were recruited. Three diets (30kcal/kg) were assigned at random each for four weeks in duration. Breakfast and supper were eaten in the dinning room of the research unit, while dinner was provided at a local vegetarian restaurant. Diet 1 (no avocado) contained: 70% carbohydrate, 10% protein, 20% fat (from soybean and safflower oils). Diet 2 (avocado diet) contained 60% carbohydrate, 10% protein, 30% fat (75% supplied by Hass avocados). Diet 3 (free with avocado): allowed participants to eat all meals at home except to come to the research unit to eat a specified amount of avocado (matched to diet 2). Changes in body weight were observed for diet 1 only. Changes in total cholesterol were not seen for any of the diets through a significant increase in total cholesterol levels were observed on diet 3 compared with diet 2. Diet 2 was the only diet to show significant decreases in both triglycerides and LDL cholesterol levels though all participants, regardless of diet, increased their cholesterol levels in the first month of the study. Decreases in HDL cholesterol levels were observed for all diets (Carranza-Madrigal, Herrera-Abarca *et al.* 1997). The quality of this study can be attributed to the results obtained. A limited sample size with poorly controlled dietary methodology (seen by the increased cholesterol levels within the first month) may have led to the negative outcomes reported.

Plasma lipid levels as a result of a monounsaturated fatty acid rich diet, based on avocado have also been investigated in Mexico. Studying sixteen healthy male and female subjects (18-37 years, BMI 22.9 kg/m^2) in a crossover design, the same research team as above, randomised the subjects into a further 3 diet groups each lasting two weeks. The monounsaturated fat rich diet contained 50% energy from carbohydrate, 20% from protein and 30% from fat. Of this fat 75% was supplied by the fatty acids contained in Hass avocado pulp (Alvizouri-Munoz, Carranza-Madrigal *et al.* 1992). The second diet group was a free-monounsaturated-enriched diet during which the subjects again consumed foods freely as in the previous study and an equivalent amount of avocado to the monounsaturated rich diet. The final diet, a low saturated fat diet contained 60% energy from carbohydrate, 20% protein and 20% fat provided by meat and safflower oil. Decreases in body weight were found for the low saturated and monounsaturated rich diets. On the monounsaturated rich diet a decrease in total cholesterol (3.6%), decrease in LDL cholesterol (4.03%) and a decrease in plasma triglyceride levels (4.6%) were observed while HDL levels also decreased by 3.5%. During the low saturated fat diet period, total cholesterol levels decreased (7.2%), LDL decreased (7.6%), HDL decreased 8.5% and triglyceride levels increased by 6.9%. It would generally be expected that a decrease in triglyceride levels and an increased in HDL levels be observed in a well controlled clinical study with low saturated fat prescriptions, however, leaving the fat to be obtained from meat and safflower oil in the low saturated fat group already raises concern due to the high saturated fat content of a number of meat choices. Similarly, the duration of the diet period (2 weeks) is not likely to be long enough. The study does not report on the order effect of the diets or whether a wash out period was observed between diets. Similar to the above study, this small sample size was likely to limit the power of the outcomes.

Another Mexican research team (Lopez, Frati *et al.* 1996) followed n=30 healthy (18-30 years) and n=37 hypercholesterolaemic patients (35-65 years) for a period of seven days. Participants randomly received either a high monounsaturated fatty acid isocaloric diet or an isocaloric control diet. Both diets contained approximately 33% carbohydrate, 14-15% protein and 52-53% fat. The high monounsaturated fatty acid diet further contained 41g/day saturated fatty acid, 49 g/day monounsaturated fatty acid (provided by 300g Hass avocado) and 26g/day polyunsaturated fatty acid, while the control diet contained 47g/day saturated fatty acid, 34g/day monounsaturated fatty acid and 33g/day polyunsaturated fatty acid. All participants were hospitalised during the intervention to ensure alcohol consumption, physical activity and work related stress remained constant. A significant decrease in total cholesterol, triglycerides and LDL cholesterol was observed for the healthy subjects after the high monounsaturated fatty acid diet. A non significant decrease in triglycerides was also observed for the control diet. For the hypercholesterolaemic subjects, a significant decrease in triglycerides, total cholesterol and LDL cholesterol was observed for the monounsaturated fatty acid diet. These changes were seen to be greater when the group was further divided into those with and without diabetes. Consumption of such a large amount of avocado on a daily basis, however, is not considered to be practical and unlikely to coincide with portion size recommendations determined as part of this project.

An Australian study of fifteen females (37-58 years) compared the effects of a low fat high complex carbohydrate diet with that of an avocado enriched diet. Usual dietary intake was monitored for a three week period before commencing the study. Following this phase the low fat diet was followed for three weeks. This diet was 20-25% lower in energy from fat than the usual dietary intake. The diet was isocaloric which was achieved by increasing the amount of carbohydrate the females consumed. The diet followed the AHA-III lipid lowering guidelines which include 20%E from fat, 65%E from carbohydrate and 15%E from protein. The avocado enriched diet provided 30-35%E from fat with 20-35% of the total energy derived from avocados. In total subjects consumed half to one avocado daily (Sharwill or Hass variety) and were free to prepare it to personal preference. Followed for three weeks this phase decreased the amount of carbohydrate in the diet. A decrease in total cholesterol (8.2%) was observed between the usual and the avocado diet and a non-significant decrease (4.9%) for the low fat diet. An increase in HDL (12.8%) was only observed between the low fat and avocado diets but not between the usual and low fat (increased 13.9%). No significant differences were observed for LDL cholesterol of triglycerides for either the usual and low fat or avocado diets. A strong positive correlation (r=0.91) was observed for the relationship between LDL cholesterol ad Apolipoprotein B and also between LDL and total cholesterol. The authors have suggested that the lipid lowering effects may be the result of phytosterols (beta-sitosterol, campestrol and delta-7-avenasterol) in the avocado compared with squalene which is found in olive oil (another monounsaturated rich food) and traditionally resulted in cholesterol lowering effects (Colquhoun, Moores *et al.* 1992).

A RCT weight loss study containing avocados included the secondary aims of determining the impact on vascular function and serum lipids (Pieterse, Jerling *et al.* 2005). This study recruited n=61 (21-57 years) free living overweight and obese males and females. The experimental group was asked to consume 200g of avocado daily on an energy restricted diet for six weeks. The avocado was used to displace 30g of other miscellaneous dietary fats from the diet. Seven day menu plans were provided based on estimated energy requirements and were composed of 30% total fat, 55% carbohydrate and 15% protein. The control group received the same menu plans but was asked to exclude avocado from their diet for the duration of the study. Of the remaining n=55 subjects who completed the study no significant differences in weight loss were observed (2.13 vs. 2.65kg in the experimental vs. control groups). Similarly changes in plasma fatty acids did not differ between the groups though the C18:0 (stearic acid) in the experimental group was found to be significantly higher at baseline. As expected, the plasma C18:1 (oleic acid) increased significantly while the C14:0 (myristic acid) decreased significantly from baseline to six weeks. Serum lipid concentrations did not differ between groups at baseline nor between groups at six weeks. The changes within each group were also not significant. This is most likely due to the sample size not being large enough to show such differences despite the notable difference in oleic acid levels. The portion size of the avocado that was required for daily consumption is also not practical under free living conditions without strictly control dietary regimes.

Despite the interest in the monounsaturated fat content of avocados, the number of specific studies for this relationship remains limited. A high number of studies from Mexico were identified, likely due to the ideal climatic conditions for fruit growth, though the majority of these were of a lower quality. The sample size of the studies was often limited, the length of the studies too short to see an effect and the background diets of the participants not adequately addressed. Of all the studies identified most utilised the avocado as a fat source with few breaking down the total fat further into its components. Though it was expected that more studies would focus on the oleic fatty acid content of the avocado, this is likely to be more common in animal or cellular research. The human clinical studies need to consider avocado as a whole food component rather than for its individual nutrient or bioactive constituents. Although avocado is considered in the literature among the studies for cardiovascular health, the fruit on its own cannot be attributed to the effect but rather the whole of diet approach implemented within the study unless all other factors remain unchanged.

Avocados and glucose diffusion/hyperglycaemia

The movement of glucose within the bloodstream and the effect of it on physiological functions has been the primary focus when considering the relationship between avocados and diabetes management. The mechanisms of glucose movement as a response to avocado appears to still warrant investigation, while human studies overlap largely with the cardiovascular health research.

Dried extracts of a number of plants with known antihyperglycaemic properties were investigated in an Irish experimental study (Gallagher, Flatt *et al.* 2003). Avocado was also considered alongside these plants. Aqueous solutions were prepared at room temperature by infusion with 1g of the dried extract used for each 40mL of distilled water. In vitro glucose movement was simulated and the movement of glucose was monitored using 50g/L plant extract vs. control. Furthermore 6.25, 12.5, 25 and 50g/L solutions were also assessed for their inhibitory effects on glucose movement. Avocado was one of the two most potent inhibitors of glucose movement after a 26hr period decreasing the movement by 60%. Avocado also significantly ($p<0.001$) increased the glucose concentrations inside the distillation tubes when compared with the control tests. The varied concentrations of the extracts affected the results. The study suggests that this glucose movement may be useful in blood glucose control in persons with diabetes. Further work would be needed to confirm this effect. The research team suggest this may relate to the monounsaturated fat content and the use of avocado in place of complex carbohydrate sources in human trials. The study itself however, comments on the need to investigate the mechanisms of movement in an in vitro environment and suggests the extract to be useful for supplement use (Gallagher, Flatt *et al.* 2003). Furthermore, it is not known whether the same strength of effect will be observed when the whole of avocado is used rather than just an extract.

One human study in persons with diabetes investigated the effect of a monounsaturated fat rich diet on glycaemic control and serum lipid measures (Lerman-Garber, Ichazo-Cerro *et al.* 1994). A group of twelve women with type 2 diabetes mellitus were randomised into a crossover study design with a four week wash-in phase. Based on the American Diabetes Association (ADA), all diets were of an isocaloric nature. Diet 1 (the ADA diet) contained 55% carbohydrate, 15% protein and 30% fat broken down into 10% saturated, monounsaturated and polyunsaturated. Diet 2 (high monounsaturated fat diet) contained 40% carbohydrate, 20% protein and 40% fat with 11% saturated, 24% monounsaturated and 5% polyunsaturated. Diet 3 (high carbohydrate diet) contained 60% carbohydrate, 20% protein and 20% fat broken down into 6.6% saturated, monounsaturated and polyunsaturated fats. Four teaspoons of olive oil and one avocado (Hass avocado) were the main sources of fat in the high monounsaturated fat diet. Each diet (high monounsaturated and high carbohydrate was followed for four weeks and a four week period between during which the ADA diet was followed. Both diets resulted in a minor decrease in total cholesterol levels with little impact on HDL cholesterol. The high monounsaturated fat diet saw a 20% decrease in triglyceride levels compared with a 7% decrease on the high carbohydrate diet. The high monounsaturated fat diet also saw a greater decrease in glycaemic control though overall the baseline values for this variable were lower compared with the high carbohydrate diet. A 1kg weight loss on average was also observed in the high monounsaturated diet group while the high carbohydrate diet remained stable, though these results were not significant. Dietary adherence was reported at 80%. Although the sample size in this study is relatively small, the control of the diet periods appears to be better managed than other dietary studies with an avocado focus. This is potentially due to the provision of menu plans for the subjects. Although the study is with participants who have diabetes, the outcomes are not primarily related to blood glucose control but rather to the cardiovascular benefits that may result.

From this literature search only two studies could be related to avocados and diabetes. The focus of these two studies does not allow clear comparisons to be made due to the differing designs, though it appears that the monounsaturated fat content of the avocado may also be attributable to blood glucose control.

Avocados and wound healing

The final relationship for avocados and health was with that of wound healing. Although the literature search was limited to human studies, the following animal study was found to be relevant. A pilot study treated Dawley rats with 1, 2, 4 and 8g/kg body weight avocado paste for 14 days. From this pilot study it was found that 1g/kg body weight could be related to faster wound healing. A further study using 300mg/kg body weight was applied topically to a 250mm long and 2mm deep wound. A control group of rats received a cellulose solution and a third group a 300mg/kg body weight fruit extract orally for nine days. Animals who received the oral dose had significantly faster healing times (13±0.54days) compared with the controls. Wound had healed completed by day 14 while the control wounds didn't heal until day 17. Similar results were observed for the topically treated wounds compared to the controls. The authors conclude that the pro-inflammatory activity of the avocado fruit may encourage the increased healing speed (Nayak, Raju *et al.* 2008). Despite this study being in animals, the model is commonly used for exploratory health research. With further animal studies, the use of an avocado paste may be found useful for lesion or burns treatment in humans.

Conclusions and Recommendations

Upon reviewing the scientific literature and the nutrient databases from a selection of countries, it appears that the more common vitamins, minerals and fatty acids are the primary factors of interest. Many vitamins and minerals are growing in their research interests as a phytochemicals i.e. carotenoids and hence are being studied in their varied forms in avocados. The literature relating to avocados and health remains limited and although studies were identified for cancer, cardiovascular disease, diabetes management and wound healing, the number of studies is not sufficient to allow for this link to be definitively made nor stated as a health claim or nutrient function claim for the product. The literature commonly uses a group of nutrients rather than a specific one, uses an extract of the nutrient from the food and tests the nutrient under laboratory conditions. The few human studies that were identified focussed on the fat profile of the avocado overall. Despite the fruit being very high in oleic acid, this was in one of the studies reviewed. A high quality, well controlled randomised controlled trial would be recommended though any relationship found should not be considered in isolation but rather in the context of the whole diet.

Table 20 above compares the nutrients values with RDI listings from the Food Standards Code. The nutrients which have been bolded provide information which may be useful in developing a nutrient claim for avocados. Based on the comparison of the nutrient composition data for Hass avocados (Table 21), the recommendation would be for analysis of all proximates (macronutrients), full fatty acid breakdown, vitamin and mineral analysis with at least the above listed nutrients though the inclusion of iodine and selenium would also be beneficial. This analysis would be recommended to be provided to FSANZ to update the available food composition data from its current 1980/90 values. Specific bioactive nutrients should include carotenoids showing a breakdown of alpha-, beta-carotene, lutein and zeaxanthin; tocopherols including alpha-, beta- and gamma-tocopherol; and phytosterols including beta-sitosterol, sigmasterol, campestrol and delta-7-avenasterol. Apart from the phytosterols some of the carotenoids and tocopherols would be captured in a standard nutrient analysis though the complete breakdown may not. Other antioxidants could also be considered depending on feasibility.

Table 21: Comparison of nutrient data with RDI for existing portion measures

Nutrient		RDI*	NUTTAB 2006 /100g	%RDI	NUTTAB 2006 /160g	%RDI	NUTTAB 2006 /190g	%RDI
Energy	kJ		862	N/A	1379.2	N/A	1637.8	N/A
Saturated fat	g	**1.5**	4.8	320.00	7.68	512.00	9.12	608.00
Dietary fibre	g	**3**	2.8	**93.33**	4.48	**149.33**	5.32	**177.33**
Magnesium	mg	320	27	8.44	43.2	**13.50**	51.3	**16.03**
Phosphorus	mg	1000	48	4.80	76.8	7.68	91.2	9.12
Potassium	mg	0	509	N/A	814.4	N/A	967.1	N/A
Sodium	mg	**120**	4	3.33	6.4	5.33	7.6	6.33
Copper	mg	3	0.271	9.03	0.4336	**14.45**	0.5149	**17.16**
Manganese	mg	5	0.232	4.64	0.3712	7.42	0.4408	8.82
Zinc	mg	12	0.6	5.00	0.96	8.00	1.14	9.50
Vitamin C	mg	40	11	**27.50**	17.6	**44.00**	20.9	**52.25**
Thiamin	mg	1.1	0.08	7.27	0.128	**11.64**	0.152	**13.82**
Riboflavin	mg	1.7	0.14	8.24	0.224	**13.18**	0.266	**15.65**
Niacin	mg	10	2	**20.00**	3.2	**32.00**	3.8	**38.00**
Pantothenate	mg	5	0.86	**17.20**	1.376	**27.52**	1.634	**32.68**
Vitamin B6	mg	1.6	0.11	6.88	0.176	**11.00**	0.209	**13.06**
Folate Equiv.	mcg	200	59	**29.50**	94.4	**47.20**	112.1	**56.05**
Vitamin A Equiv.	mcg	750	28	3.73	44.8	5.97	53.2	7.09
Beta-carotene Equiv.	mcg	750	170	**22.67**	272	**36.27**	323	43.07
Vitamin E	mg	10	1.9	**19.00**	3.04	**30.40**	3.61	36.10
Vitamin K	mcg	**80**	**21**	**26.25**	33.6	**42.00**	39.9	49.88
Lutein + zeaxanthin	mcg	**60**	**271**	**451.67**	433.6	**722.67**	514.9	858.17

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KEY BIOACTIVES AND NUTRIENTS IN AUSTRALIAN AVOCADOS

Introduction

In Australia, the statutory authority, Food Standards Australia and New Zealand (FSANZ) lists the composition of a range of food products including fruit and vegetables. The current NUTTAB 2006 data is based on samples collected from wholesale markets and supermarkets between 1983 and 1998. Currently, there is no information on Shepard avocados and no data on bioactive compounds such as phytosterols. A key aim of this project was to measure the levels of bioactives and nutrients that play a significant role in health and nutrition such as phytosterols and update data to take into account the more recent Avocado variety, Shepard.

If nutrients in a food product are consistently above 10% of the recommended daily intake (RDI) then a case can be made for making a label claim the product is a ***source*** of that nutrient under the FSANZ food labelling guidelines. If the nutrient is consistently over 25% of the RDI, then a case can be made for that product being a ***good source*** of the nutrient.

The current Food Standards Code summarises the nutrient claim in Standard 1.2.8 (FSANZ, 2008), as follows:

A nutrition claim* means a representation that states, suggests or implies that a food has a nutritional property whether general or specific and whether expressed affirmatively or negatively, and includes a reference to -

- energy; or
- salt, sodium or potassium; or
- amino acids, carbohydrate, cholesterol, fat, fatty acids, fibre, protein, starch or sugars; or
- vitamins or minerals; or
- any other nutrient; or
- a biologically active substance;

The data for a nutrient claim should be based on the "average" level of the nutrient in the product which has been determined from one or more of the following sources allowing for seasonal variability and other known factors that could cause actual values to change.

- the manufacturer's analysis of the food; or
- calculation from the actual or average quantity of nutrients in the ingredients used; or
- calculation from generally accepted data;

One of the difficulties with fresh products such as avocados is that composition can change with variety, time in storage, growing location and season (Lu *et al* (2009). This aim of this project was to measure the levels of key nutrients including monounsaturated fats and phytosterols to determine how these environmental factors affected nutrient levels in the fruit.

* Australia New Zealand Food Standards Code, incorporating amendments up to and including Amendment 100 © Commonwealth of Australia 2008. The requirements concerning Nutrition Information Panels are also contained in Standard 1.2.8.

Methods

Fruit samples for analysis were collected from the Sydney Wholesale Markets in May 2010 (Summer grown) for the cultivars Hass and Shepard from growers in Mareeba and Bundaberg. Samples were collected again in February 2011. This time, one sample of Hass was collected from Pemberton WA and another from Manjimup WA. One sample of Shepard was collected from Mareeba QLD and the other from Walkamin QLD. Each sample comprised 18 mature, A-grade ungassed (green) fruit in the size range 20-25 in good condition with minimal external blemish.

For each variety/grower/region, samples were sent to the National Measuring Institute (NMI) in Melbourne for their standard suite of food nutrition analyses (Table 1). An additional sample of 6 fruit was sent to MNI for more detailed analyses of Vitamins E and B3. A third sample of 6 fruit was analysed for Vitamin C and folate at the AHR laboratory, University of Sydney. NMI also measured Vitamin C and folate so that the AHR method could be checked against the NMI result which is a NATA accredited laboratory.

Vitamin C analysis used by AHR:

Vitamin C was analysed according to the method described by Carnevale (1980) with some modifications. In brief, 5 g of avocado was homogenized in 50 ml of 5% meta-phosphoric acid. The samples were centrifuged at 13,000 rpm for 15 min at 4°C. The supernatant was diluted 10 times in deionised water and filtered through a Millipore 0.45 µm membrane. The extracted samples were analysed using an Agilent 1200 series HPLC. Samples were injected (25 µl) through a C18 column fitted with a guard column. The flow rate was 1 ml per minute, and the mobile phase was 0.375% metaphosphoric acid in deionised water. Peaks were detected using a UV detector set at 245 nm with Vitamin C being a single peak eluting at around 4.7 minutes. The concentration of Vitamin C was calculated from a standard curve of ascorbic acid in 0.5% metaphosphoric acid in deionised water (Vitamin C).

Folate analysis used by AHR:

The concentration of folate was analysed using the AOAC method 2004.05 with some modifications. In brief, 5 g of avocado was homogenized in a blender with 100 ml of 0.1 M Na-phosphate and 1% ascorbic buffer pH 7.8 (extraction buffer). An aliquot of 5 ml of the homogenate was transferred to a 125 ml Erlenmeyer flask and 7.5 ml of deionised water was added, and the flask was covered with aluminium foil. The flask and its contents were then autoclaved at 121°C for 15 min. After cooling, 2.5 ml of the extraction buffer was added to the flask and then 0.25 ml of protease enzyme (2 mg/ml) was added. The flask was incubated in a water bath for 3 hours at 37°C. After 3 hours of incubation, the reaction of the enzyme was stopped by placing the flask in boiling water for 3 min. After cooling, 0.25 ml of α-amylase was added (20 mg/ml) and the flask was again incubated for 2 hours at 37°C in a water bath. After 2 hours of incubation 1 ml of chicken pancreas (5 mg/ml) was added and incubated for 16 hours at 37°C in a water bath in order to deconjugation the folate. After 16 hours of incubation, the reaction was stopped by placing the flask in boiling water for 3 min. The deconjugated extract was made up to a 25 ml volume with deionised water and the pH was adjusted to 4.5 with 2N HCl. The extracts were filtered through Whatman filter paper #40 and collected in an amber bottle. A blank sample using only the extraction buffer was run along with the sample extracts.

The deconjugated extracts were then diluted 20 times with a dilution buffer (0.05 M Na-phosphate and 0.15% ascorbic acid pH 6.8).

For the assay, 0.5 ml of the diluted extract in the test tube was taken and made up to a 1.5 ml volume with dilution buffer. Then 1.5 ml Folic acid *L. casei* medium was added to the test tube to make the assay volume 3 ml. The test tube was then autoclaved at 121° C for 5 min, then cooled immediately in a water bath. Then 50 µl of diluted inoculum (200 µl of cryoprotected *Lactobacillus casei* in 50 ml of 0.85% NaCl solution) was added to the test tube and incubated in a water bath at 37° C for 16 -18 h. After incubation the test tubes were placed in ice, vortexed and the absorbance was measured using a spectrophotometer at 540 nm. The calculation of total folate was performed using a standard curve of folic acid run with the sample extracts and expressed as µg/100 g of tissue.

Table 1. List of analyses undertaken by the National Measuring Institute on the avocado samples.

Proximates	**Unit**	**Method**	**Trace elements**	**Unit**	**Method**	**Vitamins**	**Unit**	**Method**
Fructose	g/100g	VL295	Copper	mg/kg	VL247	Alpha Carotene	ug/100g	VL292
Glucose	g/100g	VL296	Iodine	mg/kg	VL345	Ascorbic acid (Vitamin C)	mg/100g	VL301
Sucrose	g/100g	VL297	Magnesium	mg/kg	VL247	Beta Carotene	ug/100g	VL292
Maltose	g/100g	VL298	Manganese	mg/kg	VL248	Cobalamin (B12)	mg/100g	
Lactose	g/100g	VL299	Phosphorus	mg/kg	VL249	alpha-tocopherol	mg/100g	VL291
Sugars, total	g/100g	VL300	Potassium	mg/kg	VL250	beta-tocopherol	mg/100g	VL291
Moisture	g/100g	VL301	Selenium	mg/kg	VL251	delta-tocopherol	mg/100g	VL291
Fat (Mojonnier extraction)	g/100g	VL303	Sodium	mg/100g	VL253	Thiamin (B1)	mg/100g	VL290
Saturated Fat	g/100g	VL289	Zinc	mg/kg	VL254	gamma-tocopherol	mg/100g	VL291
Protein (N x 6.25)	g/100g	VL299				Riboflavin (B2)	mg/100g	VL290
Ash	g/100g	VL286				Niacin (B3)	mg/100g	VL293
Available Carbohydrate	g/100g					Retinol (Vitamin A)	ug/100g	VL287
Total Dietary Fibre	g/100g					Pyridoxine (Vitamin B6)	mg/100g	VL320
Energy	KJ/100g					Folate (also measured by AHR)	ug/100g	
Mono trans fats	g/100g	VL289						
Mono-unstaturated fat	g/100g	VL290						
Omega 3 fats	g/100g	VL291						
Omega 6 fats	g/100g	VL292						
Poly trans fats	g/100g	VL293						
Poly-unsaturated fat	g/100g	VL294						
Trans fat	g/100g	VL295						

Saturated Fatty Acids	**Unit**	**Method**	**Mono-unstaturated Fatty Acids**	**Unit**	**Method**	**Poly- nsaturated Fatty Acids**	**Unit**	**Method**	**Phytosterols**	**Unit**	**Method**
C4:0 Butyric	%	VL289	C14:1 Myristoleic	%	VL289	C18:2w6 Linoleic	%	VL289	Cholesterol	mg/100g	VL288
C6:0 Caproic	%	VL289	C16:1 Palmitoleic	%	VL289	C18:3w6 gamma Linolenic	%	VL289	Brassicasterol	mg/100g	VL288
C8:0 Caprylic	%	VL289	C17:1 Heptadecenoic	%	VL289	C18:3w3 alpha-Linolenic	%	VL289	Campesterol	mg/100g	VL288
C12:0 Lauric	%	VL289	C18:1 Oleic	%	VL289	C20:2w6 Eicosadienoic	%	VL289	Stigmasterol	mg/100g	VL288
C14:0 Myristic	%	VL289	C20:1 Eicosenic	%	VL289	C20:3w6 Eicosatrienoic	%	VL289	Beta-sitosterol	mg/100g	VL288
C15:0 Pentadecanoic	%	VL289	C22:1 Docosenic	%	VL289	C20:4w6 Arachidonic	%	VL289	Beta-sitostanol	mg/100g	VL288
C16:0 Palmitic	%	VL289	C24:1 Nervonic	%	VL289	C20:5w3 Eicosapentaenoic	%	VL289	Total Phytosterols	mg/100g	VL288
C17:0 Margaric	%	VL289	Total Monounsaturated Fatty Acids			C22:2w6 Docosadienoic	%	VL289			
C18:0 Stearic	%	VL289				Omega-3 Fatty Acids	%	VL289			
C20:0 Arachidic	%	VL289				Omega-6 Fatty Acids	%	VL289			
C22:0 Behenic	%	VL289				C22:4w6 Docosatetraenoic	%	VL289			
C24:0 Lignoceric	%	VL289				C22:5w3 Docosapentaenoic	%	VL289			
Total Saturated Fatty Acids	%	VL289				C22:6w3 Docosahexaenoic	%	VL289			
						Total Polyunsaturated Fatty Acids	%	VL289			
						Total Mon Trans Fatty Acids	%	VL289			
						Total Poly Trans Fatty Acids	%	VL289			
						P:M:S Ratio					

Results and Discussion

There are several nutrients that have potential for nutrient claims in avocados. These include total phytosterols, monounsaturated and polyunsaturated fatty acids, folate, Niacin (Vitamin B3), magnesium, phosphorus, potassium, and total dietary fibre.

Table 2 shows the average levels of each nutrient with potential for a source claim found in the fruit samples collected in this study and compares this data with the Recommended Daily Intake (RDI) for each nutrient. For a ***source*** claim, one serve of the food item must contain at least 10% of the RDI and for a ***good source*** claim, the serving must contain at least 25% of the RDI.

Table 2. Source of nutrients or bioactive compounds in avocado potential for a source claim

Nutrient	RDI	Nutrient content per one serve of 100 g		Type of claim
		Hass	Shepard	
Phytosterols (mg)	167-437	70-140	70-77	Good source
Total monounsaturated fatty acids (g)	30	5 – 15	7 – 8	Good source
Total poly-unsaturated fatty acids (g)		2 – 3	2	Good source
Total folate (µg)	200	100	140 – 250	Good source
Total dietary fibre (g)	3	4.5	3.5	Good source
Niacin (mg)	10	1.6	1.2	Source
B-carotene (µg)	750	28 - 63	71 – 190	Unconfirmed
Vitamin E (mg)	10	0.2 – 1.1	0.2 – 0.9	Unconfirmed
Energy (kJ)		520 – 900	590 – 690	Good source

The levels of Vitamin E and beta-carotene (precursor for vitamin A) were either too low, or too variable in the fruit tested so far to support a source claim.

Phytosterols:

The phytosterol content of Hass and Shepard avocados were at consistently high levels over growing districts and seasons (Table 3). Plant sterols reduce blood LDL cholesterol levels, can reduce blood pressure and so have the potential to reduce the risk of heart attacks and stroke (Gupta et al, 2011). The avocado phytosterols are mostly β-sitosterol which is more effective than other sitosterols in lowering LDL cholesterol (Anwar et al , 2011).

Table 3 Phytosterols

			Analysis 1980's			NMI	Analysis May 2010		Analysis Feb 2011	
Phytosterols	**Unit**	**RDI**	**Hass**	**Fuerte**	**% RDI**	**Method**	**Hass**	**Shepard**	**Hass**	**Shepard**
Cholesterol	mg/100g		0	0		VL288	<1.0	<1.0	<5.0	<5.0
Brassicasterol	mg/100g					VL288	<1.0	<1.0	<5.0	<5.0
Campesterol	mg/100g					VL288	5.4	5.2	7.3	5
Stigmasterol	mg/100g					VL288	1.9	2.2	<5.0	<5.0
Beta-sitosterol	mg/100g					VL288	59	67	120	60
Beta-sitostanol	mg/100g					VL288	3.4	3.6	11	<5.0
Total Phytosterols	mg/100g					VL288	70	77	140	70

This is an important finding, and represents a clear potential area in which to focus the attention of avocados as being an important part of a healthy diet. The other common use of phytosterols is in the chlolesterol-lowering margarines sold under the trade names Logicol™ and Pro-Activ™. The high levels of phytosterols in avocado mean there may be a potential for avocados to access this market.

Avocado oil, which is mostly monounsaturated, will also be high in phytosterols since they are fat soluble.

Monounsaturated and polyunsaturated fats:

High levels of monounsaturated and polyunsaturated fatty acids are present in both Hass and Shepard avocados. Approximately 22% of the energy in avocado is found as fat, more than half of which is monounsaturated. Monounsaturated fats have positive effects on blood lipids in a similar way to olive oil (lu et al, 2005).

Replacing saturated facts with monounsaturated fats improves blood lipids levels, specifically it reduces total and LDL-cholesterol levels (bad cholesterol) and increases HDL-cholesterol (good cholesterol) (Bos, de Vries *et al.* 2010).

Table 4 Monounsaturated Fatty Acids

			Analysis 1980's			NMI	Analysis May 2010		Analysis Feb 2011	
Mono-unstaturated Fatty Acids	**Unit**	**RDI**	**Hass**	**Fuerte**	**% RDI**	**Method**	**Hass**	**Shepard**	**Hass**	**Shepard**
C14:1 Myristoleic	%					VL289	<0.1	<0.1	<0.1	<0.1
C16:1 Palmitoleic	%		2.23	1.7		VL289	14	16.3	4.3	12.2
C17:1 Heptadecenoic	%		0	0		VL289	<0.1	<0.1	<0.1	<0.1
C18:1 Oleic	%		9.94	15.3		VL289	40.3	35.4	67.5	41.8
C20:1 Eicosenic	%					VL289	<0.1	<0.1	0.2	1.1
C22:1 Docosenic	%					VL289	<0.1	<0.1	<0.1	<0.1
C24:1 Nervonic	%					VL289	<0.1	<0.1	<0.1	<0.1
Total Monounsaturated Fatty Acids	%		12.2	17			54.3	51.7	72	55

Table 5 Polyunsaturated Fatty Acids

			Analysis 1980's			NMI	Analysis May 2010		Analysis Feb 2011	
Poly-unsaturated Fatty Acids	**Unit**	**RDI**	**Hass**	**Fuerte**	**% RDI**	**Method**	**Hass**	**Shepard**	**Hass**	**Shepard**
C18:2w6 Linoleic	%		2.84	2.43		VL289	15.7	15	13.6	14.7
C18:3w6 gamma Linolenic	%		0	0		VL289	<0.1	<0.1	<0.1	<0.1
C18:3w3 alpha-Linolenic	%					VL289	1	1.3	0.9	<0.1
C20:2w6 Eicosadienoic	%					VL289	<0.1	<0.1	<0.1	<0.1
C20:3w6 Eicosatrienoic	%					VL289	<0.1	<0.1	<0.1	<0.1
C20:3w3 Eicosatrienoic	%					VL290	<0.1	<0.1	<0.1	<0.1
C20:4w6 Arachidonic	%					VL289	<0.1	<0.1	<0.1	<0.1
C20:5w3 Eicosapentaenoic	%					VL289	<0.1	<0.1	<0.1	<0.1
C22:2w6 Docosadienoic	%					VL289	<0.1	<0.1	<0.1	<0.1
Omega-3 Fatty Acids	%					VL289	1	1.3	0.9	0.2
Omega-6 Fatty Acids	%					VL289	15.7	15	13.6	14.7
C22:4w6 Docosatetraenoic	%					VL289	<0.1	<0.1	<0.1	<0.1
C22:5w3 Docosapentaenoic	%					VL289	<0.1	<0.1	<0.1	<0.1
C22:6w3 Docosahexaenoic	%					VL289	<0.1	<0.1	<0.1	<0.1
Total Polyunsaturated Fatty Acids	%		2.8	2.4		VL289	16.7	16.4	14.4	14.9
Total Mon Trans Fatty Acids	%					VL289	<0.1	<0.1	<0.1	<0.1
Total Poly Trans Fatty Acids	%					VL289	<0.1	<0.1	<0.1	<0.1
P:M:S Ratio							0.6:1.9:1.0	0.5:1.6:1.0	1.1:5.3:1.0	0.5:1.8:1.0

Table 6 Saturated Fatty Acids

			Analysis 1980's			NMI	Analysis May 2010		Analysis Feb 2011	
Saturated Fatty Acids	**Unit**	**RDI**	**Hass**	**Fuerte**	**% RDI**	**Method**	**Hass**	**Shepard**	**Hass**	**Shepard**
C4:0 Butyric	%					VL289	<0.1	<0.1	<0.1	<0.1
C6:0 Caproic	%					VL289	<0.1	<0.1	<0.1	<0.1
C8:0 Caprylic	%		0	0		VL289	<0.1	<0.1	<0.1	<0.1
C10:0 Capric	%					VL290	<0.1	<0.1	<0.1	<0.1
C12:0 Lauric	%					VL289	<0.1	<0.1	<0.1	<0.1
C14:0 Myristic	%					VL289	<0.1	<0.1	<0.1	<0.1
C15:0 Pentadecanoic	%					VL289	<0.1	<0.1	<0.1	<0.1
C16:0 Palmitic	%		5.07	4.61		VL289	27.9	31.1	13	29.4
C17:0 Margaric	%					VL289	<0.1	<0.1	<0.1	<0.1
C18:0 Stearic	%		0	0		VL289	0.6	0.6	0.5	0.7
C20:0 Arachidic	%					VL289	0.1	<0.1	0.1	<0.1
C22:0 Behenic	%					VL289	<0.1	<0.1	<0.1	<0.1
C24:0 Lignoceric	%					VL289	<0.1	<0.1	<0.1	<0.1
Total Saturated Fatty Acids	%		5.1			VL289	28.6	31.7	13.6	30

Dietary Fibre:

Avocados are an excellent source of fibre (Table 7). The amount of fibre in a 100 g sample of avocado alone is more than the RDI for fibre (3g). This means avocados clearly contain enough fibre for a good source claim. Avocados should be actively promoted as an excellent source of dietary fibre.

In a recent review of the health effects of dietary fibre Anderson *et al.* (2009) makes the following assessment. *Dietary fibre intake provides many health benefits. Individuals with high intakes of dietary fibre appear to be at significantly lower risk for developing coronary heart disease, stroke, hypertension, diabetes, obesity, and certain gastrointestinal diseases. Increasing fibre intake lowers blood pressure and serum cholesterol levels. Increased intake of soluble fibre improves glycemia and insulin sensitivity in non-diabetic and diabetic individuals. Fibre supplementation in obese individuals significantly enhances weight loss. Increased fibre intake benefits a number of gastrointestinal disorders including the following: gastroesophageal reflux disease, duodenal ulcer, diverticulitis, constipation, and hemorrhoids. Prebiotic fibres appear to enhance immune function. Dietary fibre intake provides similar benefits for children as for adults*.

Table 7 Proximates

			Analysis 1980's			NMI	Analysis May 2010		Analysis Feb 2011	
Proximates	**Unit**	**RDI**	**Hass**	**Fuerte**	**% RDI**	**Method**	**Hass**	**Shepard**	**Hass**	**Shepard**
Fructose	g/100g		0.1	0.1		VL295	<0.2	<0.2	<0.2	<0.2
Glucose	g/100g		0.3	0.1		VL296	<0.2	<0.2	<0.2	<0.2
Sucrose	g/100g		0.1	0		VL297	<0.2	<.2	<0.2	<.2
Maltose	g/100g		0	0		VL298	<0.2	<0.2	<0.2	<0.2
Lactose	g/100g		0	0		VL299	<0.2	<0.2	<0.2	<0.2
Sugars, total	g/100g		0.6	0.2		VL300	<1	<1	<1	<1
Moisture	g/100g		70.9	71.2		VL301	78	74.5	66.8	76.4
Fat (Mojonnier extraction)	g/100g		21.2	25.4		VL303	10.2	15.2	21.1	13.2
Saturated Fat	g/100g	1.5	5.1	4.6	320	VL289	2.9	4.8	2.7	3.8
Protein (N x 6.25)	g/100g		2.0	2.0		VL299	1.4	1.8	2.0	1.7
Ash	g/100g		1.5	1.1		VL286	1.2	1.2	2.7	2.3
Total Dietary Fibre	g/100g	3	2.8	1.6	93.33	Contracted out	4.7	3.7	4.2	3.3
Available Carbohydrate	g/100g		0.6	0.2		Contracted out	5	4	3	3
Energy	KJ/100g		855	993		Contracted out	520	690	900	590
Mono trans fats	g/100g					VL289	<0.1	<0.1	<0.1	<0.1
Mono-unstaturated fat	g/100g					VL290	5.3	7.5	14.5	6.9
Omega 3 fats	g/100g					VL291	<0.1	0.2	0.2	<0.1
Omega 6 fats	g/100g					VL292	1.5	2.2	2.7	1.9
Poly trans fats	g/100g					VL293	<0.1	<0.1	<0.1	<0.1
Poly-unsaturated fat	g/100g					VL294	1.6	2.4	2.9	1.9
Trans fat	g/100g					VL295	<0.1	<0.1	<0.1	<0.1

Vitamins

Table 8 Vitamins

			Analysis 1980's			NMI	Analysis May 2010		Analysis Feb 2011	
Vitamins	**Unit**	**RDI**	**Hass**	**Fuerte**	**% RDI**	**Method**	**Hass**	**Shepard**	**Hass**	**Shepard**
Alpha Carotene	ug/100g		165	360		VL292	28	69	25	24
Ascorbic acid (Vitamin C)	mg/100g	40	13	6	27.5	VL301	<1	<1	<1.0	2.1
Beta Carotene	ug/100g	750	29	20		VL292	63	190	28	71
alpha-tocopherol	mg/100g	10	1.9		19	VL291	0.2	0.2	1.1	0.9
beta-tocopherol	mg/100g					VL291	<0.1	<0.1	<0.1	<0.1
delta-tocopherol	mg/100g					VL291	<0.1	<0.1	<0.1	<0.1
Thiamin (B1)	mg/100g	1.1	0.08	0.07		VL290	0.06	0.06	0.06	0.06
gamma-tocopherol	mg/100g					VL291	<0.1	<0.1	<0.1	<0.1
Riboflavin (B2)	mg/100g	1.7	0.14	0.15		VL290	0.08	0.07	0.05	0.05
Niacin (B3)	mg/100g	10	2.2	1.5	20	VL293	1.2	1.1	1.6	1.2
Retinol (Vitamin A)	ug/100g	750	27	58		VL287	<5	<5	<5	<5
Pyridoxine (Vitamin B6)	mg/100g	1.6	0.11		6.88	VL320	0.08	0.11	0.12	0.08
Cobalamin (Vitamin B12)	ng/100g					Contracted out	47	46	0.03	0.03
Pantothenic acid (Vitamin B5)	mg/100g	5	0.87		17.2	VL292	0.9	1	0.93	0.35
Folate (also measured by AHR)	ug/100g	200	59		29.5	Contracted out	100	140	103	250

Folate:

Avocados are a good source of folate which is necessary for normal blood formation, cell growth and development. The level of folate was high enough in all the samples measured to date to support a good source nutrient claim (Figure 1 and Table 8). The data shows that there is a high level of variability between districts and between varieties. Results from 2011 analysis from different growers and districts indicated a high level of folate content in both Hass and Shepard avocados. In all cases the level of folate was above the threshold required for a good source nutrient claim.

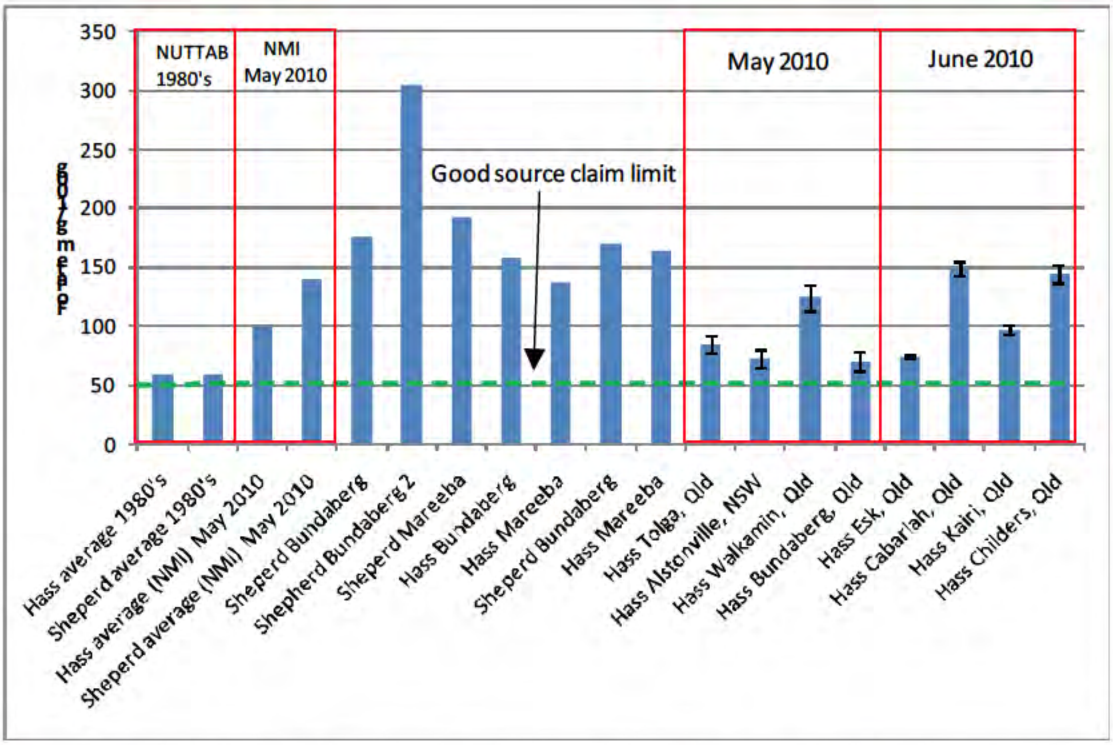

Figure 1. The folate level in avocados sourced from different districts compared to the combined samples taken in the 1980's and again in 2010.

Niacin:

The Niacin content in avocados was high enough across all the growing districts and cultivars sampled to make a source claim for this nutrient. Niacin levels ranged from 1.2 to 1.6 mg/kg and the minimum concentration for a source claim is 1.0 mg/100g (Table 9). The levels of both nutrients measured in the 2010 and 2011 samples were much lower than levels measured in the 1980's and this and is probably due to more accurate methods having been developed in recent years.

Table 9. Levels of Niacin (Vitamin B3) in avocados sourced from different locations in April 2010 and February 2011 with reference data from the NUTTAB database (1980's).

Time	Location	alpha-tocopherol	Niacin (Vit B3)	Source Claim limit	
		mg/100g	mg/ 100g	alpha-tocopherol 1 mg/100g	Niacin (Vit B3) 1 mg/100g
1980's	Hass average 1980's	1.9	2.2	✓	✓
1980's	Shepard average 1980's	1.9	2.0	✓	✓
May 2010 NMI	Shepard Mareeba, Qld	0.2	0.2	×	✓
May 2010 NMI	Shepard Bundaberg, Qld	0.1	0.1	×	✓
May 2010 NMI	Hass, Mareeba Qld	0.3	0.3	×	✓
May 2010 NMI	Hass, Queensland Qld	2.1	2.1	✓	✓
May 2010 NMI	Hass average 2010	0.2	0.2	×	✓
May 2010 NMI	Shepard average 2010	0.2	0.2	×	✓
February 2011 NMI	Shepard Mareeba, Qld	0.5	1.2	×	✓
February 2011 NMI	Shepard Walkamin, Qld	0.6	1.1	×	✓
February 2011 NMI	Hass, Pemberton WA	0.5	1.6	×	✓
February 2011 NMI	Hass, Manjimup, WA	0.9	1.4	×	✓
February 2011 NMI	Hass average 2010	1.1	1.6	✓	✓
February 2011 NMI	Shepard average 2010	0.9	1.2	×	✓

Vitamin E, Beta Carotene and Vitamin C.

The variability in vitamin C, vitamin E and β-carotene contents in avocados means no recommendations can be made at this stage. These nutrients may have potential for a nutrient claim in avocados, however more data is needed before confident claims can be made.

The results show the full nutrient analyses carried out on Hass and Shepard avocados in 2010 and 2011 from different growers and compares those results with the ones in the literature (Table 8). The data for Hass and Fuerte comes from the NUTTAB 2006 database where the results were collected in the 1980's (FSANZ, 2010).

The level of Vitamin C was measured at 13 mg/100g for Hass and 11 mg/100g for Fuerte avocados. These levels mean that avocados could be a good source of Vitamin C as one portion (100 – 190g) would contain more than 25% of the recommended daily intake for Vitamin C. Unfortunately the 2010 data shows that the level of Vitamin C is < 1 mg/100g and results obtained by AHR using samples of the same batch of fruit with a similar HPLC method obtained similar results. However, 2011 analysis shows only Shepard have slightly higher level of vitamin C content (2.1 mg/100g) but not enough for a nutrient claim. This means the product cannot be regarded as a source of Vitamin C.

The literature shows that the methodology used to determine Vitamin C does impact on the results. Raghu *et al* (2007) compared the ascorbic acid content of *Emblica officinalis* fruits using a specific enzymatic method, colorimetric method and a liquid chromatograph method. Their study showed that the colorimetric method over estimates the level of Vitamin C and their review reports this is the case in other fruit as well. In another study researchers compared the colorimeteric method and an HPLC method for vegetables (Albrecht and Schafer 1990). They describe how in the AOAC colorimetric method some compounds such as tannins, copper and iron ions and sulphur containing compounds can interfere with the colour reaction. However, their results showed that there were no differences in the levels of Vitamin C measured by the two methods in the vegetables they used in the experiment. More work is needed to clarify these results but from the literature it seems likely that the 1980's results are an over estimate of the Vitamin C content of avocado.

In relation to the vitamin E determinations, there was significant variability which could have been due to the analytical technique, or to variability within the fruit. The 2010 data shows that the results for the combined full analysis of Hass avocados with a variable result ranging from <0.1 to 1.5 mg/100g (Table 10). The 2011 data shows less variability among the samples of Hass and Shepard from different growers ranging from 0.5 to 0.9 mg/100g but still the levels were not high enough for a nutrient claim (nutrient claim requires > 1.0 mg/100g).

Table 10 Vitamin E analyses of avocado samples by NMI

Job No: APPL11/100503

NMI Registration No	Sample Description	Alpha-Tocopherol (mg/100g) Analysis Date				
		6.5.2010	7.6.2010	23.6.2010	7.7.2010	9.7.2010
V10/012021	Hass Avocado Full	0.2		1.5	1.1-0.7(*)	<0.1-1.1 (*)
V10/012022	Shepard Avocado Full	0.2		0.2		
V10/012023	Shepard Avocado Mareeba	0.2		1.1	<0.1-0.6 (*)	0.9-1.0 (*)
V10/012024	Shepard Avocado Bundaberg	0.1		0.2		
V10/012025	Hass Avocado Mareeba	0.3		0.5-0.4 (*)		
V10/012026	Hass Avocado Bundaberg	2.1	1.5			

(*) Duplicate determination.

Mineral Nutrients

The minerals magnesium, phosphorus and potassium were high enough to justify a source or good source claim (Table 11).

Table 11 Mineral nutrients

			Analysis 1980's			NMI	Analysis May 2010		Analysis Feb 2011	
Trace elements	**Unit**	**RDI**	**Hass**	**Fuerte**	**% RDI**	**Method**	**Hass**	**Shepard**	**Hass**	**Shepard**
Calcium	mg/kg		12	29		VL247	99	85	76	91
Copper	mg/kg	3	0.27			VL247	1.2	3.8	2.7	2.8
Iron	mg/kg		0.7	0.6		VL247	0.43	0.52	-	-
Magnesium	mg/kg	320	27	22	8.44	VL247	230	300	280	320
Manganese	mg/kg	5	0.233			VL247	3.9	3.2	1.6	3.2
Phosphorus	mg/kg	1000	48		4.8	VL247	350	630	440	470
Potassium	mg/kg		520	460		VL247	4300	5500	6100	4800
Selenium	mg/kg		0.0			VL247	<0.01	<0.01	<0.01	<0.01
Sodium	mg/100g	120	4.0	2.0		VL247	1.5	3.4	12.0	<1.0
Zinc	mg/kg	12	0.6	0.5		VL247	4.3	6.9	6.7	7.5
Iodine	mg/kg		0.0			VL345	0.04	0.021	0.140	0.097

Conclusion

There are several nutrients that have potential for nutrient claims in avocados. These are: total phytosterols, monounsaturated and polyunsaturated fatty acids, folate, Niacin (Vitamin B3), and total dietary fibre.

The high phytosterol content of Hass and Shepard avocados is an important finding, with the potential to be used to promote avocados as healthy food which can help to reduce blood LDL cholesterol levels with the associated beneficial effects on cardiovascular health. High levels of monounsaturated fats were confirmed and this finding adds weight to the idea that avocados are have significant potential benefits on cardiovascular health, similar to olive oil.

Avocados are an excellent source of dietary fibre, at a high enough level for a good source claim. Avocados should be actively promoted as an excellent source of dietary fibre. Avocados are also a good source of folate, which is necessary for normal blood formation and is essential for normal cell growth and development, especially during pregnancy. The level of folate is high enough in all the samples measured to date for a good source nutrient claim.

The Niacin content in avocados was high enough across all the growing districts and cultivars sampled to make a source claim for this nutrient. The levels of vitamins E, C and beta carotene were not consistently high enough to justify source claims.

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Appendix 1 Avocado composition data from the literature

		Australia			NZ	France	Finland	Denmark	USA		
Nutrient/100g	**Unit**	**Shepherd**	**Hass**	**Fuerte**	**Hass**	**Flesh (NS)**	**Flesh (NS)**	**Flesh (NS)**	**All types**	**Florida**	**California**
Energy	Kj	862	855	993	1010	564	776	765	670	501	697
Moisture	g	71	70.9	71.2	63	76.1		68	73.23	78.81	72.33
Nitrogen	g	0.33	0.33	0.32				0.3			
Protein	g	2	2	2	1.8	1.9	2.6	1.9	2	2.23	1.96
Fat	g	21.4	21.2	25.4	25.6	13.9	19.4	15.7	14.66	10.06	15.41
Ash	g	1.4	1.5	1.1				2.8	1.58	1.08	1.66
Fructose	g	0.1	0.1	0.1			0.1	0.2	0.12	0.25	0.08
Glucose	g	0.3	0.3	0.1			0.4	0.1	0.37	2.17	0.08
Sucrose	g	0.1	0.1	0			<0.1		0.06	0	0.06
Maltose	g	0	0	0			0	0	0	0	0
Lactose	g	0	0	0			0	0	0	0	0
Galactose	g						0.1		0.1		0.08
Sugars, total	g	0.5	0.6	0.2	0.6	0.66	0.7	0.4	0.66	2.42	0.3
Starch	g	0	0	0	0.1	0.11	0.1	0.05	0.11		0.11
Available Carbohydrate	g	0.5	0.6	0.2	0.7	0.8	0.8	11.7	8.53	7.82	8.64
Total Dietary Fibre	g	2.8	2.8	1.6	4.4	5.6	6.7	5.2	6.7	5.6	6.8
Insoluble fibre	g							2			
Soluble fibre	g							1.6			
Calcium	mg	14	12	29		10.7	15	12.1	12	10	13
Chromium	ug	0.3						0.7			
Copper	ug	0.271	0.271			0.28		0.19	0.19		
Fluoride	ug	120.94	121.3						7	0.311	0.17
Iodine	ug	0	0		0.1	1.2	1.4				
Iron	mg	0.6	0.7	0.6		0.77	0.5	0.4	0.55	0.17	0.61
Magnesium	mg	27	27	22		27.1	29	25	29	24	29
Manganese	mg	0.232	0.233			0.235		0.142	0.142	0.095	0.149
Molybdenum	ug	0.5									
Nickel	ug	104						59.7			
Phosphorus	mg	48	48			43.3	31	46.5	52	40	54
Potassium	mg	509	520	460		420	400	450	485	351	507
Selenium	ug	0	0			0.4	0.4	0.8	0.4		0.4
Sodium	mg	4	4	2	21	0.95	6	6	7	2	8
Zinc	mg	0.6	0.6	0.5		0.487	0	0.64	0.64	0.4	0.68
Thiamin (B1)	mg	0.08	0.08	0.07		0.067	0.07	0.1	0.067	0.021	0.075
Riboflavin (B2)	mg	0.14	0.14	0.15		0.137	0.16	0.18	0.13	0.053	0.143
Niacin (B3)	mg	2	2.2	1.5		1.37	1.1	1.1	1.738	0.672	1.912
Niacin derived from Tryptophan or Protein	mg	0.5	0.3	0.4				0.35			
Niacin Equivalents	mg	2.4	2.5	1.9			1.5	1.35			
Vitamin B6 (Pyridox	mg	0.11	0.11			0.364		0.36	0.257		
Biotin	ug	4.9	5					3.6		0.078	0.287
Folate	ug	59	59			79.3	11	93	81	35	89
Choline	mg									14.2	
Dietary Folate Equivalents	ug	59	59								
Pantothenic Acid	mg	0.86	0.87			1.29		1.1	1.389	0.931	1.463
Vitamin C	mg	11	13	6		11.3		6	10	17.4	8.8
Alpha Carotene	ug	169	165	360			10.2		24	27	24
Beta Carotene	ug	27	29	20		81			62	53	63
Cryptoxanthin	ug	117	103	290					28	36	27
Beta Carotene equivalents	ug	170	163	345				16			
Carotenoids, total	ug						406.5				

Appendix 1 Avocado composition data from the literature (continued)

		Australia			NZ	France	Finland	Denmark	USA		
Nutrient/100g	**Unit**	**Shepherd**	**Hass**	**Fuerte**	**Hass**	**Flesh (NS)**	**Flesh (NS)**	**Flesh (NS)**	**All types**	**Florida**	**California**
Retinol Equivalents	ug	28	27	58			5.2	8.33	7	7	7
Alpha Tocopherol	mg	1.9	1.9				2.1	1.3	2.07	2.66	1.97
Vitamin E	mg	1.9	2			1.34		1.3			
Vitamin K	ug						20	8	21.1		21
C8:0	g	0	0	0				0	0.001		0.001
C16:0	g	4.82	5.07	4.61				1.85	2.075	1.905	2.075
C18:0	g	0	0	0				0	0.049	0.055	0.049
Total Saturated Fatty Acids	g	4.8	5.1	4.6	4.1	1.83	2.7	1.8	2.126	1.96	2.126
C16:1	g	2.05	2.23	1.7				0.525	0.698	0.825	0.698
C17:1	g	0	0	0					0.01		0.01
C18:1	g	10.76	9.94	15.3				11.3	9.066	4.689	9.066
C20:1	g								0.025		0.025
C22:1	g								0		0
Total Monounsaturated Fatty Acids	g	12.8	12.2	17	16.1	9.83	12.6	11.8	9.799	5.513	9.799
C18:2 (undifferentiated)	g	2.66	2.84	2.43			1.146	1.29	0.125	1.58	1.674
C18:3 (undifferentiated)	g	0	0	0			0.124	0.06	0.015	0.096	0.125
C20:3									0.016		0.016
C20:4								0.016	0		0
Omega-3					0.1			0.06			
Omega-6					0			1.31			
Total Polyunsaturated Fatty Acids	g	2.7	2.8	2.4	3.3	1.48	1.6	1.4	1.816	1.676	1.816
Sterols	mg						75.3				
Stigmasterol	mg								2		2
Campesterol	mg								5		5
Beta-sitosterol	mg								76		76
Cholesterol	mg	0	0	0	0	0		0	0		0
Alanine	mg	92		90				120	109	121	106
Arginine	mg	87		86				64	88	99	87
Aspartic Acid	mg	154		151				430	236	264	232
Cystine + Cysteine	mg	37		36					27	31	27
Glutamic Acid	mg	204		200				230	287	321	282
Glycine	mg	84		83				76	104	116	102
Histidine	mg	39		39				33	49	55	48
Isoleucine	mg	71		70				64	84	94	83
Leucine	mg	121		119				100	143	160	141
Lysine	mg	103		101				94	132	147	129
Methionine	mg	28		27				30	38	42	37
Phenylalanine	mg	73		71				67	232	260	228
Proline	mg	74		73				73	98	110	96
Serine	mg	96		94				79	114	128	112
Threonine	mg	77		76				55	73	82	72
Tryptophan	mg	26		26				21	25	28	25
Tyrosine	mg	195		191				43	49	54	48
Valine	mg	100		99				88	107	120	105
Organic acids, total						0.3					
Citric Acid	g	0.1	0.1	0.1							
Lactic Acid	g	0	0	0							
Malic Acid	g	0.3	0.4	0.2							
Oxalic Acid	g	0	0	0							
Quinic Acid	g	0	0	0							

NB: Values shown are as they appear in the database from which they originate. Australian data, though from a 2006 database has originated primarily from analytical work of the 1980s. Abbreviations: NS- Not specified.

PORTION SIZE MODELLING

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Executive Summary

This report aims to establish a reference serve size for avocado based on existing government and non-government recommendations in order to conduct dietary modelling which incorporates avocado into a healthy, balanced diet. A search of relevant previous known government and non-government organisation documents was undertaken and a summary of recommendations extracted. Avocado is referred to using a number of different serve sizes and considered as a fruit, vegetable or fat/oil serving within the diet. The different serve sizes reflect the equivalent energy value of the food that avocado would be replacing in the diet (smaller portions for lower calorie foods and larger portions for higher calorie foods). A reference energy value for of around 250KJ would enable avocado to equate as a serve of a fruit (267kJ) and a serve of fats/oils - equivalent in kilojoules to 1.5tsp of oil. Based on the review of the authoritative documents, a serving size of 2 slices (9cm x 1cm), 1/8 whole (11cm x 7.5cm) or 30g would act as a reasonable reference amount for an average healthy adult to build up into a healthy diet plan. In this current project, dietary modelling was conducted using this reference serving size. Diet models were created for adults males and females based on the number of serves of food groups referred to in the Australian Guide to Healthy Eating (AGHE). Five sets of composite food groups (ie a category of foods comprising a defined number of individual foods, and a defined value taken for nutrient composition) were created for each of the food groups referred to in the AGHE . These were extended to 110 composite groups in total in consideration of the types of foods consumed by both males and females. A collection of five base diet models for males and females were created. Following this, a further ten diet models were created, the first five replacing one serving of fruit with avocado and a further five models in which avocado replaced one fat serving. The diet values for some nutrients, mainly monounsaturated, polyunsaturated and saturated fatty acids and retinol where changed by including avocado in the model. When avocado replaced fruit, the dietary values for Vitamin C, fibre and sugars were also affected. The nutrient values affected by replacing a fat serving with avocado were less substantial than when avocado replaced a fruit serving. In this sense avocado might be better considered as a healthy alternative to fats and oils within the context of a healthy balanced diet.

Background

In Australia guidelines exist for the general public on the serving size and number of serves of particular food items. Foods have been grouped based on common characteristics to allow for variability of intakes and dietary patterns resulting from these guidelines. When considering Avocados, however, a challenge arises. The challenge is two-fold in which firstly, the classification of the food is not clearly defined and secondly as a result of this, the serving sizes of the food remains largely open to interpretation. Avocado, from a botanical perspective can be considered as a fruit while compositionally it is high in monounsaturated fatty acids. The latter means avocado can be seen as an alternative to spreads such as margarine on sandwiches. In practice the serving size may vary, for example from a small segment to spread on bread to a whole avocado to consume in a meal or snack. For dietary modelling purposes, however (that is, 'in theory') a serving size is usually defined in order to work out how much of the food might equate to that of a food which is being replaced in the diet. The defining quality is usually the energy (calorie) value. The smaller this value the greater the utility in including multiple serves in the model.

This report will aim to:

Establish a suitable reference serve size for avocado (based on existing government and non-government materials) to enable dietary modelling which readily incorporates avocado into a healthy, balanced diet.

Methods

Portion Size review

A search of relevant previous known government and non-government organisation documents was undertaken and a summary of recommendations extracted. Sources included:

- NH&MRC Dietary Guidelines and Core Food Groups publications
- Commonwealth Department of Health Australian Guide to Healthy Eating
- Dietitians Association of Australia (DAA) 7-A-Day Program resource material and publications
- Strategic Intergovernmental Alliance on Nutrition (SIGNAL)
- The Australian Fruit & Vegetable Coalition
- State Department of Health publications
- School Canteen Guidelines (State associations and FOCUS)

Existing regulations and guidelines in Australia were also reviewed on the labelling of avocado serve sizes on food packaging. From the government and non-government reports and the outcomes of the literatures review, a reference serve size was developed to enable modelling in of avocado both as a fruit and as a healthy fat alternative.

Dietary modelling

Dietary modelling was conducted, incorporating the reference avocado serve size from (1) into a healthy, balanced diet. FoodWorks nutrition analysis software (2009, v6.0.2500 Xyris Pty Ltd, Highgate hill QLD) with the AUSNUT 1999 database was utilised. Models were created based on reference dietary patterns for adults males and females with a BMI of 22.5kg/m² and moderate activity level (PAL 1.8). The age for each of the genders was selected as the midpoint between 19 and 65 years. Models for a healthy dietary approach were created using the suggested serving sizes and number of serves from the Australian Guide to Healthy Eating (AGHE)(Smith, Kellet *et al.* 1998). Hass and Shepard avocado samples were sent for analysis to update the nutrient data presently available in the Australian Food Composition database. Each was entered into the software as a new food item and then a composite for avocados was created as an average of the two types.

Composite food groups were created for each of the core food groups. These were created using a recipe approach in FoodWorks and a randomly selected food item for each of the food groups of the 1995 National Nutrition Survey(Australian Bureau of Statistics 1995) food hierarchy. Weighting was applied to each individual food based on the proportion in which the food group within which it sits was consumed in the NNS (Table 22). The weightings were calculated as a proportion of the total amount of the food group consumed in the NNS.

Five sets of composite food groups were created for each of the core food groups and for males and females. This resulted in 110 composite groups and was comprised of groups for cereals and cereal products, fish and seafood, fruit, egg products and dishes, meat and poultry products and dishes, milk products and dishes, seed and nut products and dishes, vegetable products and dishes, legume products and dishes and then two extra croups of fats and oils and alcoholic beverages.

Table 22: Example of foods and weightings used for model 1 of the fruit products and dishes composite food group for females

NNS food grouping	Randomly selected food item	Quantity (weighting)
Pome fruit	Pear, brown, raw, peeled	43.3g
Berry fruit	Blackberry, raw	2.5g
Citrus fruit	Orange, Not Specified Type, raw	19.3g
Stone fruit	Peach, canned in light syrup, drained	17.8g
Tropical fruit	Pineapple, canned, Not specified type packing liquid, drained	31.4g
Other fruit	Date, raw	23.1g
Mixtures of fruit	Fruit salad, canned in light syrup	4.9g
Dried fruit	Sultana	2.6g

A collection of five base models were then created for males and females using the composite food groups and recommended number of weekly servings from the AGHE as well as the recommended serving sizes. Following this a further ten models were then created the first five replacing one serving of fruit with the composite avocado group using the serving size determined from the portion size review and a further five models in which the composite group for avocados replaced one fat serving.

Portion Size review

The serve size provided on the Avocado Australia website is given as 190g. This would need to be considered in the context of how the avocado is being consumed. The serve size for fruit given in the Australian Guide to Healthy Eating (1 cup) equates more closely to 160g, and this is close to the standard 162g serve size quoted for one avocado in the New Zealand Food composition tables.(Athar, Spriggs *et al.* 1999) In the US publication of food values of portions commonly used, the serve size is given as 98g.(Pennington 1994) The definition of the serve size is an important consideration for statements about nutrient sourcing. For example, some nutrients would be regarded as a 'source' (by definition providing at least 10% of the RDI) with a 190g or 160g serve, but not with a 100g serve (magnesium, copper, thiamin, riboflavin, vitamin B6). If the larger serve sizes are to be relied upon to support nutrient function and health claims, it would be wise to have some consumer research demonstrating that these are typically consumed serve sizes. The scientific literature reviewed in the initial stages of this project commonly used 100g as the standard of reference for the avocado when comparing nutrient values. One study, however, did analyse the nutrient composition based on a per serve basis. This serve size was determined to be 90g though the study was conducted in Norway.(Stangeland, Remberg *et al.* 2009) From a regulatory perspective, the serve size is open to determination by the manufacturer, but it is likely to be the consumer who determines this for avocado, depending on how they intend to use it in a meal. There are no specific guidelines or regulations. In terms of food labelling, a common measure that is applied is 100g.

A summary of authoritative guidelines and documents (Table 22) is indicative of the lack of clarity in classifying avocados into a food group. Of the 19 documents containing data relating to avocados, only 3 referred to avocados as a fruit. Four documents referred to it as a vegetable, one within the fruit and vegetables group and six referred to it as a fat and/or healthy fat alternative. The Australian Guide to Healthy Eating defined its fruit group based on the larger content of vitamin C, while the vegetables group was largely defined by its vitamin A content (4 times greater than fruit). The fat spreads (included in the extras grouping) were also initially considered as a contributor to vitamin A, however as other food groups also provide this nutrient, the fats were not considered to be a food group of their own (Smith, Kellet *et al.* 1998). Many of the documents reviewed did not refer to a serving size for avocado at all. The range of serving sizes that were referred to largely depended on which food group the organisation had considered avocados to sit within. The sizes ranged from 15g (1 slice) to 159g (1 whole) with many documents providing sizes that are highly variable and dependant on the type of avocado selected. This may well reflect the way in which avocado is integrated in to a number of cuisine patterns. For dietary modelling purposes, however, we have defined a reference serve size to see how avocado might fit into a healthy diet plan form a number of perspectives.

Reference servesize for modelling purposes

Based on the review of the authoritative documents, a serving size of 2 slices (9cm x 1cm), 1/8 whole (11cm x 7.5cm) or 30g is a reasonable amount to apply in the dietary modelling for an average healthy adult. This takes into consideration avocado as both a fruit (267kJ) and as a fat choice equivalent in kilojoules to 1.5tsp of oil. The number of serves of this portion would then depend on the energy requirement for that person and cuisine base (ie all the other foods) in which the diet model is being produced.

Table 23: Portion size review of government and non-government documents

Author	Title	Organisation State/Country	Serve Size	Note
Smith A, Kellet E, Schmerliab Y(Smith, Kellet *et al.* 1998)	The Australian Guide to Healthy Eating	Commonwealth Department of Health and Family, Australia	Not specified. (Using FoodWorks to convert kJ to gram weight ~ 34g/2.33 9x1cm slices)	• Avocado is listed under the ***fruit*** group. • Avocado is not given a specific serve size. The guide specifies that a serve of fruit is based on about 300kJ.
Australian Government(Australian Government)	Avocado, Go for 2 and 5: National campaign (2 fruit and 5 vegetables).	A joint Australian Government, State and Territory Health initiative, Australia	1 cup, avocado raw diced (159g)	• 1 cup of avocado provides one serve of ***vegetables***. • All state health sites have link to '2 n 5' campaign.
National Health and Medical Research Council(National Health and Medical Research Council 2003)	Food for Health: Dietary Guidelines for Australian Adults	NHMRC, Australia	-	• Avocado is listed under the fruit group. • Mentioned in 'Limit saturated fats and moderate total fat intake' – ***Healthier Fats***
Australian Government/Monash University(Monash University)	Healthy Eating At Various Life stages	Department of Health and Ageing, Australia	Serving sizes suggested in healthy eating plans: Boys 12 yrs – 2 slices (267kJ) Men 23 yrs – 2 slices (267kJ) Girl 6 yrs – 3 tsp (134kJ) Girl 16 yrs – 2 slices (267kJ)	• Avocado not in suggested healthy eating plans for the following life stages: Boys: 1-3 yrs, 4-8 yrs, 14-18 yrs, Males: 31-50 yrs, 50-70 yrs, 70+ yrs, Girls: 1-3 yrs, 9-13 yrs • Avocado is mentioned as a good source of folate for females 19-30 yrs, 31-50 years, breast feeding or pregnant (no serving suggested). • Healthy Eating – avocado mentioned in ***Good Fats*** and Bad Fats under monounsaturated fats (no serving serves discussed). • 267kJ converted to ~30g in FoodWorks
Queensland Health(Queensland Government)	A Better Choice – Healthy Food and Drink Supply Strategy for Queensland Health Facilities	Queensland Government, Australia	-	• Recommended to eat with plain rice or corn thins (green category) and avocado as dip (amber category). • Green – best choices, available all the time • Amber – supplied in smaller quantity not actively promoted.
United States Department of Agriculture(USDA ; USDA)	Inside the Pyramid – How do I count the oils I eat? MyPyramid	USDA, United States of America	½ medium = 3 tbsp of oil (15g)	• Within ***Oils***, oil allowance given in teaspoons with foods given as equivalent. • Footnote that Avocado listed as part of ***fruit*** group. • Within the fruit group, serving not listed for avocado. • Sample Menu (2000 Calorie)–avocado ½ cup with lunch. • MyPyramid offers personalized eating plans and interactive tools to help you plan/ assess your food choices based on the Dietary Guidelines for Americans
Health Canada(Health Canada 2007)	What is a Food Guide Serving of Vegetables and Fruit?	Health Canada, Canada	½ medium	• Avocado is on the ***fruit*** list.

Dietitians Association of Australia(Dietitians Association of Australia)	Fat	DAA, Australia	-	• Mentioned in '***Fat***' topic as source of monounsaturated fatty acids – no serve. • Not listed under fruit or vegetable.
Food and Agriculture Organization (FAO) of the United Nations(Food and Agriculture Organization of the United Nations)	Food based dietary guidelines – Food Guidelines by Country	FAO, United Nations	-	• Countries that had food based dietary guidelines in English but had no information on avocado: Namibia; Nigeria; Bangladesh; India; Indonesia; Malaysia; Nepal; Philippines; Singapore; Thailand; Bulgaria; Hungary; Ireland; Latvia; Netherlands; Poland; United Kingdom; Dominica; Grenada; Panama; Saint Lucia; St Vincent/Grenadines; Canada. • Countries that had food based dietary guidelines in language other than English: China; Japan; France; Germany; Italy; Portugal; Argentina; Bolivia; Brazil; Chile; Columbia; Cuba; Dominican Republic; Ecuador: Guatemala; Mexico; Uruguay; Venezuala; Turkey • Albania – not in English but avocado pictured in tip of pyramid with cakes and ***oil***. • El Salvador – not in English but avocado pictured with ***oil*** and cream.
The South African Department of Health(Department of Health June 2004)	South African guidelines for healthy eating for adults and children over the age of seven years	Department of Health, Directorate: Nutrition, South Africa	-	• It is suggested as sandwich filling and as a source of 'unsaturated' ***fats***
Department of Nutrition, Ministry of Health, Oman(Department of Nutrition May 2009)	The Omani Guide to Healthy Eating	Ministry of Health, Oman	-	• Source of monounsaturated fats – no serving size suggested for ***fats and oils*** groups.
Eat Well Tasmania(Eat Well Tasmania 2009a; Eat Well Tasmania 2009b)	What's a serve? Enjoy Veg 'n' Fruit with Every Meal	Eat Well Tasmania, Australia	75g	• A serving of ***vegetables*** is given as 75g.
Dietitians Association of Australia(Dietitians Association of Australia 2008)	Australia's Healthy Weight Week (AHWW) consumer brochure	DAA, Australia	-	• Suggested as topping a burger.
Australian Government(Australian Government ; Australian Government)	Recommended serves and serving sizes. Measure Up – What should I be eating? Why choose seasonal food?	National Campaign – Measure Up, Australia	½ cup	• Mentioned as source of monounsaturated fatty acids. • Within seasonal produce section avocados listed as ***vegetable***. A serve of 'other' (non starch, non dark green) vegetables = ½ cup.
Avocado Australia(Australian Avocados)	Nutrition Information Panel, Nutrition	Australia	190g – one whole avocado (no skin, no seed)	• Nutrition Information Panel – 190g is the amount listed in the Nutrition Information Panel other than per 100g. • 190g listed to provide 1273kJ.
McLennon W, Podger A(McLennan and Podger 1999)	National Nutrition Survey Foods Eaten 1995	ABS, Australia	-	• Avocado listed as ***Vegetable*** *Products and Dishes* within the sub category *other fruiting vegetables*. • *Other fruiting vegetables:* Mean daily intake (Males, 19 years and older) = 27.8g, (Females, 19 years and older) = 29.9g, (Persons, 19 years and older) = 28.9g

Food Standards Australia New Zealand(Food Standards Australia New Zealand 2007a) *	NUTTAB 2006, Australian Food Composition Tables	FSANZ, Australia	-	• All measured in 100g edible portion
Lesperance, L et al(Lesperance, Clark *et al.* 2009) *	The Concise New Zealand Food Composition Tables (2009 – 8th Edition)	Plant and Food Research Ministry of Health, New Zealand	162g (1 whole)	• Data given as per 100g and per 1 avocado (162g)
Food Standards Agency, U.K.(Food Standards Agency)	Nutrition essentials – Fruit and veg, Healthy Diet	Food Standards Agency, United Kingdom	½ avocado or 80g	• Listed under ***Fruit and Veg***

No information relating to avocados was found in the Federation of Canteens in Schools, the Australian School Canteen Association or the Strategic Intergovernmental Alliance on Nutrition guidelines.
** food composition databases*

Dietary modeling

Analysed nutrient data

Table 24: Nutrient data obtained for Shepard and Hass avocados provided by NMI laboratory analyses

Nutrient/100g	Unit	Shepard	Hass
Energy	kJ	690	520
Moisture	g	74.5	78
Protein	g	1.8	1.4
Fat	g	15.2	10.2
Ash	g	1.2	1.2
Available Carbohydrate	g	4	5
Fructose	g	<0.2	<0.2
Glucose	g	<0.2	<0.2
Sucrose	g	<0.2	<0.2
Maltose	g	<0.2	<0.2
Lactose	g	<0.2	<0.2
Galactose	g	-	-
Sugars, total	g	<1	<1
Starch	g	-	-
Total Dietary Fibre	g	3.7	4.7
Calcium	mg	85	99
Copper	ug	0.38	0.12
Iodine	ug	2.1	4
Iron	mg	5.2	4.3
Magnesium	mg	30	23
Manganese	mg	0.32	0.39
Phosphorus	mg	63	35
Potassium	mg	550	430
Selenium	ug	<0.001	<0.001
Sodium	mg	3.4	1.5
Zinc	mg	0.69	0.43
Thiamin (B1)	mg	0.06	0.06
Riboflavin (B2)	mg	0.07	0.08
Niacin (B3)	mg	1.1	1.2
Niacin Equivalents	mg	1.400*	1.433*
Vitamin B6 (Pyridoxine)	mg	0.11	0.08
Folate	ug	140	100
Pantothenic Acid	mg	1	0.9
Vitamin C	mg	<1	<1
Alpha Carotene	ug	69	28
Beta Carotene	ug	190	63
Retinol Equivalents*	ug	61	24
Alpha Tocopherol	mg	0.2	2.0
Beta Tocopherol	mg	**	<0.1

Delta Tocopherol	mg	**	<0.1
Gamma Tocopherol	mg	**	<0.1
<C8:0	g	< 0.1	< 0.1
C16:0	g	31.1	27.9
C18:0	g	0.6	0.6
Total Saturated Fatty Acids	g	31.7	28.6
C16:1	g	16.3	14
C17:1	g	<0.1	<0.1
C18:1	g	35.4	40.3
C20:1	g	<0.1	<0.1
C22:1	g	<0.1	<0.1
Total Monounsaturated Fatty Acids	g	51.7	54.3
C18:2 (undifferentiated)	g	15.0	15.7
C18:3 (undifferentiated)	g	<0.1	<0.1
C20:3	g	<0.1	<0.1
C20:4	g	<0.1	<0.1
Omega-3	g	1.3	1
Omega-6	g	15	15.7
Total Polyunsaturated Fatty Acids	g	16.4	16.7
Stigmasterol	mg	2.2	1.9
Campesterol	mg	5.2	5.4
Beta-sitosterol	mg	67	59
Cholesterol	mg	<1.0	<1.0

** calculated data ** not available at time of re-analysis*

The data provided from the analyses shown in Table 24 were used to create a composite food group for avocados for the purposes of substituting avocados into a healthy balanced diet (2.3) as both a) a fruit serving and b) a fat (extras) serving.

Composition of the dietary models

Each dietary model used for this project was based on a standardised format which included the recommended number of servings from each food group for each gender (Table 25). When the avocado composite was used as a substitute, 1 daily serving of the fats and oils group was replaced and 1 daily serving of the fruit group.

Table 25: Composition of base model 1 for adult males showing food group, quantity and frequency

Breakfast		
12_1 Composite MALES cereals and cereal products group	40g	3.5w
12_1 Composite MALES cereals and cereal products group	60g	3.5w
19_1 Composite MALES milk products and dishes group	250g	3.5w
14_1 Composite MALES fat and oils group	5g	3.5w
16_1 Composite MALES fruit group	150g	7w
Morning tea		
19_1 Composite MALES milk products and dishes group	150g	7w
16_1 Composite MALES fruit group	75g	7w

Lunch		
12_1 Composite MALES cereals and cereal products group	120g	7w
23_1 Composite MALES vegetable group	150g	7w
14_1 Composite MALES fat and oils group	10g	7w
17_1 Composite MALES egg products and dishes group	60g	1w
19_1 Composite MALES milk products and dishes group	20g	1w
Afternoon tea		
16_1 Composite MALES fruit group	150g	7w
Dinner		
12_1 Composite MALES cereals and cereal products group	360g	7w
18_1 Composite MALES meat, poultry etc group	75g	5w
15_1 Composite MALES fish and seafood group	80g	2w
24_1 Composite MALES legumes group	75g	3.5w
23_1 Composite MALES vegetable group	300g	7w
Supper		
21_1 Composite MALES seed and nut group	45g	2.5w
19_1 Composite MALES milk products and dishes group	250g	3w
28_1 Composite MALES alcoholic beverages group	120g	3.5w
16_1 Composite MALES fruit group	75g	7w

Model composed of 5 servings breads and cereals, 2 servings dairy, 3 servings fruit, 6.5 servings vegetables (incl. legumes), 1.5 servings meat and 3 extras (including fats and oils) based on number of servings for a healthy diet for adult males(Smith, Kellet et al. 1998)

In the context of a healthy balanced diet the outcomes are shown below in Table 26 for females and Table 27 for males. Replacement of one serving of fat with avocado resulted in some changes in nutrient value for the dietary model. For the 'female' models these changes included an increase in the saturated, polyunsaturated and monounsaturated fatty acids for all models, reductions in the retinol content in 3/5 models and an increase in the folate levels in 1/5 of the models. The changes to the fat profile was due to the replacement of serving equivalence rather than calorically equivalent items. As seen in table 3, avocados are proportionately high in fatty acids, hence these changes were expected. The retinol is the result of the avocado primarily replacing margarines and butters which are the main components of the fats and oils composite group. The increased folate levels in only one of the models was likely due to the component foods of the composite groups within the model. For the 'male' models the saturated, polyunsaturated and monounsaturated fatty acids also increased in all models though the retinol only decreased in 3/5 models. Replacing one serving of fruit with avocado resulted in increases to the saturated, polyunsaturated and monounsaturated fatty acids for all models for both the males and females. For the 'female' models all models also saw a decline in the Vitamin C levels, 1/5 a decline in the water levels, 1/5 in the fibre levels, 2/5 in the sugar levels, 2/5 in the beta-carotene levels and 1/5 in the Vitamin A equivalence levels. For the males, again less nutrients were affected though sugars were also reduced in 4/5 models and Vitamin C in 2/5 models. The nutrients affected by this substitution are not only of a greater range but also likely to have a larger impact on the overall diet quality. As the fruits food group is primarily identified by its high Vitamin C and natural sugar content, the decline in these levels, when replaced with avocado, were anticipated. The changes to the Vitamin A equivalents and beta-carotene levels however were not expected as these are fat-soluble nutrients not commonly found in significant quantities in fruit.

Table 26: Modelling outcomes for females showing percentage difference from base model for both fat and fruit substitutions

Nutrients	Model 1					Model2					Model 3				
	Base	**Fat**	**%diff**	**Fruit**	**%diff**	**Base**	**Fat**	**%diff**	**Fruit**	**%diff**	**Base**	**Fat**	**%diff**	**Fruit**	**% diff**
weight_g	1661.07	1686.32	1.50	1541.32	-7.77	1661.07	1686.32	1.50	1541.32	-7.77	1661.07	1686.32	1.50	1541.32	-7.77
energy_kj	11729.68	11759.27	0.25	11434.90	-2.58	14053.80	14081.89	0.20	13919.44	-0.97	9949.15	9982.10	0.33	9737.51	-2.17
protein_g	90.48	90.96	0.52	89.89	-0.66	107.99	108.45	0.43	107.51	-0.45	95.78	96.24	0.48	94.73	-1.11
total-fat_g	84.03	83.74	-0.35	87.76	4.25	83.99	83.66	-0.39	87.75	4.28	67.80	67.60	-0.29	71.44	5.10
saturated-fat_g	21.98	29.91	**26.53**	31.10	**29.33**	27.51	35.23	**21.89**	36.63	**24.90**	18.91	26.71	**29.20**	28.03	**32.54**
polyunsaturated-fat_g	22.09	25.81	**14.44**	27.09	**18.48**	17.42	21.08	**17.39**	22.42	**22.33**	18.62	22.47	**17.11**	23.63	**21.19**
monounsaturated-fat_g	32.44	47.00	**30.97**	48.47	**33.07**	31.34	46.15	**32.09**	47.37	**33.84**	24.33	39.00	**37.61**	40.36	**39.72**
cholesterol_mg	119.66	116.45	-2.76	119.66	0.00	193.49	189.60	-2.05	193.49	0.00	123.04	119.07	-3.34	123.04	0.00
carbohydrate_g	392.97	394.29	0.34	368.19	-6.73	522.72	524.06	0.25	507.59	-2.98	319.83	321.16	0.42	302.42	-5.75
sugars_g	118.34	118.64	0.25	94.64	-25.04	261.47	261.74	0.11	246.15	-6.22	96.27	96.55	0.29	78.26	-23.02
starch_g	269.61	269.58	-0.01	269.41	-0.07	257.93	257.93	0.00	257.88	-0.02	222.77	222.77	0.00	222.58	-0.09
water_g	1026.75	1049.04	2.12	933.89	-9.94	870.08	892.42	2.50	765.51	**-13.66**	1099.00	1121.25	1.99	1001.62	-9.72
alcohol_g	5.81	5.81	0.00	5.81	0.00	4.45	4.45	0.00	4.45	0.00	2.23	2.23	0.00	2.23	0.00
dietary-fibre_g	39.08	40.35	3.15	36.86	-6.03	39.45	40.72	3.12	38.19	-3.28	47.35	48.62	2.61	42.87	**-10.47**
thiamin_mg	1.70	1.71	1.06	1.66	-2.11	1.97	1.98	0.91	1.96	-0.48	2.13	2.15	0.85	2.10	-1.32
riboflavin_mg	1.83	1.85	1.21	1.79	-1.87	3.39	3.41	0.60	3.37	-0.42	2.29	2.31	0.89	2.25	-1.87
niacin_mg	23.46	23.80	1.45	23.39	-0.28	18.56	18.91	1.82	18.66	0.52	23.40	23.74	1.44	22.78	-2.71
niacin-equivalents_mg	40.73	41.16	1.03	40.57	-0.41	39.67	40.09	1.05	39.70	0.09	43.82	44.23	0.94	43.01	-1.87
vitamin-c_mg	118.96	118.96	0.00	97.76	**-21.69**	95.78	95.78	0.00	81.45	**-17.60**	164.29	164.29	0.00	126.44	**-29.93**
total-folate_ug	330.72	367.02	9.89	351.75	5.98	309.95	346.25	**10.48**	338.39	8.40	333.46	369.76	9.82	362.32	7.97
total-vitamin-a-equivalents_ug	898.71	853.22	-5.33	871.56	-3.12	733.94	686.68	-6.88	709.73	-3.41	1267.55	1221.03	-3.81	1146.18	**-10.59**
retinol_ug	346.54	306.98	**-12.89**	346.54	0.00	358.19	315.32	**-13.60**	358.19	0.00	458.78	416.59	**-10.13**	458.78	0.00
beta-carotene-equivalents_ug	3316.06	3318.44	0.07	3191.90	-3.89	2259.78	2271.57	0.52	2153.81	-4.92	4829.47	4841.27	0.24	4152.70	**-16.30**
sodium_mg	2542.94	2535.91	-0.28	2538.34	-0.18	3825.54	3807.74	-0.47	3819.90	-0.15	2509.35	2479.07	-1.22	2502.99	-0.25
potassium_mg	3524.09	3671.91	4.03	3437.21	-2.53	4854.85	5002.26	2.95	4840.28	-0.30	3408.35	3555.71	4.14	3339.95	-2.05
magnesium_mg	458.06	466.04	1.71	448.23	-2.19	452.36	460.31	1.73	449.31	-0.68	439.64	447.60	1.78	431.16	-1.97
calcium_mg	1040.40	1068.00	2.58	1049.63	0.88	1635.55	1662.79	1.64	1646.18	0.65	1056.91	1084.14	2.51	1044.64	-1.17
phosphorus_mg	1695.28	1710.03	0.86	1686.25	-0.54	2040.76	2054.88	0.69	2038.82	-0.10	1582.26	1596.57	0.90	1570.69	-0.74
iron_mg	15.04	16.48	8.71	15.75	4.51	17.38	18.82	7.63	18.10	3.94	17.42	18.86	7.61	18.22	4.40
zinc_mg	14.97	15.14	1.12	14.82	-1.01	17.38	17.55	0.96	17.25	-0.76	11.95	12.12	1.39	11.69	-2.24

	Model 4					Model 5				
	Base	**Fat**	**% diff**	**Fruit**	**% diff**	**Base**	**Fat**	**% diff**	**Fruit**	**% diff**
weight_g	1661.07	1686.32	1.50	1541.32	-7.77	1661.07	1686.32	1.50	1541.32	-7.77
energy_kj	9762.93	9807.17	0.45	9579.06	-1.92	9758.45	9789.18	0.31	9497.85	-2.74
protein_g	82.19	82.62	0.52	81.57	-0.76	79.56	80.02	0.58	78.83	-0.93
total-fat_g	67.97	68.09	0.18	71.64	5.12	62.60	62.34	-0.41	65.08	3.82
saturated-fat_g	24.26	32.53	**25.43**	33.38	**27.32**	22.82	30.57	**25.37**	31.61	**27.82**
polyunsaturated-fat_g	14.29	18.03	**20.75**	19.30	**25.94**	13.76	17.76	**22.53**	18.44	**25.39**
monounsaturated-fat_g	23.09	37.69	**38.72**	39.13	**40.98**	19.91	34.40	**42.14**	35.42	**43.80**
cholesterol_mg	142.13	140.49	-1.17	142.13	0.00	206.44	202.60	-1.89	205.46	-0.47
carbohydrate_g	325.37	326.71	0.41	306.87	-6.03	335.97	337.31	0.40	316.13	-6.27
sugars_g	89.23	89.51	0.32	71.93	**-24.04**	92.33	92.61	0.30	75.13	**-22.89**
starch_g	231.18	231.18	0.00	231.07	-0.04	238.55	238.55	0.00	237.04	-0.64
water_g	1120.24	1142.20	1.92	1020.08	-9.82	1118.69	1140.98	1.95	1020.67	-9.60
alcohol_g	3.24	3.24	0.00	3.24	0.00	6.23	6.23	0.00	6.23	0.00
dietary-fibre_g	38.04	39.31	3.23	37.08	-2.58	33.29	34.56	3.68	31.49	-5.71
thiamin_mg	1.80	1.82	1.00	1.79	-0.57	3.18	3.20	0.57	3.16	-0.87
riboflavin_mg	2.03	2.06	1.07	2.01	-1.31	2.62	2.64	0.78	2.57	-1.84
niacin_mg	19.70	20.04	1.70	19.64	-0.30	24.06	24.41	1.41	23.99	-0.31
niacin-equivalents_mg	35.84	36.25	1.13	35.63	-0.58	39.74	40.16	1.05	39.53	-0.54
vitamin-c_mg	105.59	105.59	0.00	91.63	**-15.24**	180.15	180.15	0.00	159.75	**-12.77**
total-folate_ug	338.73	375.03	9.68	363.37	6.78	372.30	408.60	8.88	398.02	6.46
total-vitamin-a-equivalents_ug	966.09	918.38	-5.20	846.68	**-14.10**	1006.45	960.52	-4.78	970.33	-3.72
retinol_ug	344.20	301.04	**-14.34**	344.20	0.00	669.00	627.54	-6.61	658.60	-1.58
beta-carotene-equivalents_ug	3735.50	3746.23	0.29	3056.91	**-22.20**	2020.06	2031.48	0.56	1906.65	-5.95
sodium_mg	2115.62	2087.65	-1.34	2112.03	-0.17	2303.79	2281.24	-0.99	2293.90	-0.43
potassium_mg	2883.05	3029.79	4.84	2846.15	-1.30	3201.21	3348.59	4.40	3095.93	-3.40
magnesium_mg	401.96	409.93	1.94	399.02	-0.74	443.24	451.20	1.76	432.87	-2.40
calcium_mg	1000.14	1027.53	2.67	1009.81	0.96	863.24	890.53	3.06	876.38	1.50
phosphorus_mg	1554.25	1568.60	0.91	1548.24	-0.39	1639.91	1654.07	0.86	1628.98	-0.67
iron_mg	15.70	17.14	8.38	16.62	5.51	17.89	19.32	7.43	18.84	5.03
zinc_mg	10.58	10.75	1.58	10.47	-1.06	9.88	10.05	1.67	9.84	-0.43

Bolded values indicate a change of +/-≥10%

Table 27: Modelling outcomes for males showing percentage difference from base model for both fat and fruit substitutions

	Model 1					Model 2					Model 3				
	Base	**Fat**	**% diff**	**Fruit**	**% diff**	**Base**	**Fat**	**% diff**	**Fruit**	**% diff**	**Base**	**Fat**	**% diff**	**Fruit**	**% diff**
weight_g	2026.07	2051.321	1.23	1906.32	-6.28	2026.07	2051.32	1.23	1906.32	-6.28	2026.07	2051.32	1.23	1906.32	-6.28
energy_kj	14908.47	14952.92	0.30	14815.23	-0.63	11818.28	11850.11	0.27	11721.57	-0.83	12057.18	12138.83	0.67	11984.12	-0.61
protein_g	172.69	173.13	0.25	172.27	-0.24	104.30	104.75	0.43	104.03	-0.26	105.36	105.83	0.45	105.52	0.16
total-fat_g	111.75	111.88	0.11	115.44	3.20	80.81	80.59	-0.27	84.50	4.37	87.81	88.92	1.25	91.50	4.03
saturated-fat_g	39.99	48.22	**17.06**	49.11	**18.57**	28.74	35.89	**19.93**	37.86	**24.09**	28.81	36.91	**21.95**	37.93	**24.05**
polyunsaturated-fat_g	24.44	28.32	**13.72**	29.44	**17.00**	20.71	25.40	**18.47**	25.71	**19.47**	22.73	27.00	**15.81**	27.74	**18.05**
monounsaturated-fat_g	38.11	52.61	**27.56**	54.14	**29.61**	23.47	37.92	**38.10**	39.50	**40.59**	28.86	44.05	**34.48**	44.89	**35.71**
cholesterol_mg	326.85	325.30	-0.48	326.85	0.00	187.31	180.73	-3.64	187.31	0.00	183.70	180.17	-1.96	183.70	0.00
carbohydrate_g	446.06	447.40	0.30	432.94	-3.03	388.29	389.61	0.34	374.63	-3.65	386.54	387.89	0.35	373.54	-3.48
sugars_g	208.57	208.85	0.14	196.74	-6.01	93.27	93.54	0.28	81.05	**-15.08**	107.30	107.59	0.27	93.72	**-14.49**
starch_g	230.01	230.01	0.00	230.00	0.00	287.52	287.52	0.00	287.52	0.00	277.42	277.42	0.00	277.28	-0.05
water_g	1182.25	1204.19	1.82	1076.71	-9.80	1354.88	1377.19	1.62	1248.10	-8.56	1365.51	1386.35	1.50	1255.87	-8.73
alcohol_g	1.54	1.54	0.00	1.54	0.00	3.14	3.14	0.00	3.14	0.00	3.07	3.07	0.00	3.07	0.00
dietary-fibre_g	48.89	50.16	2.53	48.32	-1.18	54.26	55.53	2.28	53.71	-1.02	56.71	57.98	2.19	56.16	-0.99
thiamin_mg	3.57	3.59	0.51	3.57	0.07	2.65	2.67	0.68	2.65	0.10	2.29	2.31	0.79	2.28	-0.53
riboflavin_mg	6.99	7.01	0.31	6.95	-0.53	2.20	2.22	0.93	2.18	-1.01	2.20	2.22	0.96	2.20	0.31
niacin_mg	30.03	30.37	1.12	29.78	-0.84	23.67	24.02	1.42	23.43	-1.05	27.97	28.31	1.20	28.16	0.69
niacin-equivalents_mg	56.52	56.93	0.72	56.20	-0.57	43.77	44.19	0.94	43.60	-0.38	48.73	49.15	0.85	49.00	0.55
vitamin-c_mg	152.61	152.61	0.00	146.74	-4.00	152.21	152.21	0.00	147.56	-3.15	252.64	252.63	0.00	222.86	**-13.36**
total-folate_ug	583.20	619.50	5.86	617.83	5.60	423.23	459.52	7.90	457.96	7.58	370.10	406.40	8.93	406.27	8.90
total-vitamin-a-equivalents_ug	1104.61	1057.99	-4.41	1092.82	-1.08	637.55	591.53	-7.78	629.53	-1.27	1662.40	1606.88	-3.46	1661.46	-0.06
retinol_ug	890.07	848.10	-4.95	890.07	0.00	425.76	384.86	**-10.63**	425.76	0.00	548.26	499.16	-9.83	548.26	0.00
beta-carotene-equivalents_ug	1246.25	1256.57	0.82	1219.63	-2.18	1257.73	1264.68	0.55	1253.79	-0.31	6680.74	6680.49	0.00	6708.93	0.42
sodium_mg	4381.11	4358.39	-0.52	4375.80	-0.12	3371.74	3334.26	-1.12	3366.48	-0.16	2468.39	2463.12	-0.21	2465.93	-0.10
potassium_mg	7381.07	7528.01	1.95	7365.35	-0.21	4055.03	4201.68	3.49	4010.31	-1.12	4480.26	4627.93	3.19	4525.42	1.00
magnesium_mg	794.92	802.88	0.99	792.27	-0.33	574.76	582.67	1.36	573.71	-0.18	555.19	563.17	1.42	559.98	0.86
calcium_mg	3927.52	3954.96	0.69	3945.38	0.45	1033.75	1060.91	2.56	1053.98	1.92	1314.09	1341.61	2.05	1336.93	1.71
phosphorus_mg	3979.70	3994.09	0.36	3977.94	-0.04	2118.91	2132.80	0.65	2117.27	-0.08	2061.02	2075.41	0.69	2069.63	0.42
iron_mg	24.36	25.80	5.57	25.35	3.88	21.51	22.95	6.25	22.64	5.00	21.54	22.97	6.25	22.82	5.61
zinc_mg	21.68	21.85	0.78	21.54	-0.61	13.96	14.13	1.19	13.98	0.12	15.60	15.77	1.06	15.62	0.11

	Model 4					Model 5				
	Base	Fat	% diff	Fruit	% diff	Base	Fat	% diff	Fruit	% diff
weight_g	2026.07	2051.32	1.23	1906.32	-6.28	2026.07	2051.32	1.23	1906.32	-6.28
energy_kj	11265.98	11295.19	0.26	11210.08	-0.50	10851.56	10885.42	0.31	10751.31	-0.93
protein_g	86.69	87.16	0.53	86.57	-0.15	102.46	102.94	0.46	102.20	-0.26
total-fat_g	68.51	68.22	-0.44	72.20	5.11	60.91	60.74	-0.29	64.60	5.71
saturated-fat_g	18.10	26.07	**30.55**	27.23	**33.50**	24.94	32.38	**22.98**	34.06	**26.77**
polyunsaturated-fat_g	16.70	21.41	**22.01**	21.71	**23.06**	9.48	13.91	**31.85**	14.49	**34.55**
monounsaturated-fat_g	28.01	41.55	**32.58**	44.04	**36.40**	20.23	34.68	**41.69**	36.26	**44.21**
cholesterol_mg	130.85	127.30	-2.79	130.85	0.00	171.68	167.76	-2.34	171.68	0.00
carbohydrate_g	410.06	411.40	0.33	398.80	-2.82	383.80	385.13	0.35	369.91	-3.75
sugars_g	101.81	102.09	0.28	91.74	**-10.98**	90.55	90.84	0.31	78.11	**-15.93**
starch_g	301.18	301.18	0.00	301.18	0.00	284.73	284.73	0.00	284.72	-0.00
water_g	1402.39	1424.69	1.57	1292.78	-8.48	1399.04	1421.25	1.56	1292.46	-8.25
alcohol_g	3.75	3.75	0.00	3.75	0.00	2.57	2.57	0.00	2.57	0.00
dietary-fibre_g	32.61	33.88	3.75	32.05	-1.74	40.66	41.93	3.03	40.12	-1.34
thiamin_mg	2.08	2.10	0.87	2.08	0.12	2.25	2.27	0.80	2.26	0.12
riboflavin_mg	1.79	1.81	1.16	1.78	-0.45	1.90	1.92	1.16	1.88	-1.18
niacin_mg	21.43	21.78	1.58	21.33	-0.50	27.31	27.65	1.24	27.06	-0.92
niacin-equivalents_mg	39.00	39.42	1.07	38.83	-0.46	47.17	47.60	0.89	47.00	-0.37
vitamin-c_mg	155.74	155.74	0.00	149.46	-4.20	189.79	189.79	0.00	159.98	**-18.63**
total-folate_ug	368.41	404.71	8.97	403.00	8.58	375.97	412.27	8.80	412.20	8.79
total-vitamin-a-equivalents_ug	978.86	929.99	-5.25	968.48	-1.07	684.35	640.18	-6.90	675.62	-1.29
retinol_ug	366.27	322.56	**-13.55**	366.27	0.00	378.53	339.05	**-11.64**	378.53	0.00
beta-carotene-equivalents_ug	3629.37	3636.67	0.20	3611.41	-0.50	1821.56	1832.03	0.57	1813.42	-0.45
sodium_mg	1737.32	1718.39	-1.10	1735.01	-0.13	2522.20	2497.36	-1.00	2516.99	-0.21
potassium_mg	3255.80	3403.20	4.33	3215.66	-1.25	4205.44	4353.53	3.40	4160.20	-1.09
magnesium_mg	334.93	342.88	2.32	333.81	-0.33	443.85	451.82	1.76	442.89	-0.22
calcium_mg	739.50	766.84	3.57	759.50	2.63	826.76	854.35	3.23	846.98	2.39
phosphorus_mg	1414.35	1428.56	0.99	1415.42	0.08	1822.16	1836.56	0.78	1820.42	-0.10
iron_mg	16.39	17.82	8.05	17.52	6.46	16.89	18.33	7.83	18.03	6.30
zinc_mg	10.29	10.46	1.61	10.31	0.17	11.91	12.08	1.39	11.93	0.14

Bolded values indicate a change of +/-≥10%

Conclusions and limitations

The data contained in this report encompass the limitations of using food composition databases. For the purposes of this project, these primarily include a limited range of nutrient values available for all food items. Missing data for only one food item has the ability to modify the outcomes and hence should not be reported. Furthermore, the use of FoodWorks software in this project results in the output data being limited to those within the software package. In particular this affected the alpha-tocopherol/Vitamin E results for this project. Although avocados do contain this nutrient, the database used in FoodWorks does not allow alpha-tocopherol to be added and therefore this data was unable to be reported.

The dietary intake data used in this project to weight the composite food groups was also limited to that available from the 1995 National Nutrition Survey. This data is presently 15 years old. The food consumption patterns of Australians are likely to have changed in this time period. This is still, however, the only comprehensive collection of food intake data for adults in Australia until the next survey is completed in the coming years.

The models in this project have shown that replacing fruit and fat servings with avocados does have an impact on the total nutrient composition of the diet. The nutrients affected by replacing a fat serving were less significant than replacing a fruit serving and therefore it would be suggested that avocado be considered as a healthy fat alternative within the context of a healthy balanced diet. The models created did incorporate avocado as a serving on a daily basis and were limited to the use of a serving size determined from authoritative sources (1/8 whole) rather than from separate modelling work as well. Future work would recommend the serving size for avocados be modelled before it is incorporated into a healthy balanced diet and that a collection of options for the frequency of intake be considered. This would take into consideration the various cuisine patterns that use avocado as a spread, a dip, a key component in significant dishes, or a light meal or snack in itself. It would also be possible to link this with the diet models that have been developed using the reference serve size developed for the modelling exercise undertaken in this report. Finally, with avocado purchased in the fresh unit state, it is likely to be the consumer who determines portion size depending on the way in which the food is going to be used. In this context nutritional information on 100g will remain useful, preferably supplemented with recipe and culinary suggestions.

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CONSUMER RESEARCH FINDINGS (PROJECT FI-175) BASED ON CONSUMER FOCUS GROUP STUDIES

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Disclaimer

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Executive Summary

Studies specifically addressing the beliefs and opinions of the consumer in relation to health and nutrition messages for avocados have not been published in the scientific literature within the past ten years nor are they specific to the Australian market. For this reason, this report describes consumer research conducted to explore the beliefs and opinions of a sample of Australian grocery shoppers in relation to avocados. Focus group interviews were conducted with main grocery buyers in the Illawarra region of New South Wales. Three groups were conducted with female participants aged 50+ years, 35-49 years and 20-34 years and an additional focus group was conducted with males (25+ years) due to high levels of interest. In total n=24 female and n=8 male participants attended the focus group interviews.

Avocados were recognised as a food product of interest by all participants in the focus group sessions. Three key influences relating to convenience, food use and healthiness perceptions (nutrition messages) were identified as having an impact on the regular inclusion of avocados in the diet across all groups, although variations in emphasis was evident depending on the life stage and gender of the main grocery buyer.

Convenience

Convenience was the primary reported influence on choice of food shopping venues in all groups. However the participants reported there was an acknowledged trade off with limiting shopping venues to large supermarkets. Some participants regularly sought out green grocers or local markets for the quality of the product. Price and quality were also reported to influence the frequency of purchases and hence frequency of consumption of the avocado. The impact of significant others on food selection was noted primarily through factors such as meeting flavour preferences and managing time constraints.

Food use

The taste preferences of spouses and children reportedly influenced the ways in which avocados were utilised in the home. Overall, avocados were reported to be used primarily as a snack or a fat replacement product. It was often used to replace margarine or butter on sandwiches and added to salads. Older females enjoyed using avocados in cooked dishes while some of the male participants expressed a distaste for hot avocado products. Storage of avocados during ripening and after cutting them open was also an area of concern commented upon within all groups.

Healthiness perceptions (nutrition messages)

The messages related to avocados were seen to be reassuring for the younger participants but were not seen to be particularly useful. Messages specifically referring to antioxidant and vitamins were often related to beauty products as opposed to foods and messages that were strongly associated with other product categories A disconnect was raised over claims relating to specific minerals for the female groups, while the males were not as concerned and felt listing minerals could be useful. The wording of the messages had a strong impact on the acceptance of the claim with scientific terms often rejected.

Recommendations

Areas that could be further pursued from a sales and marketing perspective may include:

- Taste testing promotions in supermarket chains to increase overall awareness and disseminate recipe ideas for the use of avocado

- Different varieties that are available seasonally may be linked in with recipe campaigns and used to link in new uses for avocado e.g. cold/fresh dishes in the hotter months and warm/creamy dishes in the cooler months.

- Packaging promotions where multiple avocados can be purchased together. The packaging/container could be used to educate consumers.

- Storage containers/techniques/implements to decrease the desire to eat the entire avocado in one sitting yet maintain quality of the fruit for use in the next sitting, potentially increasing the frequency of purchasing due to decreased concerns about food wastage.

Background

The avocado fruit has long been consumed by the general public but a limited amount of consumer research exists for the use of sales and marketing approaches within the industry. One recent Australian and New Zealand consumer study of the impacts of Hass fruit quality on intention to purchase addressed the percentage of dry matter, bruising and firmness of the fruit. The study was conducted using taste testing of fruits that varied in the maturity and viewing photographs of different degrees of bruised fruit. It was discovered that increased dry matter and ripeness was preferred at a level of 6.5N (a measure between hand firmness and instrumental texture measurements). Cost of the product, level and incidence of bruising all affected the decision to purchase though level and incidence had the greater impact. (Gamble et al, 2010) Studies specifically addressing the beliefs and opinions of the consumer in relation to health and nutrition messages have not been published in the scientific literature within the past ten years nor are they specific to the Australian market. For this reason, this report will describe consumer research conducted to explore the beliefs and opinions of Australian grocery shoppers in relation to avocados. It will focus not only on health and nutrition messages that are or may be used for the fruit but also existing beliefs, misconceptions and uses of the product. A qualitative grounded theory approach (Creswell, 2007) was applied to ensure that the data obtained was valid and consistent.

Rationale and objectives

The aim of this report is to describe social factors that may influence the sales and marketing of Avocados and the role that nutrition might play as part of their selection in the diet.

Methods

Focus group interviews were conducted with main grocery buyers in the Illawarra region of New South Wales. Three groups were conducted with female participants aged 50+ years (FG1), 35-49 years (FG2) and 20-34 years (FG3) and an additional focus group was conducted with males (25+ years, FG4) due to high levels of interest. All participants were recruited by convenience sample from a community announcement transmitted via email. Participants were screened to determine their eligibility and were further invited to participate in the focus group corresponding to their age/gender. Focus groups were conducted by the same facilitator with an observer/note taker present for all groups. Participants were shown visual aids of avocado meals and health related messages (Figure 1) throughout the session. All participants received a $50 Myer voucher after completion of the focus group.

In total n=24 female and n=8 male participants attended the focus group interviews. On average, females had a Body Mass Index (BMI) of 24.8kg/m^2 positioning them within the upper end of the healthy weight category (BMI 20-25 kg/m^2), while male participants had a BMI of 25.5 kg/m^2 positioning them just outside the healthy weight category. Males had an average of 2 children (n=3 no children), were either married or in a defacto relationship and all were tertiary educated via TAFE or University. Females had an average of 2 children (n=9 no children), the majority were married (n=14) and University educated (n=14).

All groups were audio recorded and transcriptions were professionally transcribed verbatim and checked by a researcher for accuracy. Each individual focus group was analysed categorically and each group was then checked for consistency by a different member of the research team. Once consistency was achieved data was uploaded into NVivo qualitative analysis software (version 8, QSR International) for thematic analysis.

- Antioxidants in avocados help protect the body against free radical damage
- Avocados are low in salt
- Avocados are a good source of vitamin C, vitamin E, niacin, pantothenic acid, beta-carotene and folate
- Avocado is a natural source of antioxidants, vitamin A, C and E that help protect the cells from oxidative damage
- Avocados form part of a healthy diet of fruits and vegetables
- A natural source of antioxidants – to help keep your body healthy
- Avocados are a natural source of antioxidants that help protect the cells from oxidative damage
- Avocados are cholesterol free
- Avocados are a source of vitamins B1, B2, B6, magnesium and copper
- Avocados are a natural source of antioxidants
- Avocados are high in fibre

Figure 2: Nutrition related messages discussed in the focus groups

Key Findings

Avocados were recognised as a food product of interest by all participants in the focus group sessions. Three key influences relating to convenience, food use and healthiness perceptions were identified as impacting on the regular inclusion of avocados across all groups although variations in emphasis was evident depending on the life stage and gender of the main grocery buyer. This was especially evident when comparing the responses of the younger female and older female focus groups. The beliefs about the inclusion and use of avocados in the diet of the younger females were seen to be more fluid as they are apparently still largely embedding their own food knowledge and skills. The influences of family were also beginning to emerge in the younger female group with recognition of significant others such as partners or younger children influencing food choice. This observation was also reported in the female 35-49 year old age group but less evident in the 50+ females and older males represented in the male group. That is, older females and males reported their independence about food selection and not being as strongly influenced by significant others as many had children who had moved out of home and had established more flexible 'new' food habits as a result. Different life stages also demonstrated variations in healthiness perceptions with the 50+ female older age group expressing more concern about nutrition and health benefits of foods in general and avocados specifically than the younger group. The following section outlines additional factors impacting on these key influences and the variations identified within each age group and gender.

Within each of these themes, shifts in opinions were evident as outlined below.

Convenience

Convenience was the primary influence impacting participants' choice of food shopping venues in all groups.

"…whatever's quickest and easiest [for food shopping]." (FG2)

However, the participants reported there was an acknowledged trade off with limiting shopping venues to large supermarkets. Participants reported supermarkets offerings imposed constraints on *price* and *quality* parameters which were also key areas of concern reported for vegetable selection and avocados specifically.

"Well, I usually go to the supermarket because it's quick and convenient but for fruit and vegetables I'll often go to a separate fruit and vegetable store. Um, often they're cheaper and the quality's better". (FG3)

Variations in *shopping behaviours* were, however, reported as relating to different life stages in terms of the emphasis and rationale given. For instance females in the 50+ age group were clearly focussed on the importance of the quality and the price of the avocados as key influencers of purchase which was reflected in their use of other suppliers such as home delivery or green grocers.

"It's also variety – when you go to greengrocers, like we have a lot of vinaigrette salads so things like the, the ah, salad mix that you can get at greengrocers you can't get at Woollies and Coles." (FG1)

Price and *quality* were also reported to influence the *frequency of purchases* and hence *frequency of consumption* of the avocado. For instance quality products were often acknowledged as coming at a either a price premium out of season or price appealing within season. Many participants reported this was a key influence on the number of avocados consumed and how quickly they were consumed to avoid any issues of wastage from a monetary and product loss perspective.

"We thrive on people like…you know, you go along and you "Oh this is too soft, this is too soft" and at the end of the day you go to a supermarket and they've got this stall where they've got all the stuff that's too soft, that's starting to discolour" and you buy six avocados for $1.50 and they're all perfect. You go and have them that night not a problem." (FG2)

Choosing supermarkets as the primary shopping venue also was acknowledged to impact on the *frequency of purchase* with the bulk buy options that were commonly available in store favoured when avocados were in season.

"My wife works longer hours than me so I do get to do the bulk of the grocery shopping. Ah, she comes shopping with me when she can but, um, we have a supermarket a couple of blocks away so it's a walk to the supermarket for the bulk of our stuff. Um, whatever's in season when it comes to fruit and veg um, but when we're after something special we go for a drive to a greengrocers in [suburb] and um, do a bulk buy." (FG4)

The regular reported use of supermarkets for purchasing avocados highlights perceptions about limited control on *quality* and *price* parameters for the consumer but does provide some opportunities for education and marketing. For instance making them a focal point for any promotional campaigns to encourage further trial and purchase of avocados may be explored.

The impact of *significant others* on food selection was noted primarily through factors such as meeting *flavour preferences* and managing *time constraints* and were also seen to be entwined in the *convenience* driver.

"I'd say we definitely have. I think we buy a lot more fruit than we used to because the kids eat a lot of fruit. Um, we probably don't buy as many vegetables as we used to; because it's kind of irritating to cook things that you know they're not going to eat…" (FG4)

Participants with young children or grandchildren acknowledged avocados as a nutritious food choice for children while others saw it as a ready to eat snack.

"Um, grandchildren, they're great like with little kids and really good, you just sort of cut the top off and spoon it out of the top and then pop the top back on; you don't have to cut them lengthwise – you just take the top off and actually use it as a cup and actually you can spoon it out for little kids." (FG1)

Younger participants commented on the significance of *time constraints* which drove their decision to purchase produce from large supermarket chains.

"Not so much. I think for me it's more the convenience thing. Having a small child, you know, I just need to get in and out as quickly as possible. (Laughs) So, I don't care. I'll just spend whatever." (FG3)

However, again, life stage demonstrated differences in reported behaviour with older participants speaking of their ability to purchase as needed and select particular green grocers for such purchases to ensure *quality*.

"Um, it [green grocer] is cheaper. It [green grocer] is a lot cheaper and their, um, quality seems to be pretty good. But you've got to shop around. You know, you watch the papers and see what's going." (FG1)

The rationale for selecting avocados varied across the age groups and could also be related to life stage. This included meeting immediate taste preference needs for the younger male and female participants whilst acknowledging concerns related to food *quality* and *pricing.*

"When they're in the supermarket and they're, they're not $6.00 each I would use them every, every second day" (FG3)

Older grocery buyers were similarly aware of the price barrier but were not as concerned with its impact, stating that if avocados were needed for a recipe, they would be purchased despite the price. This became particularly evident through discussions relating to entertaining for special occasions and holidays.

"If it's $1.50 or $2.00 for a little one, it's like there's no point so it's got to be a reasonable one, um balanced with the price. If I'm having a dinner party I'll buy it because you need it but for every day use, if it's at the $3.00 mark I'm not buying it." (FG4)

The need to choose home grown and local produce was raised more commonly amongst the older (50+) females with the concept of organic produce also creating interest. The *quality* of these products was reportedly the driving factor for this decision.

"Um, I'm passionate about my organic veggie garden; and um it's not um you can't turn your back on children or gardens. So, I've been away for three months so it needs a lot of hard work but I absolutely love it and, and I like to choose my own fruit and vegetables... I love to grow my own. There's nothing like pulling something out that you've grown and using it." (FG1)

Interestingly the male participants noted this was not a consideration as they assumed that avocados available for purchase were Australian. However, the male participants also reported that they prefered to purchase Australian produce whilst acknowledging that *price* could impact their decision.

"If there's a choice of Australian and overseas and the price is within 50 cents, I'll go Australian every time. If it's over 50 cents, I'll judge the size of the avocados – um, yeah, but I do try to buy the Australian avocados first." (FG4)

Point of sale displays may allow the consumer to make decisions relating to their personal preferences for the origin of the produce.

Food use

Overall avocados were well recognised but the use of the fruit generally was limited. The taste preferences of spouses and children reportedly influenced the ways in which avocados were utilised in the home. Participants who had young children or grandchildren spoke of the importance of avocados as a good choice for both snacking and as a tasty addition with meals.

"…even on a pizza; that's a good one, pizza, slices of avocado – the kids are making our own bread and stuff so if we make fresh pizza they just put slices of avocado just on top…" (FG4)

Overall, avocados were reported to be used primarily as a snack or a fat replacement product. Eaten on their own with minimal seasoning or used to replace margarine or butter on sandwiches and added to salads.

"I never use margarine; I use avocado" (FG2)

Older females enjoyed using avocados in cooked dishes while some of the male participants expressed a distaste for hot avocado products.

"I've never heated avocado or browned it or grilled it or anything like that because when I've had it, I don't know how, it just tastes weird." (FG4)

Male participants did however comment on a wider range of food uses for avocados including dips and pizzas.

"… particularly white sauce based sorts of dishes, if there's a bit of cheese, avocado on the top so it's a pasta on chicken with a sauce or yeah things like that" (FG4)

One participant spoke of its use in a vegan diet using it to bind foods together in place of traditional dairy sources. Overall though, considering participants in all groups were reportedly regular avocado consumers, usage was fairly limited offering an opportunity to broaden understanding of range of uses. This usage could be linked with education related to the seasonality and differing varieties of avocado available.

Storage of avocados during ripening and after cutting them open was also an area of concern commented upon within all groups. Participants commented on a variety of methods used to manage cut avocados ranging from always consuming immediately through to utilising foil wrap and refrigeration to avoid food spoilage.

"if I've got half an avocado I either put the empty skin back on it and put it in the fridge with an elastic band around it or just some paper towel, wet paper towel and put that over the cut part and have that in the fridge." (FG1)

There was variation in the acceptability of managing superficially spoiled avocados. A mixed response was heard about concerns focussed on the discolouration or spoilage with some participants preferring to remove it prior to use and others not concerned.

"… even if it might not be exactly the same colour green …, it doesn't make much difference to the taste of it." (FG4)

An additional area of concern related to managing the ripening process and there were variations in the reported confidence of using techniques such as using other fruit to increase the speed of ripening. Discussions often became animated in the group as participants shared the knowledge about how best to accomplish the ripening process in home.

"…buy three or four kilo at a time then we manage the ripening process by putting them in and out of the fridge and whatnot to have them coming on for a time." (FG4)

The environment of ripening was also addressed with paper bags, dark places and windows sills being the primary choices.

"In a brown paper bag in a dark cupboard with a banana." (FG1)

Consumer focussed education to address appropriate *storage* methods and ripening techniques should also be considered to lessen the impact of negative perceptions about lack of control on managing the fruit for maximum enjoyment in the home.

Healthiness perceptions (nutrition messages)

Nutrition did not appear to be the primary driver for avocado use. The messages related to avocados were seen to be reassuring for the younger participants but were not seen to be particularly useful. Messages specifically relating to antioxidant and vitamins were often related to beauty products as opposed to foods and messages that were strongly related to other product categories e.g. high in fibre were also rejected.

"I think Weetbix when I see that." (FG4)

A disconnect was raised in relation to claims relating to specific minerals for the female groups, while the males were not as concerned and felt listing minerals such as copper could be useful.

"Copper's a little scary." (FG3)
"I can handle that one [list of nutrients]compared to the other ones [nutrition statements]." (FG4)

The wording of the messages had a strong impact on the acceptance of the claim.

"I think the, um, statement is, is um, I mean it's pulling some very, very um key words – it says "natural", it says "protect" – those words in particular... They're really good key words there passing across particular messages which might, um, catch a lot of people's eye…" (FG1)

Scientific language was not seen as particularly beneficial though simple messages such as cholesterol free were well accepted. For instance the use of the word 'antioxidant' was not seen in a very positive light due to its perceived overuse and was related to misinformation associated with other products.

"It doesn't really resonate with me because I don't really deliberately seek out antioxidants." (FG2)

The focus of health within the messages was another key factor with a strong awareness of connection to cholesterol related benefits. There was some opportunity to identify the type of fat found in avocados for the female participants in the 35-49 years age group.

"Um, I assume it's good fat but if you were to ask me what the good fats are I probably wouldn't be able to tell you. I don't know if it's mono or poly or unsaturated – I don't know which are which but I always assume it – just because of the taste and it's nice and buttery and um, that it has some fats but they're good fats but beyond that, yeah…" (FG2)

Education campaigns directed towards younger children were suggested as a means of improving awareness about nutrition attributes of avocados. Other ideas raised include incorporation of nutrition related messages into cooking shows on television were reported as being more useful activities to increase general consumer perception overall.

Recommendations

The consumer beliefs and opinions in relation to Avocados showed a strong influence of significant others and a widespread awareness of avocados and their benefits. The feeling of the participants overall seemed to express a need for familiarity. Participants wanted messages related to nutrient contributions to be comparable with something familiar. Point of sale messages were not seen to be particularly useful and utilising other forms of media to broaden the overall awareness of the product may strengthen the approach. More generalised nutrition messages and an increased focus on the utilisation of the avocado may also improve awareness. The strong snacking preferences lead to suggestions of product developments similar to the kiwifruit spoon/knife for ease of consumption. The traditional method of slicing the fruit around the stone was not raised very often though confusion relating to the different varieties of avocado, their seasonality and their taste may be an avenue for consumer education.

Areas that may be further pursued from a sales and marketing perspective may include:

- Taste testing promotions in supermarket chains to increase overall awareness and disseminate recipe ideas for the use of avocado
- Different varieties that are available seasonally may be linked in with recipe campaigns and used to link in new uses for avocado e.g. cold/fresh dishes in the hotter months and warm/creamy dishes in the cooler months.
- Packaging promotions where multiple avocados can be purchased together. The packaging/container could be used to educate consumers.
- Storage containers/techniques/implements to decrease the desire to eat the entire avocado in one sitting yet maintain quality of the fruit for use in the next sitting, potentially increasing the frequency of purchasing due to decreased concerns about food wastage.
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TECHNOLOGY TRANSFER

1. Presentation at the 8th Annual Avocado R & D Integrated Workshop. Parliament House, Canberra, 24th and 25th June 2010. Dr Jenny Jobling presented an overview of the results to date to the industry.

2. Teleconference with Avocados Australia, Professor Linda Tapsell and HAL October 2010 to discuss the portion size modelling aspect of the project.

3. The University of Wollongong (UOW) is currently writing a scientific paper describing the modelling and consumer survey work. This paper cannot be published at the time of writing of this report because there is an embargo in place on the publication of project results until 12 months from the end of the project. UOW has been in communication with Avocados Australia on this point and the industry body wishes to adhere to the conditions of the embargo. The paper will therefore be published 12 months from now.

RECOMMENDATIONS

Regulatory review

This review has not assessed whether any of these potential claims have sufficient scientific substantiation to support the claim. In the case of function and health claims this would involve a substantial body of work to search for and summarise all the relevant scientific studies. It is no longer sufficient to rely on single studies to support such claims; a food company has to demonstrate they have followed the FSANZ substantiation guidelines, which require a defined literature search strategy, evaluation of the quality of each study, and an overall assessment of the balance of evidence, with particular emphasis placed on human clinical trials.

Upon reviewing the scientific literature and the nutrient databases from a selection of countries, it appears that the more common vitamins, minerals and fatty acids are the primary factors of interest. Many vitamins and minerals are growing in their research interests as a phytochemicals i.e. carotenoids and hence are being studied in their varied forms in avocados. The literature relating to avocados and health remains limited and although studies were identified for cancer, cardiovascular disease, diabetes management and wound healing, the number of studies is not sufficient to allow for this link to be definitively made nor stated as a health claim or nutrient function claim for the product.

The literature commonly uses a group of nutrients rather than a specific one, uses an extract of the nutrient from the food and tests the nutrient under laboratory conditions. The few human studies that were identified focussed on the fat profile of the avocado overall. Despite the fruit being very high in oleic acid, this was in one of the studies reviewed. A high quality, well controlled randomised controlled trial would be recommended though any relationship found should not be considered in isolation but rather in the context of the whole diet.

Based on the comparison of the nutrient composition data for Hass avocados (Table 21), the recommendation would be for analysis of all proximates (macronutrients), full fatty acid breakdown, vitamin and mineral analysis with at least the above listed nutrients though the inclusion of iodine and selenium would also be beneficial. This analysis would be recommended to be provided to FSANZ to update the available food composition data from its current 1980/90 values. Specific bioactive nutrients should include carotenoids showing a breakdown of alpha-, beta-carotene, lutein and zeaxanthin; tocopherols including alpha-, beta- and gamma-tocopherol; and phytosterols including beta-sitosterol, sigmasterol, campestrol and delta-7-avenasterol. Apart from the phytosterols some of the carotenoids and tocopherols would be captured in a standard nutrient analysis though the complete breakdown may not. Other antioxidants could also be considered depending on feasibility.

Nutrient labelling and source claims

Several nutrients have potential for nutrient claims in avocados. These are: total phytosterols, monounsaturated and polyunsaturated fatty acids, folate, Niacin (Vitamin B3), and total dietary fibre. We suggest good source claims for total phytosterols, monounsaturated and polyunsaturated fatty acids, folate and total dietary fibre and a source claim for Niacin (Vitamin B3). Supporting data should be reviewed to ensure it meets the requirements of the new FSANZ legislation relating to this area.

The high phytosterol content of Hass and Shepard avocados is an important finding, with the potential to be used to promote avocados as healthy food which can help to reduce blood LDL cholesterol levels with the associated beneficial effects on cardiovascular health. High levels of monounsaturated fats were confirmed and this finding adds weight to the idea that avocados are have significant potential benefits on cardiovascular health, similar to olive oil.

Human studies to test effects of avocado on blood serum HDL and LDL cholesterol levels are strongly recommended.

Portion size modelling

The models in this project have shown that replacing fruit and fat servings with avocados does have an impact on the total nutrient composition of the diet. The nutrients affected by replacing a fat serving were less significant than replacing a fruit serving and therefore it would be suggested that avocado be considered as a healthy fat alternative within the context of a healthy balanced diet.

Future work would recommend the serving size for avocados be modelled before it is incorporated into a healthy balanced diet and that a collection of options for the frequency of intake be considered. This would take into consideration the various cuisine patterns that use avocado as a spread, a dip, a key component in significant dishes, or a light meal or snack in itself. It would also be possible to link this with the diet models that have been developed using the reference serve size developed for the modelling exercise undertaken in this report.

Finally, with avocado purchased in the fresh unit state, it is likely to be the consumer who determines portion size depending on the way in which the food is going to be used. In this context nutritional information on 100g will remain useful, preferably supplemented with recipe and culinary suggestions.

Consumer surveys

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- Packaging promotions where multiple avocados can be purchased together. The packaging/container could be used to educate consumers.

- Storage containers/techniques/implements to decrease the desire to eat the entire avocado in one sitting yet maintain quality of the fruit for use in the next sitting, potentially increasing the frequency of purchasing due to decreased concerns about food wastage.
- Wording of health information (Cholesterol, antioxidant). There was a perceived overuse of the word “antioxidant” and general claims such as “high in fibre” were not well regarded by consumers (despite avocados actually being an important source of fibre). The words “Cholesterol free”, “natural” and “protect” were well regarded by consumers.