Valuation of ingredients in feeds for Aquaculture

NYC | 22 August 2023

Stephen Gunther
Director: Consulting and Applied Sciences

US SOY Delivers Solutions

USSEC



Wittaya Aqua International

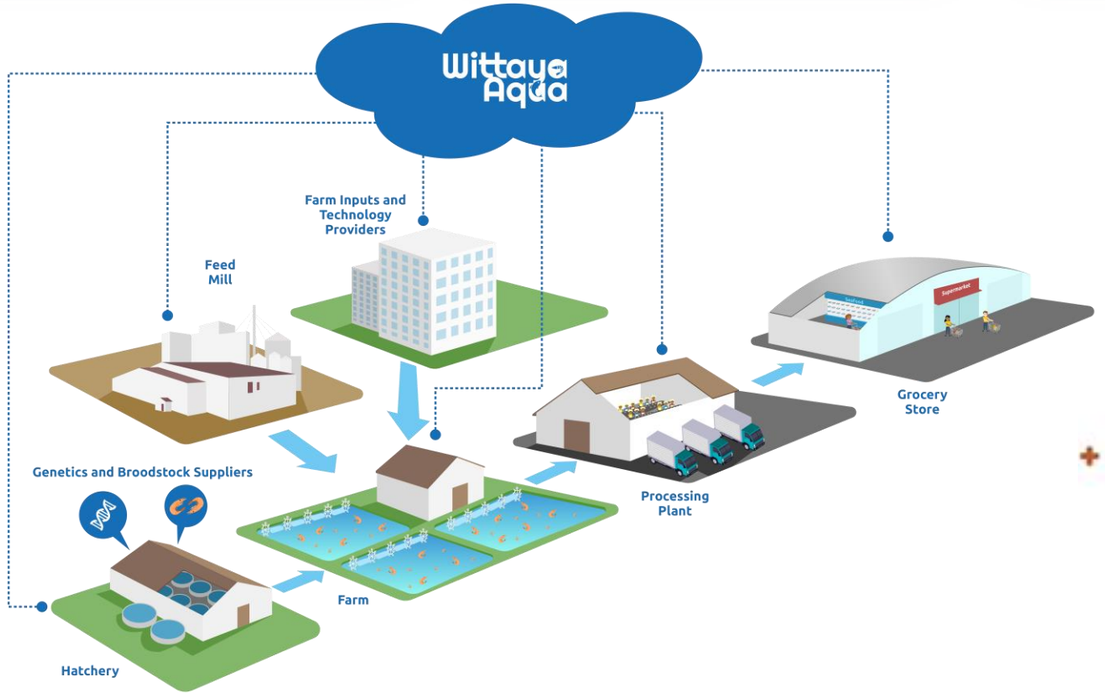
We are a team of aquaculture experts developing data-driven solutions that help the global aquaculture industry flourish

We are the Aquaculture Feed Specialists for USSEC

Aquaop Farm

Aquaop Feed

Aquaop Solutions



USSOY

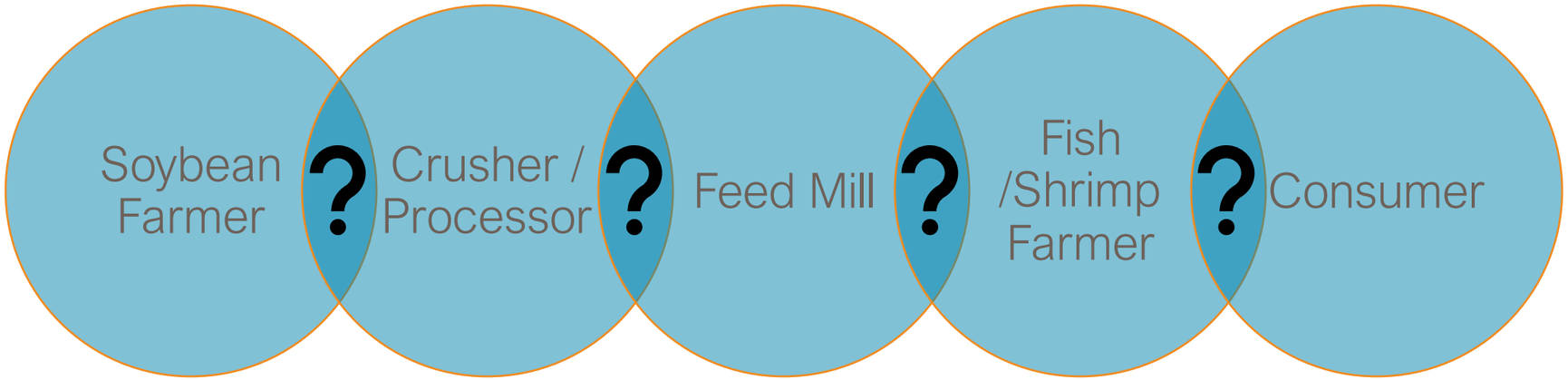
“

PRICE IS WHAT YOU PAY. VALUE IS WHAT YOU GET

WARREN BUFFETT

The Aquaculture Feed Supply Chain

- Each stakeholder must understand what is of value to their client
- Implement processes that capture that value
- Define price based on the value proposition



? What, then does each stakeholder “value”?

Can we quantify it?

Valuing Ingredients

- Animals do not require ingredients they require nutrients
- Every ingredient contains a unique blend of essential and non-essential nutrients
  - Amino acids (protein), Fatty acids (lipids), Carbohydrates, Vitamins, Minerals
- The quantity of one, or more, key essential nutrients is what, typically, determines the price of an ingredient
  - Protein (fish meals, terrestrial animal meals, vegetable meals)
  - Lipid (Fish oils, animal fats, vegetable oils)
- The value of an ingredient, however, is much more complex and determined by such thing as:

Quality and Nutritional Value	Cost Efficiency	Supply chain transparency	Traceability and safety
Innovation and Research	Sustainability and Environmental Impact	Collaboration and Partnerships	Customer Satisfaction

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Quality and Nutritional Value

Sustainability and Environmental Impact

Quality and Nutritional Value (Farmer)

RESEARCH CENTER FOR AQUAFEED NUTRITION AND FISHERY POST-HARVEST TECHNOLOGY (APOTEC)

Final Report

Aquaculture Nutrition Research – Comparative Analysis of Soy from Different Origins

Comparison of the Nutritive Value of Soybean Meals from Different Origins Fed to Nile Tilapia

Quality and Nutritional Value (Farmer)

Parameters	Soybeans		
	Brazil	USA	Argentina
Raw soybeans (kg)	28	28	28
Size (mm)	3.6 ± 0.5	4.2 ± 0.5	3.8 ± 0.5
Color	Dark yellow	Bright yellow	Bright yellow
Good quality beans (%)	82.9	92.5	87.5
Split beans (%)	11.4	5.54	8.39
Foreign materials (%)	1.07	0.82	0.89
Damaged beans (%)	4.6	1.14	3.18
Heated beans (%)	0.06	0	0
Sprouted beans (%)	0	0	0

Reference: Nguyen et al., 2021 -Aquaculture Nutrition Research – Comparative Analysis of Soy from Different Origins

Sprouted

Moldy

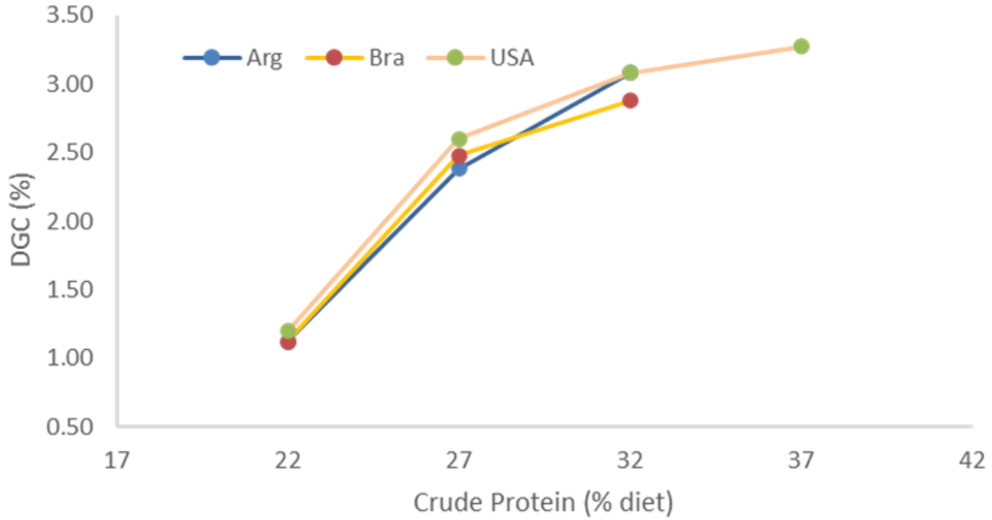
Burned

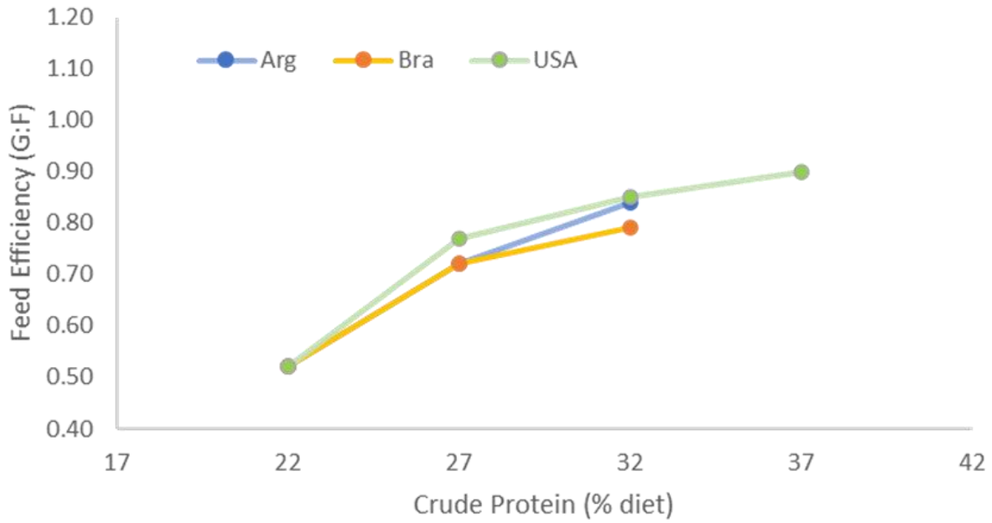
Broken & Split

Source: Mateos, G.G. 2020. US soybean meal: a choice of digestible protein and amino acids in diets for aquaculture

Quality and Nutritional Value (Farmer)

Ingredients	Apparent Digestibility Coefficients %		
	Crude protein	Lipid	Gross Energy
Argentinian SBM	88	86	79
Brazilian SBM	85	83	83
US SBM	91	87	86
Rice and cassava products	75	66	64
Significance			
Argentinian SBM	P<0.0001	P<0.0001	P<0.0001
Brazilian SBM	P<0.0001	P<0.0001	P<0.0001
US SBM	P<0.0001	P<0.0001	P<0.0001
Rice and cassava products	P<0.0001	P<0.0001	P<0.0001





Quality and Nutritional Value (Processor)

Control
Not cooked

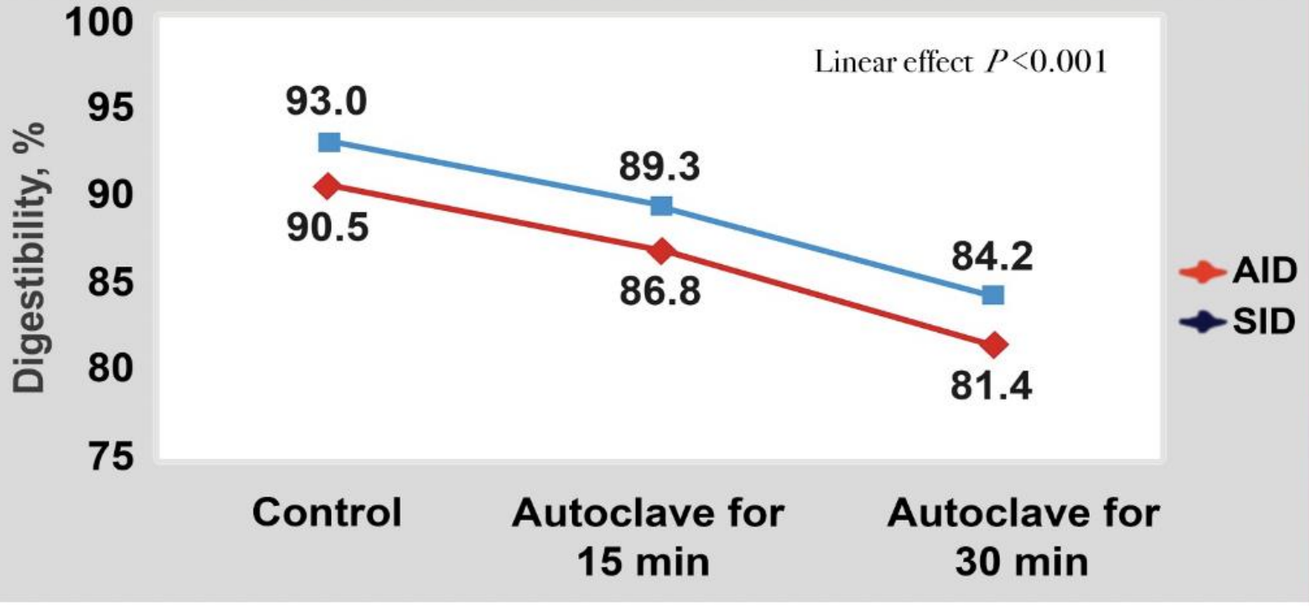
Autoclaved @125°C for 15 minutes

Autoclaved @125°C for 30 minutes

L*	76.7	61.7	52.5
a*	3.4	10.0	12.5

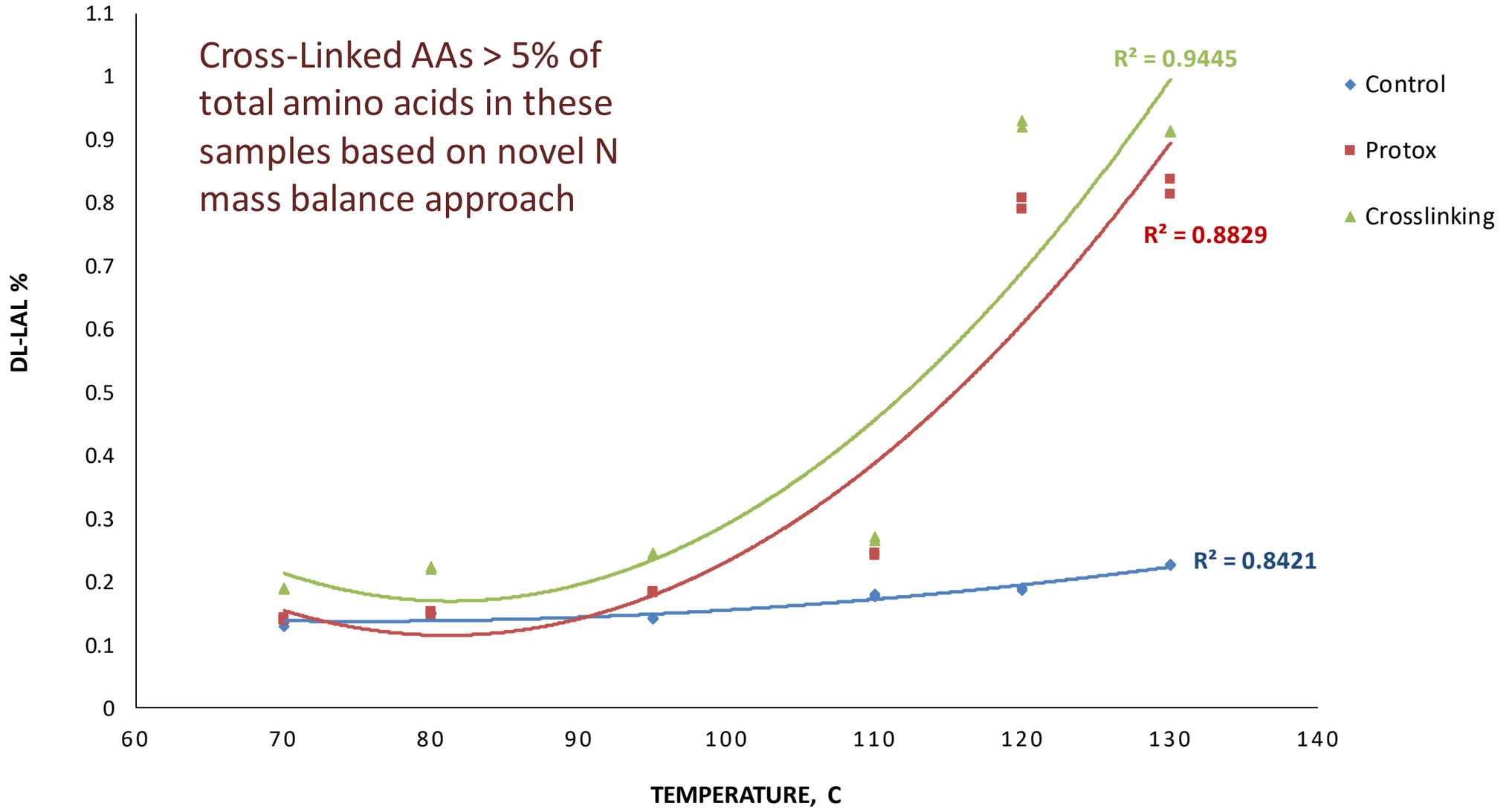
L* : Indication of the lightness of the product
a*: Measurement of the redness of the colors

Effect of autoclaving time on apparent ileal digestibility (AID) and standardized ileal digestibility (SID) of lysine in pigs fed soybean treated products in their diets **(Temperature: 125 °C)**



Gonzalez- Vega et al., 2011

Quality and Nutritional Value (Processor)



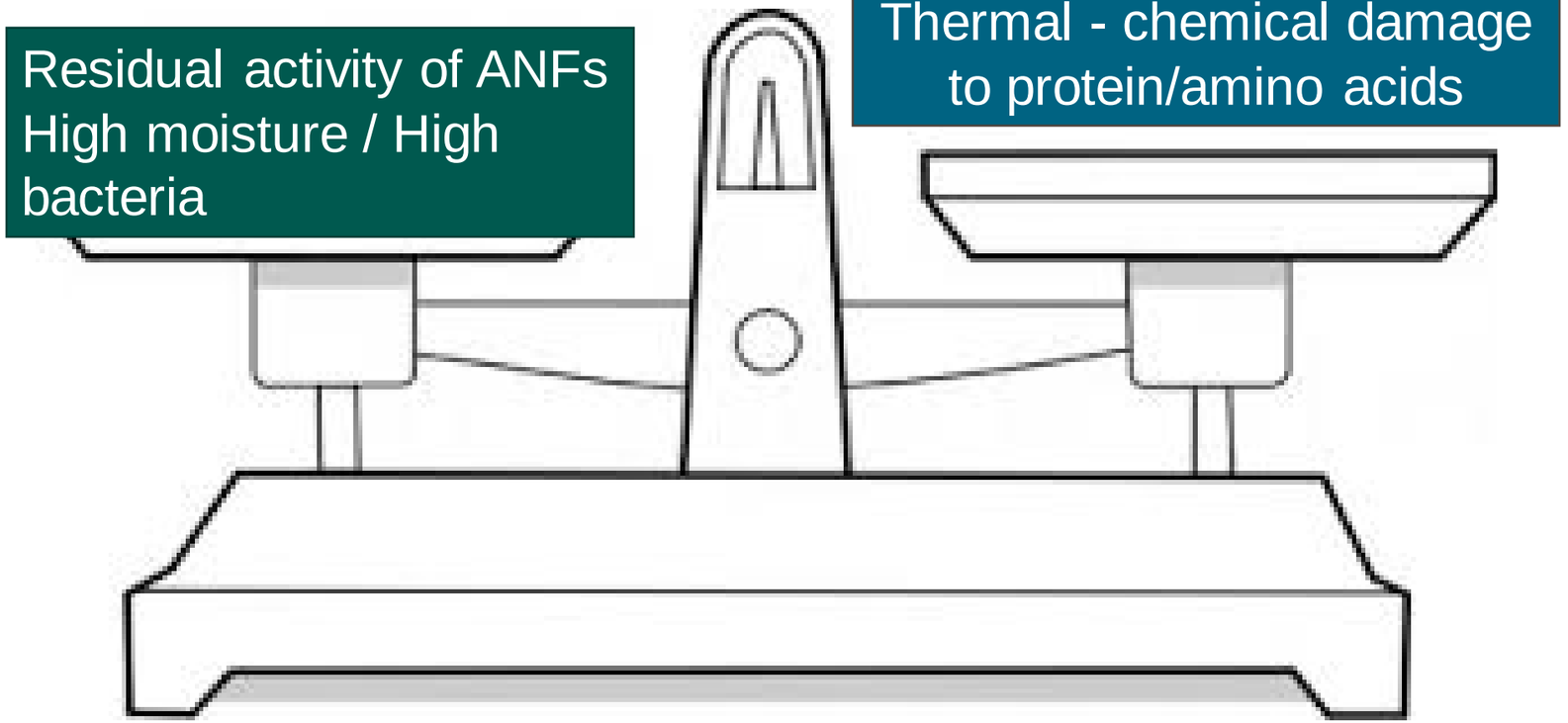
Quality and Nutritional Value (Processor)

Under Processing

Residual activity of ANFs
High moisture / High bacteria

Over Processing

Thermal - chemical damage to protein/amino acids



Need to balance thermal processing

Quality and Nutritional Value

Received: 14 September 2018 | Revised: 18 December 2018 | Accepted: 22 January 2019

DOI: 10.1111/are.13998

ORIGINAL ARTICLE

WILEY Aquaculture Research

Evaluation of soybean meal from different sources as an ingredient in practical diets for Pacific white shrimp *Litopenaeus vannamei*

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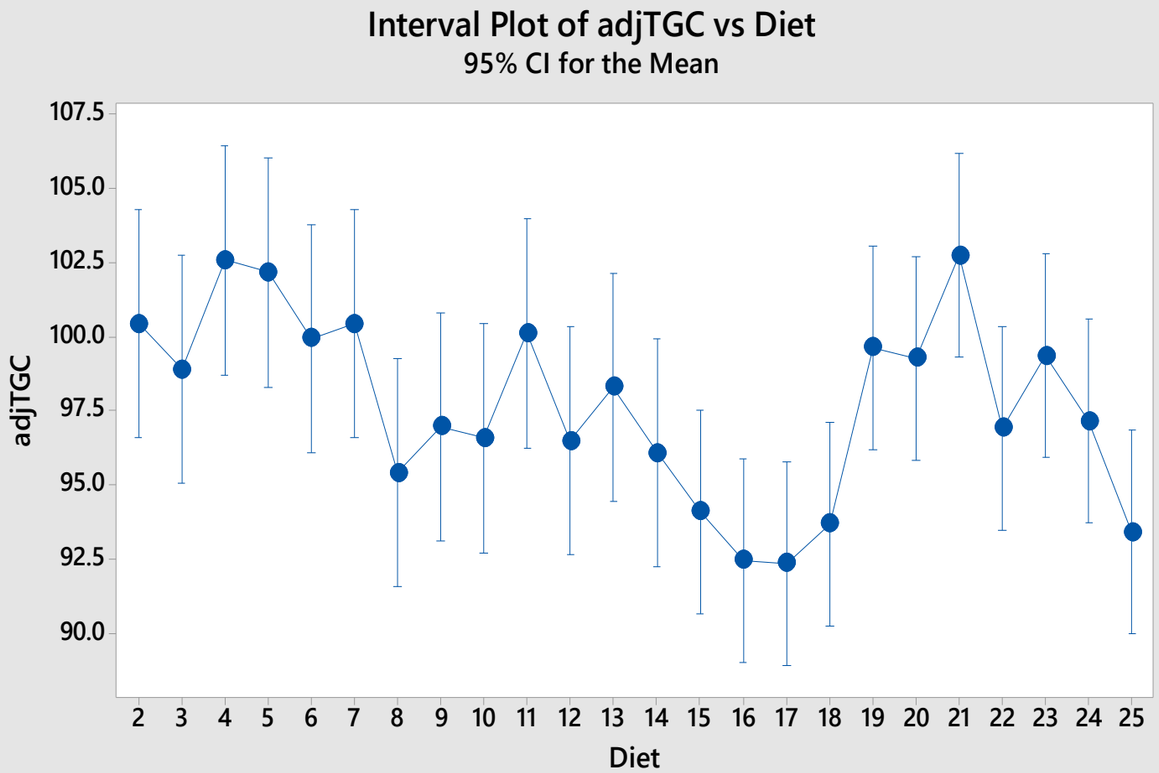
25 identical feed formulations each containing a different source of SBM



The pooled standard deviation is used to calculate the intervals.

Estimating the Value of Nutrients?

	Fishmeal	US SBM
Price USD$/tonne	1,800	700
Dry matter, %	92	90
Crude protein, %	70	48
Digestible protein, %	62	43
Crude Lipids, %	10	1.4
Digestible energy, kcal/kg	4450	3127
Dig. Lysine, %	5.2	2.7
Dig. Methionine, %	1.7	0.7
Dig. Threonine, %	2.4	1.6
Alanine, %	4.5	2.1
EPA+DHA, %	2.2	0

Ingredients are priced on their nutrient contents (protein, lipid, etc.)

Ingredient quality affects nutrient quality affects animal performance

How much each nutrient is worth?

Dig. Lysine is part of digestible protein

Dozens of different compounds with different values

Some nutrients may have no/low real value (e.g. alanine)

Estimating the Value of Nutrients?

Two main approaches

1. **Price Shadowing**

   Scenario specific

   Estimated using least-cost feed formulation software, feature available in most of these software

   Some nutrients may have no real value depending if they are not driving the cost (some nutrient come along other more limiting and thus more "expensive" nutrients)

2. **Economic Valuation**

   More broad and general evaluation

   Method of St-Pierre and Glamocic (2000)

   - Based on advanced statistical analysis model

   Implemented in AquaOp Feed software developed by Wittaya Aqua

Price Sensitivity (Shadow Pricing)

Thailand

Key Price Sensitivity Analysis Statistic

Key Ingredient	Soybean meal, USA, dehulled, Standard, 47% CP
% Production Based on Complete Feed	100 %
Optimal Market Price (USD/Tonne)	$ 820.00
Inclusion Level at Optimal Price (%)	24.47 %
Estimated Usage Volume at Optimal Price (Tonne/Year)	118,871.43
Estimated Optimal Sales Potential ($)	$ 97,474,575.08

Price Sensitivity (Shadow Pricing)

Chile

Key Price Sensitivity Analysis Statistic

Key Ingredient	Soybean meal, USA, dehulled, Standard, 48% CP
% Production Based on Complete Feed	100 %
Optimal Market Price (USD/Tonne)	$ 280.00
Inclusion Level at Optimal Price (%)	5.18 %
Estimated Usage Volume at Optimal Price (Tonne/Year)	52,977.89
Estimated Optimal Sales Potential ($)	$ 14,833,809.51

Economic Valuation model

Adapted from St-Pierre and Glamocic (2000)

Market prices of "n" ingredients (Y)

The level of "m" nutrients in each ingredient

Estimate Unit cost of each Nutrient (B)

Using relationships between market price of feed stuff (n), and level of nutrients (m) in each feed ingredient

$$Y_i = \sum_{j}^{2} X_{ij}B_j + e_i$$

by minimizing the sum of squares of deviations of each equation/relationship using "least square maximum likelihood method"

Ingredient Count		31					
Select Country		Chile					
Ingredient Name		Price	marine_dig_protein	veg_dig_protein	terrestrial_dig_protein	synthetic_dig_protein	dig_lipid_fish
Fish meal, Chile, 64% CP	$	2,300.00	56.6	0.0	0.0	0.0	8.0
Fish meal, Peru, 67% CP	$	2,020.00	55.8	0.0	0.0	0.0	9.0
Fish meal, processing by-products	$	1,385.00	58.9	0.0	0.0	0.0	7.2
Blood meal, whole, spray-dried	$	1,100.00	0.0	0.0	83.7	0.0	0.6
Feather meal B, 77% CP	$	940.00	0.0	0.0	62.5	0.0	3.6
Porcine meal, 65% CP	$	755.00	0.0	0.0	55.7	0.0	10.8
Poultry by-product meal, feed-grade, 60% CP	$	1,030.00	0.0	0.0	53.4	0.0	10.5
Corn gluten meal, 60% CP	$	1,070.00	0.0	53.9	0.0	0.0	1.4
Corn protein concentrate, Empyreal75, Cargill	$	1,370.00	0.0	68.0	0.0	0.0	4.2
Lupin seed meal, 49% CP	$	875.00	0.0	42.1	0.0	0.0	6.7
Lupin meal, Chile	$	790.00	0.0	33.7	0.0	0.0	4.8
Pea, seed, shelled and extruded	$	545.00	0.0	21.9	0.0	0.0	1.0
Rapeseed/Canola meal, high protein, 39% CP	$	560.00	0.0	32.6	0.0	0.0	0.9
Soy protein concentrate, 60% CP	$	1,530.00	0.0	55.7	0.0	0.0	1.5

n * m matrix of coefficients (X)

	marine_dig_protei	veg_dig_protein	terrestrial_dig_pro	synthetic_dig_pro	dig_lipid_fish
marine_dig_protei	1	-0.272213689	-0.123489508	-0.101905906	-0.040511631
veg_dig_protein	-0.272213689	1	-0.313928946	-0.259060177	-0.288775371
terrestrial_dig_pro	-0.123489508	-0.313928946	1	-0.117522429	-0.082402623
synthetic_dig_pro	-0.101905906	-0.259060177	-0.117522429	1	-0.136508423
dig_lipid_fish	-0.040511631	-0.288775371	-0.082402623	-0.136508423	1
starch	-0.144714739	-0.089321528	-0.166891481	-0.137722045	-0.174270135
epa_dha	0.076177523	-0.188820061	-0.08565806	-0.070686671	0.584846261
phosphorus	0.002507478	-0.255917905	-0.04599363	-0.127322806	-0.120820942

Economic Value of Nutrients

Estimated Cost of Nutrients	USD$/tonne	USD$/tonne
	Thailand	Chile
Marine Digestible Protein	2.56	2.98
Vegetable Digestible Protein	2.07	1.97
Terrestrial Digestible Protein	1.63	1.62
Synthetic AA Digestible Protein	1.90	3.25
Digestible Lipid	1.34	1.71
Starch	0.29	0.66
EPA+DHA	3.83	7.78
Phosphorus	2.64	3.34

Digestible Nutrient Composition of Soybean meals

	Parameters %	US SBM	Argentinian SBM	Brazilian SBM
Proximate Composition	Dry Matter	89.8	89.1	88.0
	Crude Protein	48.0	47.0	48.0
	Lipid	1.4	1.7	1.4
	Ash	6.2	6.6	6.2
Apparent Digestibility Coefficient	Crude Protein	90	87	85
	Arginine	90	87	85
	Histidine	90	87	85
	Isoleucine	90	84	68
	Lysine	90	87	85
	Threonine	84	77	74
Digestible Nutrients	Dig. Protein	43.2	40.9	40.8
	Dig. Arginine	3.2	3.0	2.8
	Dig. Histidine	1.2	1.1	1.0
	Dig. Isoleucine	2.0	1.8	1.5
	Dig. Lysine	2.7	2.5	2.4
	Dig. Threonine	1.6	1.4	1.4

This is what companies buy

This is what companies get

Economic Valuation

Thailand

Economical Valuation - Thailand 2023-08-04 9:07am

Ingredient	Current Mkt Price (USD)	Model Estimated Value (USD)	Difference (USD/Tonnes)	% Difference
Rice polishings	340.00	494.00	154.00	45%
Rice, broken	400.00	395.00	-5.00	-1%
Soy protein concentrate, 60% CP	1,090.00	1,201.00	111.00	10%
Soybean meal, Brazil, dehulled, Standar...	700.00	887.00	187.00	27%
Soybean meal, USA, dehulled, Standard...	695.00	919.00	224.00	32%
Fermented soybean meal, 53% CP	955.00	1,030.00	75.00	8%
Wheat gluten meal, 78% CP	2,320.00	1,499.00	-821.00	-35%

Estimated Cost of Nutrient (USD/Kg)

Nutrient	Cost (USD/Kg)
Marine Digestible Protein	2.56
Vegetable Digestible Protein	2.07
Terrestrial Digestible Protein	1.63
Synthetic AA Digestible Protein	1.90
Dig Lipid - fish	1.34
Starch	0.29
EPA+DHA	3.83
Phosphorus	2.64

Relatively even spread of attribute cost

- Wide variety of farmed species
  - Whiteleg shrimp, river prawn, tilapia, catfishes, Asian seabass
  - Moderately nutrient dense feeds
- US soy nutrient density and quality imparts high value

Economic Valuation

Chile

Economical Valuation - Chile 2023-08-04 9:10am

Ingredient	Current Mkt Price (USD)	Model Estimated Value (USD)	Difference (USD/Tonnes)	% Difference
Soy protein concentrate, 60% CP	1,100.00	1,166.00	66.00	6%
Soybean meal, Argentina, dehulled, Sta...	660.00	872.00	212.00	32%
Soybean meal, Brazil, dehulled, Standar...	690.00	865.00	175.00	25%
Soybean meal, Bolivian, non-dehulled, ...	585.00	819.00	234.00	40%
Soybean meal, USA, dehulled, Standard...	690.00	914.00	224.00	32%
Starch, wheat	830.00	651.00	-179.00	-22%

Estimated Cost of Nutrient (USD/Kg)

Nutrient	Cost (USD/Kg)
Marine Digestible Protein	2.98
Vegetable Digestible Protein	1.97
Terrestrial Digestible Protein	1.62
Synthetic AA Digestible Protein	3.25
Dig Lipid - fish	1.71
Starch	0.66
EPA+DHA	7.78
Phosphorus	3.34

Premium paid for key nutrients valued for salmonids

- Salmonid species
  - Atlantic salmon, Coho salmon, rainbow trout
  - High nutrient dense feeds
- US soy nutrient density and quality imparts high value

Sustainability

- GFLI
  - https://globalfeedlca.org/gfli-database/
  - Publicly available database
  - Life Cycle Assessment (LCA) methodology
  - Environmental impacts are:
    - At Farm
    - At Vessel
    - At Plant

Global Metrics for Sustainable Feed

- Wittaya Aqua has combined GFLI 2.0 data with literature resources and proprietary models
  - Some values estimated based on understanding of the ingredient
  - Results do not include transportation or feed manufacturing
  - Use Global Warming Potential (GWP) values excluding Land Use Change (LUC)
  - Based on Economic allocation and Recipe Method
  - Work in Progress

Feed Formulation Tool

Sustainability – Whiteleg Shrimp

Thailand

US Soy – $700 / tonne – 28% inclusion – 18% contribution to emissions

Species	Life Stage	Production System	Cost Of Feed
Pacific Whiteleg shrimp CF TEST	General	N/A	$829.74 (Per Tonne)

Sustainability Indicators

FIFO	FFDRo	FFDRm
0.635	0.894	0.542
min: 0 | max: 1	min: 0 | max: 1	min: 0 | max: 1

Carbon Footprint Estimation (Beta)

Formulation

723 kg CO_2eq/tonne

Brazilian Soy – $700 / tonne – 29.5% inclusion – 22% contribution to emissions

Species	Life Stage	Production System	Cost Of Feed
Pacific Whiteleg shrimp CF TEST	General	N/A	$832.08 (Per Tonne)

Sustainability Indicators

FIFO	FFDRo	FFDRm
0.635	0.895	0.542
min: 0 | max: 1	min: 0 | max: 1	min: 0 | max: 1

Carbon Footprint Estimation (Beta)

Formulation

745 kg CO_2eq/tonne

Wittaya Aqua is working to capture the value of other attributes such as sustainable, certified, functional in the EVT model

Take home messages

Ingredients are packages of nutrients

The value of an ingredient is determined by more than its nutrient contents

US soy can help lower the carbon emissions of aquaculture feeds

The quality, quantity, and sustainability of the nutrients in US soy are highly valued