



# Aquaculture Nutrition: Formulating Balanced Diets for Aquaculture

Rodrigue Yossa, WorldFish, Penang, Malaysia



RESEARCH  
PROGRAM ON  
Fish

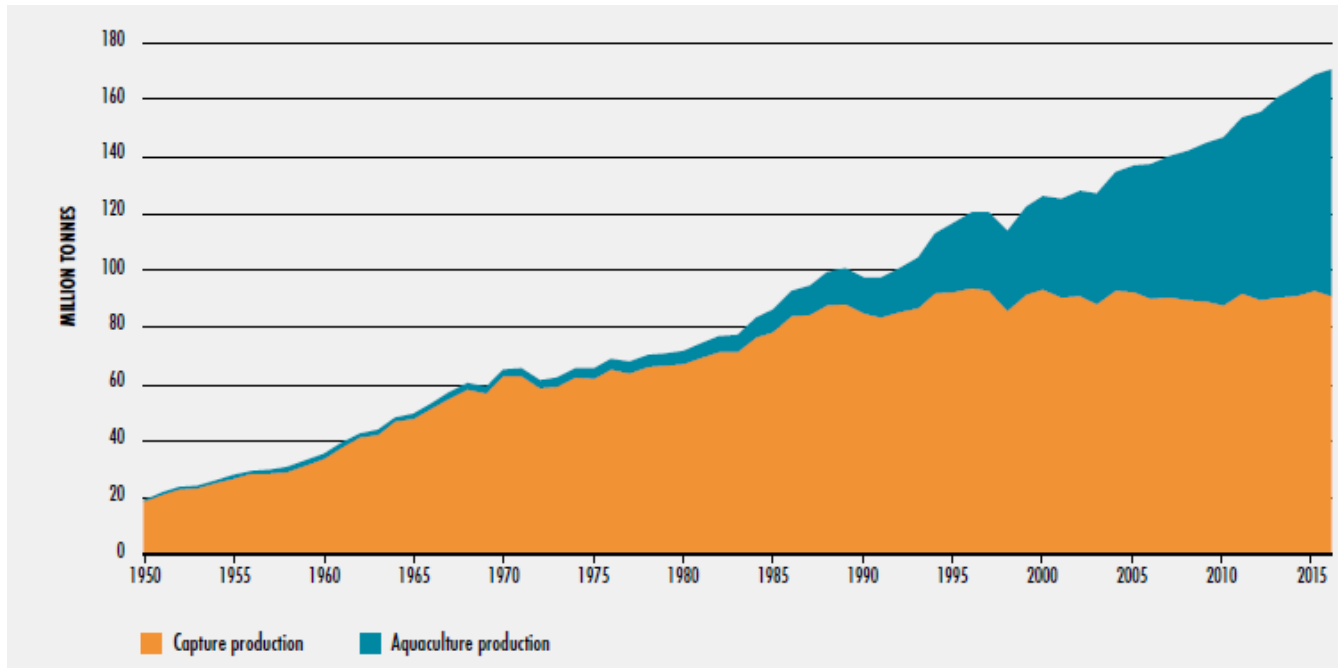
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# Content

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1. Introduction
2. Aquaculture Nutrition: Opportunities and Challenges
3. Nutrient Requirements of Fish
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# Introduction



FAO, 2018

“Aquaculture is the fastest growing sector in agricultural production globally”

“Aquaculture production represents 47% of the total 171 M tonnes”

→ Momentum should at least be kept, and at best be spurred to satisfy the seafood demand of growing world population.

# Introduction (continued)



Aquaculture Nutrition is now a clear, specific field in the aquaculture sector/science: there is even a special journal, *Aquaculture Nutrition*

Dr. Roy Palmer: “every other scientist that I meet is an aquaculture nutritionist”

→ Because feed is still the most expensive input  
→ (50-70% in semi-intensive and intensive systems).



# Aquaculture Nutrition: Opportunities and Challenges

- Positive changes in aquaculture nutrition can affect the entire industry

↓ FCR → Prod. Cost

Make fish more affordable to feed the world

- To indirectly feed people by directly feeding the fish

Feed → Fish → Humans



# challenges



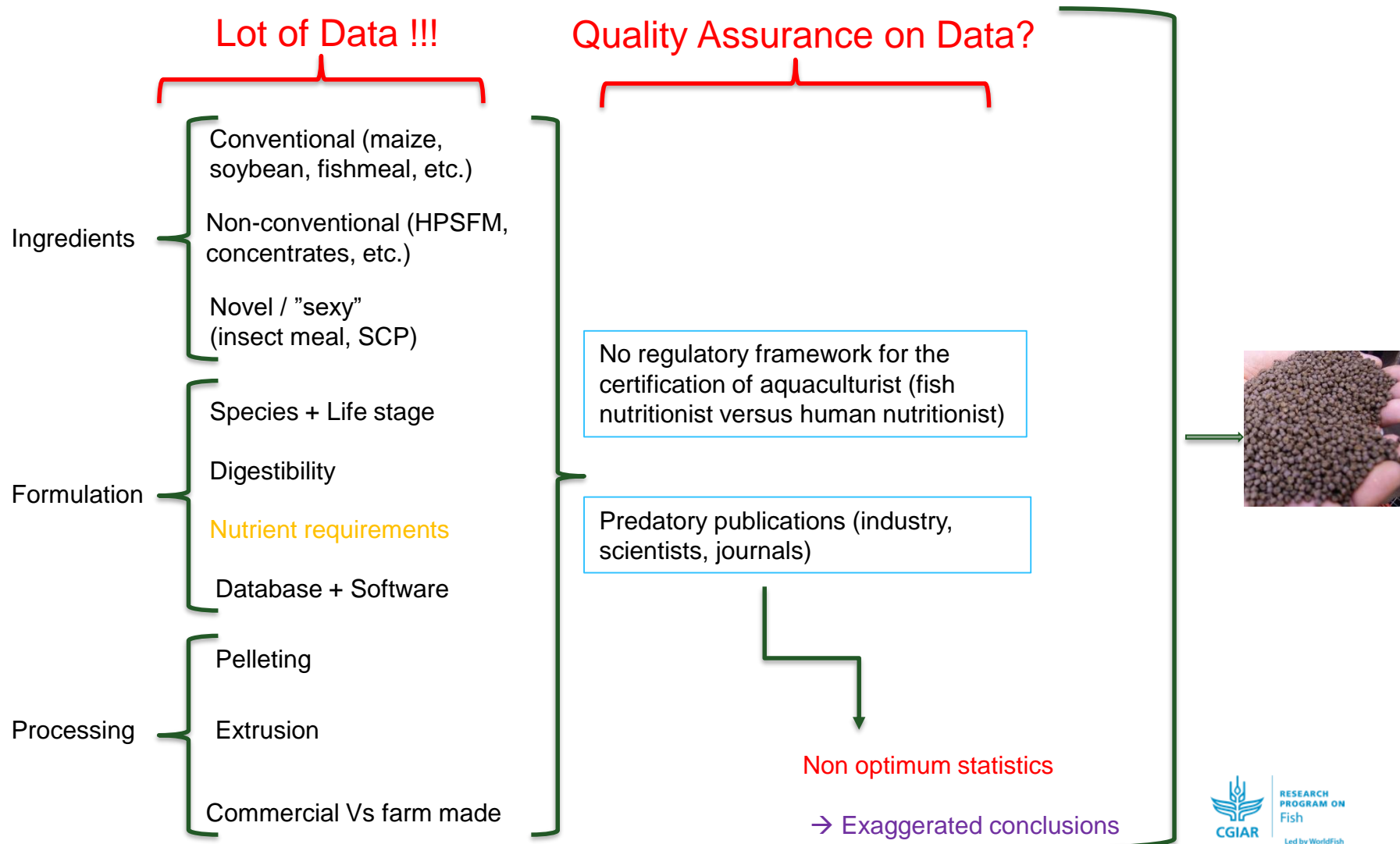
## Quality Data & Relevant Information

# Aquaculture Nutrition: one challenge-Data



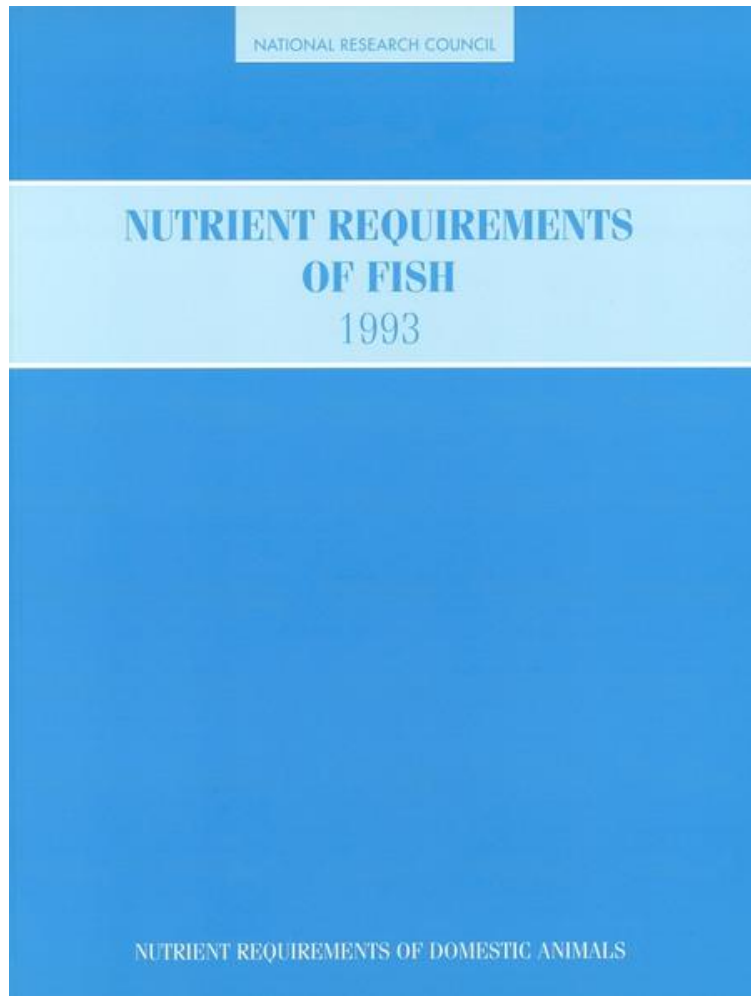
## Quality control on data available???

# Aquaculture Nutrition: Nutrient requirements of fish

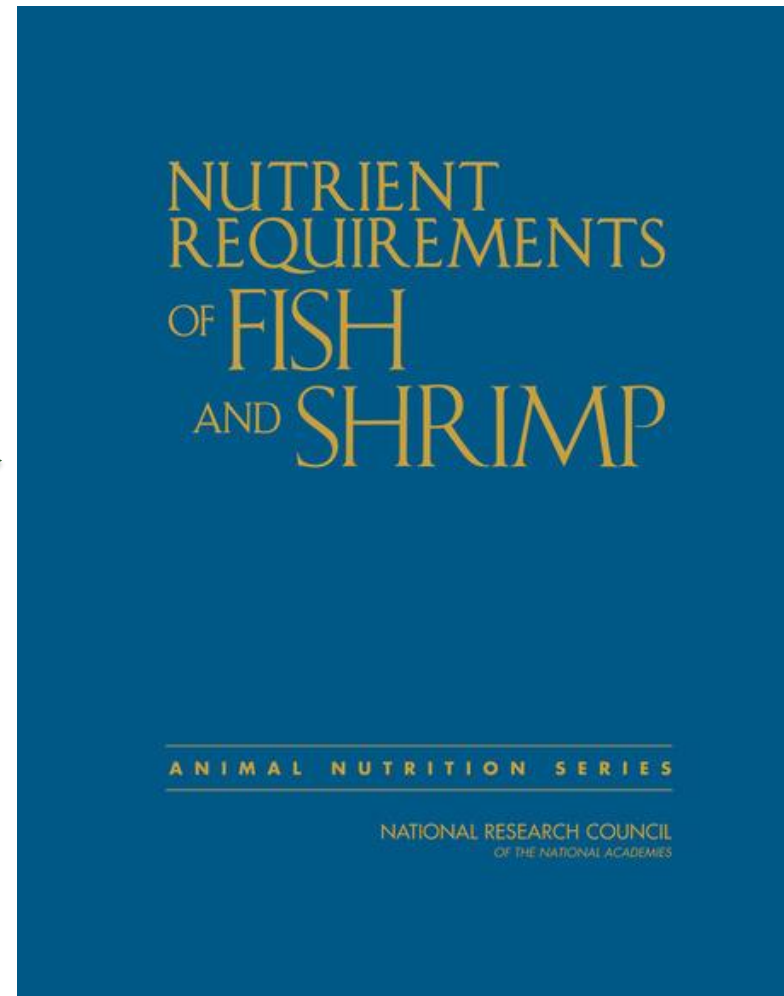




# Aquaculture Nutrition: Nutrient requirements of fish



18 years



# Aquaculture Nutrition: Nutrient requirements of fish

Aquaculture 437 (2015) 344–350



Contents lists available at ScienceDirect

Aquaculture

journal homepage: [www.elsevier.com/locate/aqua-online](http://www.elsevier.com/locate/aqua-online)



Short communication

## Misuse of multiple comparison tests and underuse of contrast procedures in aquaculture publications



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Most of the experimental variable in aquaculture nutrition are quantitative

Ex: level of protein (0%, 5%, 10%, 15% and 20%)

→ The right statistics to be used is the polynomial procedure

# Aquaculture Nutrition: Nutrient requirements of fish

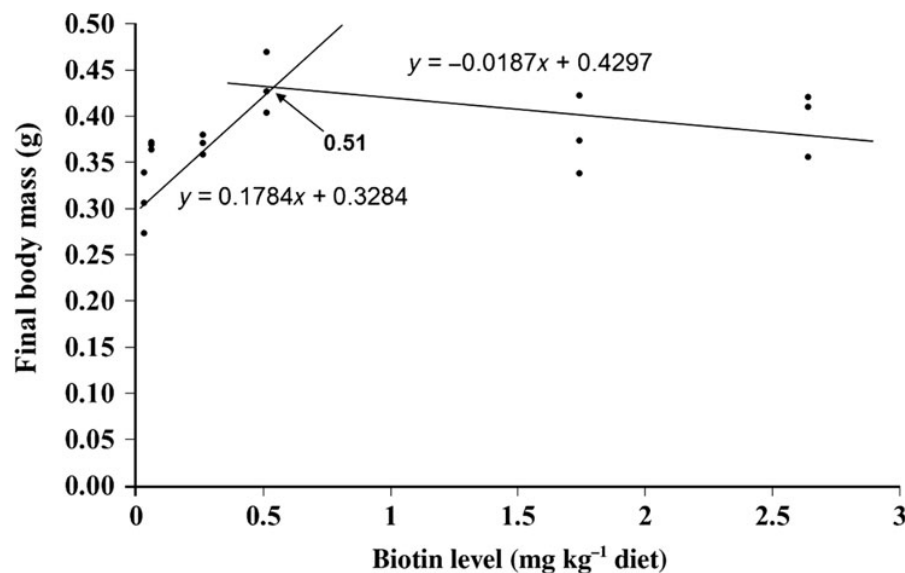
**Table 2** Final mass, protein efficiency ratio (PER) and feed conversion ratio (FCR) of zebrafish (*Danio rerio*) fed diets supplemented with various levels of biotin for 12 weeks<sup>a</sup>.

Parameters	0.031	0.062	0.124	0.248	0.496	P-value	Pooled SEM
Initial mass (g)	0.136	0.138	0.136	0.136	0.136		
Final mass (g)	0.306 <sup>c</sup>	0.306 <sup>c</sup>	0.306 <sup>c</sup>	0.306 <sup>c</sup>	0.395 <sup>ab</sup>	0.0058	0.017
PER (g g <sup>-1</sup> ) <sup>†</sup>	0.44 <sup>b</sup>	0.44 <sup>b</sup>	0.44 <sup>b</sup>	0.44 <sup>b</sup>	0.51 <sup>a</sup>	0.0257	3.537
FCR <sup>‡</sup>	1.88	1.88	1.88	1.88	1.88	0.0001	0.052

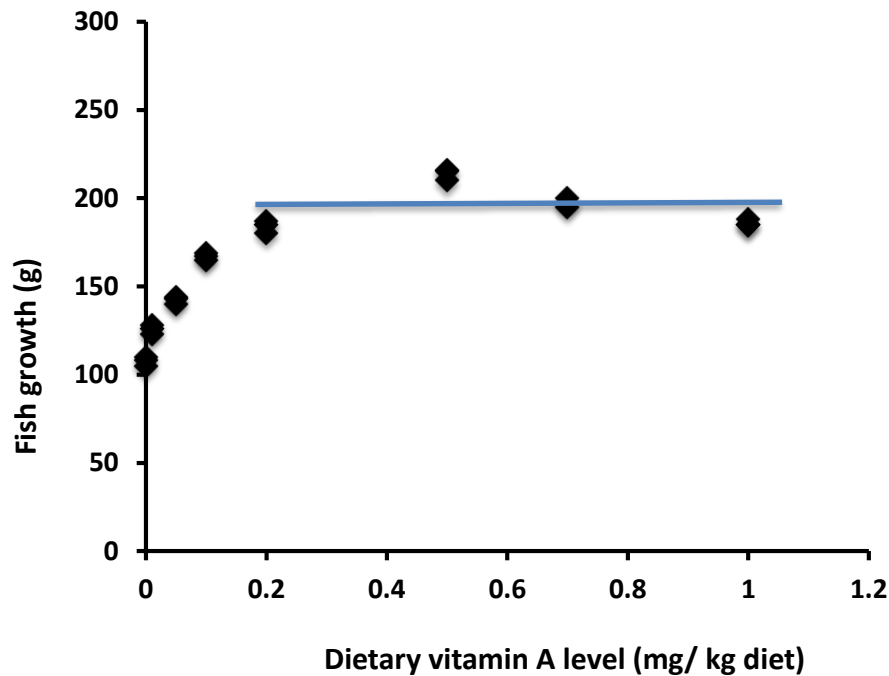
<sup>a</sup>Means with different superscripts in a row are significantly different ( $P < 0.05$ ).

<sup>†</sup>Protein efficiency ratio (PER) = (final wet mass (g) - initial wet mass (g)) / (Quantity of feed (g) × protein content of the feed (g g<sup>-1</sup>))

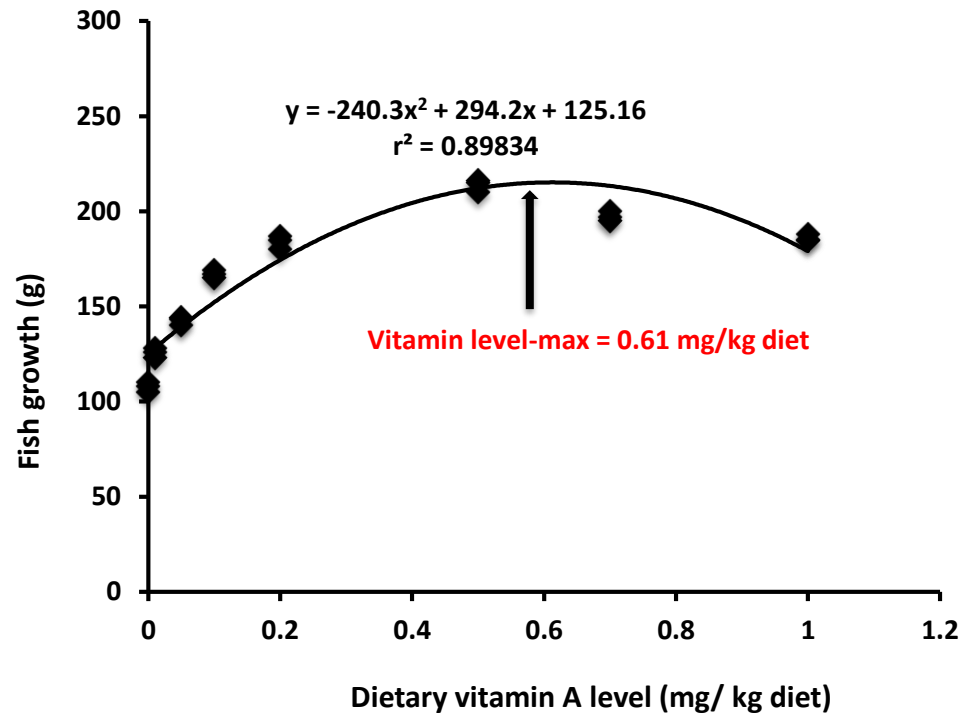
<sup>‡</sup>Feed conversion ratio FCR (g g<sup>-1</sup>) = (Ingested feed (g) × Dry matter content of feed) / (final wet mass (g) - initial wet mass (g))



# Aquaculture Nutrition: Nutrient requirements of fish



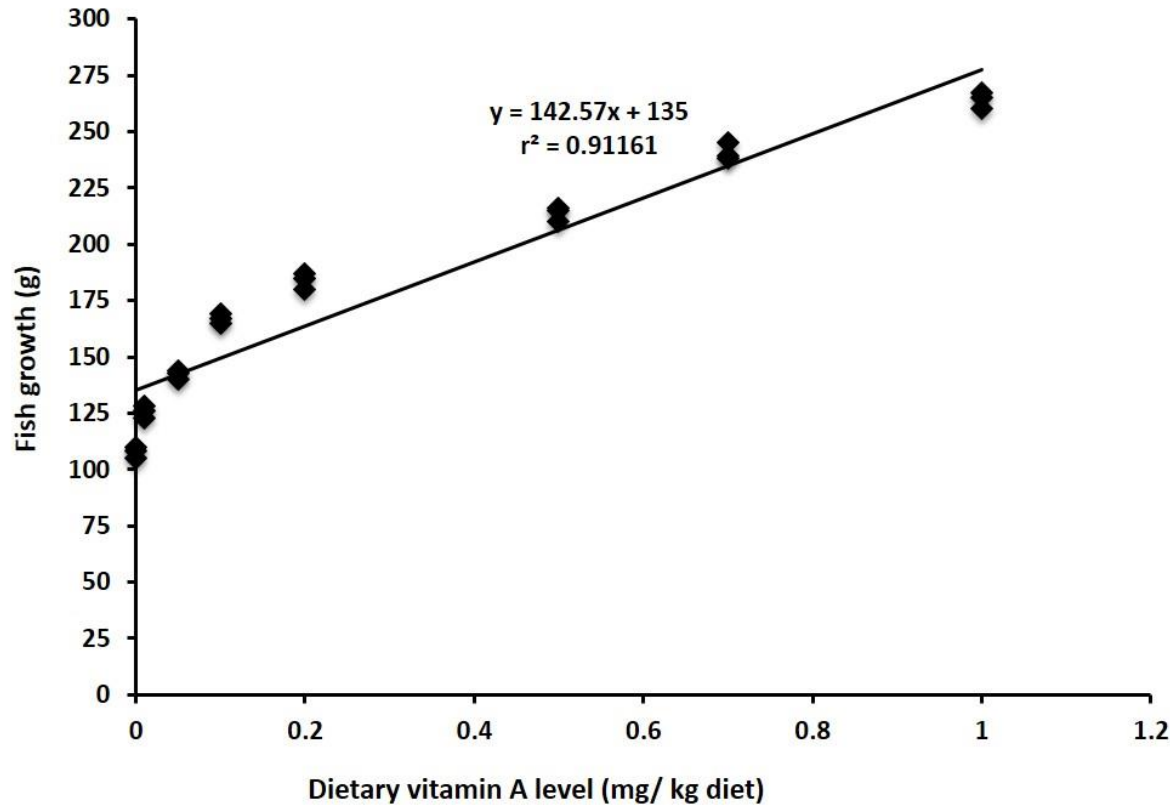
Multiple comparison test



Regression analysis



# Aquaculture Nutrition: Nutrient requirements of fish



Regression analysis

# Aquaculture Nutrition: Nutrient requirements of fish



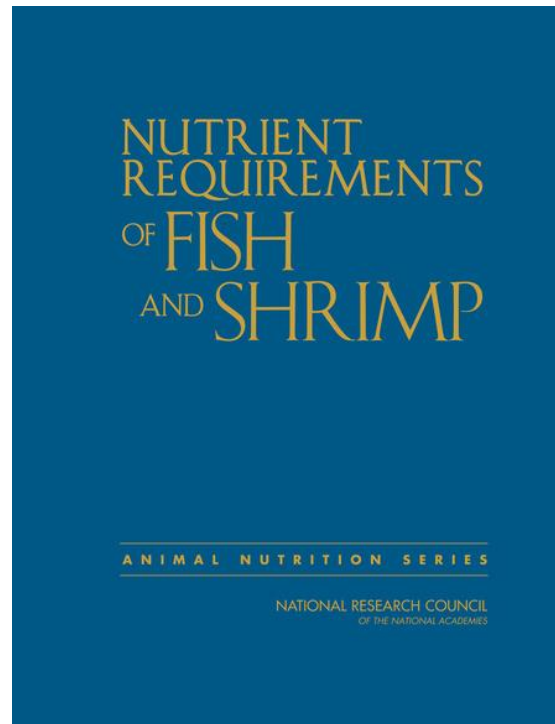
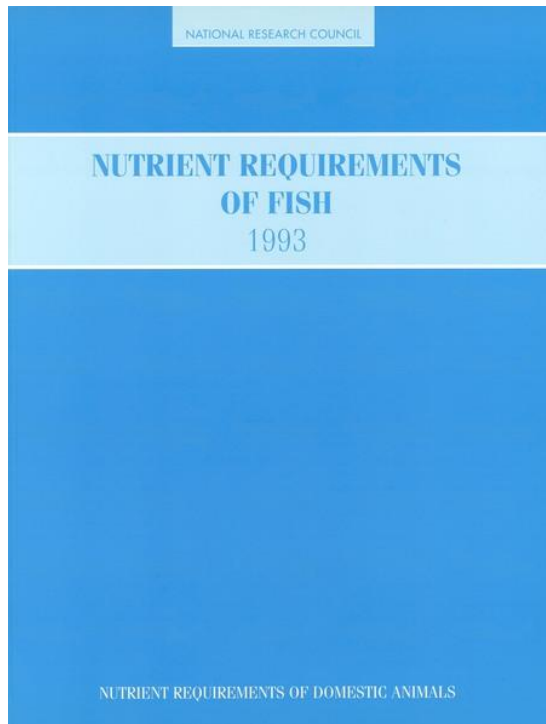
A lot of Data is very good !

But need to know how to sort them out !

Consider “Quality Data & Relevant Information”!

# Aquaculture Nutrition: Nutrient requirements of fish

## Consolidation of data and information on requirements, ingredients, diets and feeds



Annual (and not every 2 decades)


National or regional (not just the US)


ISFNF should have a data section with metadada

More nutritional modeling


# Databases

← → ↻ [iaffd.com](https://iaffd.com) 🔍 ☆ ⌵

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 **IAFFD.COM**

The International Aquaculture Feed Formulation Database (IAFFD) is an open access, free of charge, database that provides a potentially valuable tool to aquaculture industry formulators



**Aquaculture Species Nutritional Specifications Database (ASNS)**  
(Ver5.0 updated October-30, 2019)

Nutrient specifications for over 30 species that are commercially important in Asia and elsewhere.



**Feed Ingredients Composition Database (FICD)**  
(Ver5.0 updated October-30, 2019)

Detailed information on the chemical composition and nutritional value of over 400 ingredients



















# Databases

← → ↻ iaffd.com ☆

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## Our Partners



# Databases

ure Feed Formulation Database



Nutritional Specification Database



Feed Ingredient Database



## Nutrient Specification Database

Fish Species

Abalone (Abalone )

Target Moisture Level of Feed (%)

0

Stage/Live Weight Range (g)

< 5 g

[Export Report to .CSV](#)

☐ Include all species & stages

## Specification Report

Code	Specification	Short Name	Unit	Restriction Type	Value
PA02	Moisture	H2O	%	Minimum	0
PA03	Crude Protein	CP	%	Minimum	31.58
PA04	Crude Lipids	LIPID	%	Minimum	5.26
PA05	Crude Fibre	CF	%	Maximum	0.00
PA06	Ash	ASH	%	Maximum	0.00
PA07	NFE	NFE	%	Maximum	0.00
PA08	NDF	NDF	%	Maximum	0.00
PA09	ADF	ADF	%	Maximum	0.00
PA11	Starch	STARC	%	Minimum	21.05
ADDF00	Dis CD fish	DD	%	Minimum	20.40

# Databases

ure Feed Formulation Database



Nutritional Specification Database



Feed Ingredient Database



## Nutrient Specification Database

Fish Species

N-Tilapia-Regular (N-Tilapia-Reg)

Target Moisture Level of Feed (%)

10

Stage/Live Weight Range (g)

50-200 g (Pre-grower)

[Export Report to .CSV](#)

☐ Include all species & stage

### Specification Report

Code	Specification	Short Name	Unit	Restriction Type	Value
PA02	Moisture	H2O	%	Minimum	10
PA03	Crude Protein	CP	%	Minimum	35.05
PA04	Crude Lipids	LIPID	%	Minimum	5.68
PA05	Crude Fibre	CF	%	Maximum	0.00
PA06	Ash	ASH	%	Maximum	0.00
PA07	NFE	NFE	%	Maximum	0.00
PA08	NDF	NDF	%	Maximum	0.00
PA09	ADF	ADF	%	Maximum	0.00
PA11	Starch	STARC	%	Minimum	15.16

# Databases

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om/nutrients.html?v=4.3

ure Feed Formulation Database Nutritional Specification Database Feed Ingredient Database



## Nutrient Specification Database

Fish Species

Common Carp-Regular (Commo

Target Moisture Level of Feed (%)

10

Stage/Live Weight Range (g)

500-1500 g (Finisher)

[Export Report to .CSV](#)

☐ Include all species & stages

## Specification Report

Code	Specification	Short Name	Unit	Restriction Type	Value
PA02	Moisture	H2O	%	Minimum	10
PA03	Crude Protein	CP	%	Minimum	25.58
PA04	Crude Lipids	LIPID	%	Minimum	9.47
PA05	Crude Fibre	CF	%	Maximum	0.00
PA06	Ash	ASH	%	Maximum	0.00
PA07	NFE	NFE	%	Maximum	0.00
PA08	NDF	NDF	%	Maximum	0.00
PA09	ADF	ADF	%	Maximum	0.00
PA11	Starch	STARC	%	Minimum	18.95



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# Databases

Future Feed Formulation Database



Nutritional Specification Database



Feed Ingredient Database



## Nutrient Specification Database

Fish Species

African Catfish (African Catfish)

Target Moisture Level of Feed (%)

10

Stage/Live Weight Range (g)

5-50 g (Fry)

[Export Report to .CSV](#)

☐ Include all species & stages

### Specification Report

Code	Specification	Short Name	Unit	Restriction Type	Value
PA02	Moisture	H2O	%	Minimum	10
PA03	Crude Protein	CP	%	Minimum	35.05
PA04	Crude Lipids	LIPID	%	Minimum	9.47
PA05	Crude Fibre	CF	%	Maximum	0.00
PA06	Ash	ASH	%	Maximum	0.00
PA07	NFE	NFE	%	Maximum	0.00
PA08	NDF	NDF	%	Maximum	0.00
PA09	ADF	ADF	%	Maximum	0.00
PA11	Starch	STARC	%	Minimum	14.21
ADDF02	Dig. Cr. Fibre	DCF	%	Maximum	0.00

# Databases

International Aquaculture Feed Formulation Database



Nutritional Specification Database



Feed Ingredient Database

Help/FAQ



## Feed Ingredient Composition Database

[Export Report to .CSV](#)

Show 25 entries

Search:

Ing_Code	Ing_Descr_E	Dry Matter(%)	Moisture(%)	Crude Protein(%)	Crude Lipids(%)	Crude Fibre(%)	Ash(%)
10000	Fish meal, India, 74% CP	90.80	9.20	74.16	4.97	0.50	10.00
10001	Fish meal, Chile, 64% CP	92.00	8.00	63.60	8.40	0.50	15.60
10002	Fish meal, Peru, 67% CP	93.90	6.10	66.95	11.50	0.00	15.40
10003	Fish meal, Danish, 70% CP	92.50	7.50	70.69	9.74	0.30	11.70
10004	Fish meal, Thailand, 55% CP	91.80	8.20	55.00	6.00	0.50	30.00
10005	Fish meal, 55% CP	90.00	10.00	54.04	8.73	0.65	23.77
10006	Fish meal, 65% CP	90.90	9.10	63.85	8.14	0.20	18.68
10007	Fish meal, 70% CP, low temperature	92.00	8.00	70.00	10.00	0.00	12.00
10008	Fish meal, Alaskan pollock, processing waste	94.40	5.60	69.00	7.60	0.50	17.30
10009	Fish meal, anchovy	91.90	8.10	66.95	8.83	0.70	15.40
10010	Fish meal, cod, processing waste	92.00	8.00	70.20	5.60	0.00	16.20



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# Databases

International Aquaculture Feed Formulation Database

Nutritional Specification Database

Feed Ingredient Database

Help/FAQ



## Feed Ingredient Composition Database

[Export Report to .CSV](#)

Show 25 entries

Search:

Ing_Code	Ing_Descr_E	Dry Matter(%)	Moisture(%)	Crude Protein(%)	Crude Lipids(%)	Crude Fibre(%)	Ash(%)	NFE(%)	NDF(%)	ADF(%)	Total CHO(%)	Starch(%)	Sugars(%)	Gross E
10000	Fish meal, India, 74% CP	90.80	9.20	74.16	4.97	0.50	10.00	1.17	0.00	0.00	1.87	0.00	0.00	19.72
10001	Fish meal, Chile, 84% CP	92.00	8.00	83.80	8.40	0.50	15.60	3.90	0.00	0.00	4.40	0.00	0.00	19.03
10002	Fish meal, Peru, 67% CP	93.90	6.10	66.95	11.50	0.00	15.40	0.05	0.00	0.00	0.05	0.00	0.00	20.29
10003	Fish meal, Danish, 70% CP	92.50	7.50	70.89	9.74	0.30	11.70	0.08	0.00	0.00	0.38	0.00	0.00	20.54
10004	Fish meal, Thailand, 55% CP	91.80	8.20	55.00	6.00	0.50	30.00	0.30	0.00	0.00	0.80	0.00	0.00	15.46
10005	Fish meal, 55% CP	90.00	10.00	54.04	8.73	0.65	23.77	2.81	0.00	0.00	3.46	0.00	1.00	16.75
10006	Fish meal, 65% CP	90.90	9.10	63.85	8.14	0.20	18.68	0.03	0.00	0.00	0.23	0.00	0.00	18.28
10007	Fish meal, 70% CP, low temperature	92.00	8.00	70.00	10.00	0.00	12.00	0.00	0.00	0.00	0.00	0.00	0.00	20.42
10008	Fish meal, Alaskan pollock, processing waste	94.40	5.60	69.00	7.80	0.50	17.30	0.00	0.00	0.00	0.50	0.00	0.00	19.33
10009	Fish meal, anchovy	91.90	8.10	66.95	8.83	0.70	15.40	0.01	0.00	0.00	0.71	1.00	0.00	19.37
10010	Fish meal, cod, processing waste	92.00	8.00	70.20	5.80	0.00	16.20	0.00	0.00	0.00	0.00	0.00	0.00	18.75
10011	Fish meal, freshwater alewife	93.00	7.00	65.70	12.70	0.00	14.60	0.00	0.00	0.00	0.00	0.00	0.00	20.46
10012	Fish meal, herring, 70% CP	92.50	7.50	70.89	9.74	0.30	11.70	0.08	0.00	0.00	0.38	0.00	0.00	20.54
10013	Fish meal, mackerel	93.50	6.50	67.25	10.65	0.25	15.05	0.30	0.00	0.00	0.55	0.00	0.00	20.12

Showing 1 to 25 of 462 entries

Previous 1 2 3 4 5 ... 19 Next

# Formulation

DIET-FORMULATOR [Compatibility Mode] - Excel

File Home Insert Page Layout Formulas Data Review View Tell me what you want to do... Yossa, Rodrigue (WorldFish) Share

Clipboard: Cut, Copy, Paste, Format Painter

Font: Arial, 10, Bold, Italic, Underline, Text Color, Background Color

Alignment: Wrap Text, Merge & Center

Number: General, Percentage, Decimal, Fraction

Styles: Conditional Formatting, Format as Table, Cell Styles

Cells: Insert, Delete, Format

Editing: AutoSum, Fill, Clear, Sort & Filter, Find & Select

Formulas: A5

Instructions:

- 1) Insert new ingredient and its composition and current cost in one row at the right category in the current list in the sheet "Database"
- 2) Select the ingredients of interest by entering their number in the column B of the "database" sheet
- 3) In the " Diet Caculation" sheet, insert the number of the ingredients that you would like to use to formulate your diets in the column A and the corresponding amount you want in the feed in coloumn C
- 4) See the result (feed formula) in the colomns E-J, rows 39-108 of the "Diet calculation" sheet

Read me Database BLANK Diet Calc



# Formulation

DIET-FORMULATOR [Compatibility Mode] - Excel

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File Home Insert Page Layout Formulas Data Review View Tell me what you want to do...

Paste Cut Copy Format Painter Clipboard Font Alignment Number Styles Cells Editing

D101 Palm cake

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
91			87	Cholesterol	90.0	0.0	39.0	38.0	0	0	39.0	0	0	0	0	0	0
92			88	CMG	90.0	0.0	0	0	0	0	0	0	0	0	0	0	0
93			89	Lecithin - Soy (70%)	97.0	0.0	28.6	28.0	0	0	70.0	0	23	3	0	0	0
94			90	Limestone	95	95	0	0	0	0	0	0	0	0	0	0	0
95			91	Salt (NaCl)	95	90	0	0	0	0	0	0	0	0	0	0	0
96			92	Trace mineral premix	90.0	38.0	8.0	2.0	5.0	2.0	0.5	4.0	0	0	0	0	0
97			93	Vitamin C	90.0	5.3	15.7	11.8	13.5	12.1	2.0	3.0	0	0	0	0	0
98			94	Vitamin premix	90.0	5.3	15.8	11.8	13.5	12.1	3.9	3.0	0	0	0	0	0
99			95	WATER	0	0	0	0	0	0	0	0	0	0	0	0	0
100			96														
101	New ingredients		97	Palm cake	93.0	4.1	18.1	2313.0	16.3		8.9	16.9					
102			98	Maize bran													
103			99	DL-Methionine	98.0	0.0	22.6	21.0	90.0	95.0	0.0						
104			100	L-Lysine	95.0	1.0	21.7	20.3	86.0	95.0	0.3						
105			101	Acid insoluble ash	95.0												
106			102	L-Glutamic acid	98.0	0.0	23.1	22.9	98.0	99.0	0.0						
107			103	L-Threonine	98.0	0.0	21.8	18.2	78.1	99.0	0.0						
108			104														
109			105														
110			106														
111			107														
112			108														
113			109														
114			110														
115			111														

Read me Database BLANK Diet Calc

Average: 106.0602564 Count: 46 Sum: 4136.35

# Formulation

DIET-FORMULATOR [Compatibility Mode] - Excel

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FileHomeInsertPage LayoutFormulasDataReviewViewTell me what you want to do...

CutCopyFormat PainterClipboard

Arial10Font

Wrap TextMerge & CenterAlignment

NumberNumber

Conditional FormattingFormat as TableCell StylesStyles

InsertDeleteFormatCells

AutoSumFillClearEditing

Sort & FilterFind & Select

A5

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	
1			Diet	Analysis of ingredient expressed on an 'as-used' basis																		
2	Ingredient	Description	amount	DM	Ash	GE	DE	CP	DCP	Lipid	Fibre	18:2n-6	18:3n-3	20:4n-6	20:5n-3	22:6n-3	Σ n-3	Σ n-6	Σ PL	CHOL	ASTAX	AR
3	Number		kg																			
4			0	60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5			0	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6			0	20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7			0	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25			0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

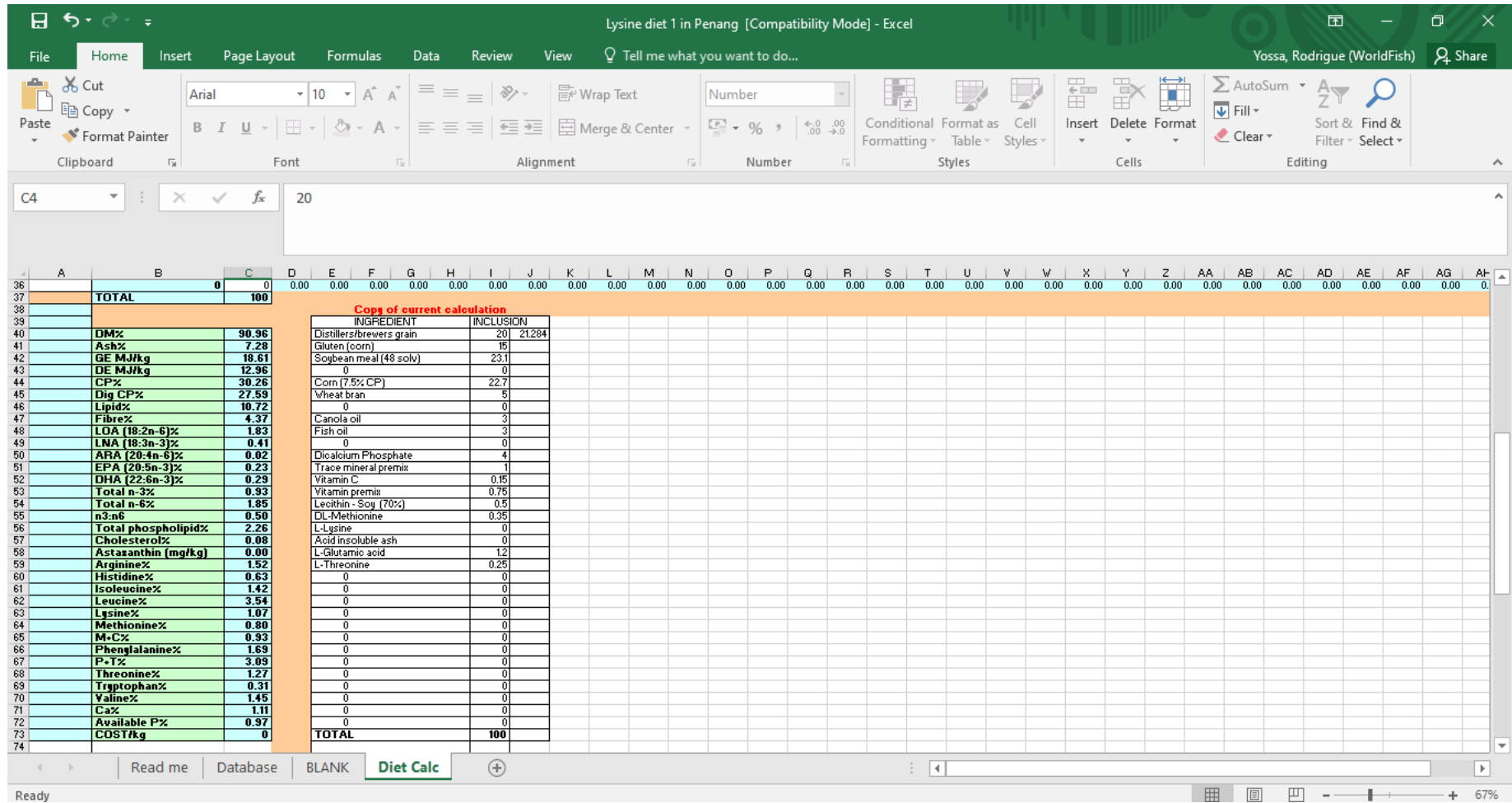
Read meDatabaseBLANKDiet Calc

Ready

# Formulation

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# Formulation



# Feed Preparation





# Feed Preparation





# Feed Preparation



# Feed Preparation





# Feed Preparation



# Feed Preparation



# Feed Preparation





# Feed Preparation





# Feed Preparation



# Feed Preparation





# Feed Preparation



# Feed Preparation





# Feed Preparation



# Practicals

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Formulate 2 tilapia feeds using 8 ingredients available in your country, at the life stages of 50-200 g and 500-1500 g respectively.



# Practicals

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Formulate 2 African catfish feeds using 8 ingredients available in your country, at the life stages of <5 g and 50-200 g respectively.

# Thank You



RESEARCH  
PROGRAM ON  
Fish

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