Aquaculture Nutrition: Formulating Balanced Diets for Aquaculture

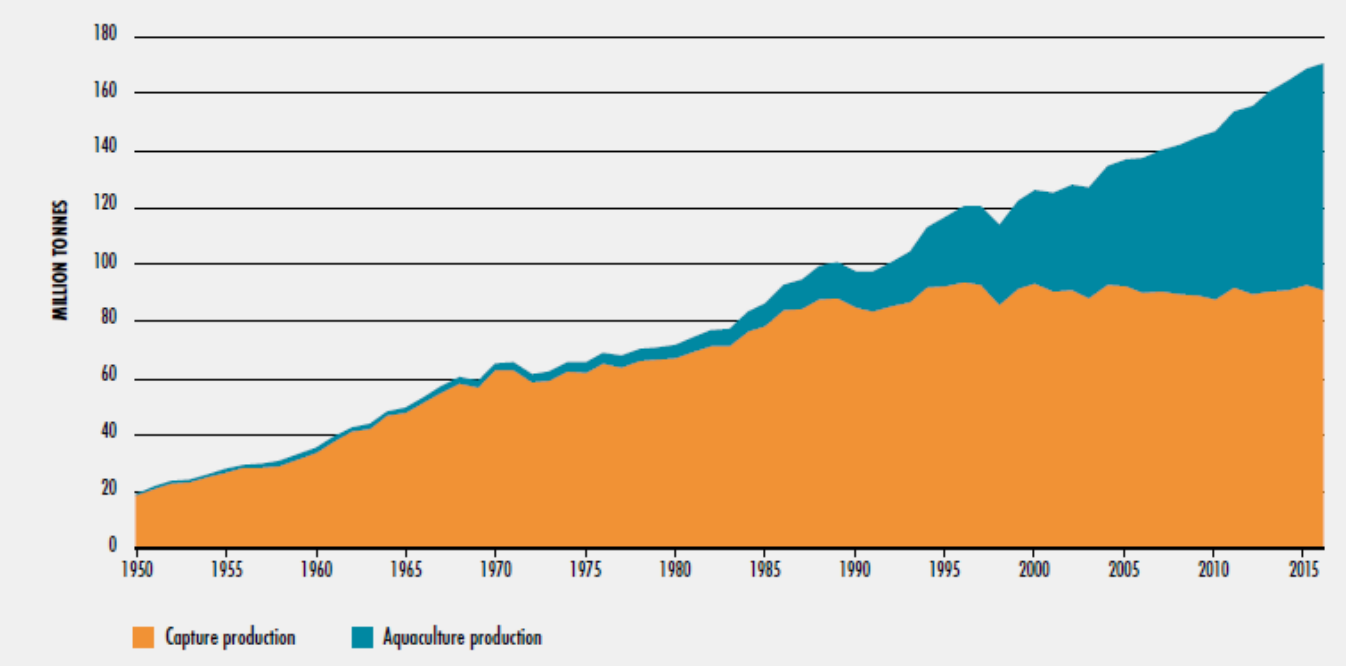
Rodrigue Yossa, WorldFish, Penang, Malaysia

CGIAR RESEARCH PROGRAM ON Fish
Led by WorldFish

Content

1. Introduction
2. Aquaculture Nutrition: Opportunities and Challenges
3. Nutrient Requirements of Fish
4. Databases
5. Formulation
6. Feed Preparation
7. Practicals

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.

CGIAR RESEARCH PROGRAM ON Fish
Led by WorldFish

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).

CGIAR RESEARCH PROGRAM ON Fish
Led by WorldFish

Aquaculture Nutrition: Opportunities and Challenges

- Positives 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

CGIAR RESEARCH PROGRAM ON Fish Led by WorldFish

Aquaculture Nutrition: Opportunities and challenges

Quality Data & Relevant Information

CGIAR RESEARCH PROGRAM ON Fish Led by WorldFish

Aquaculture Nutrition: one challenge-Data

Quality control on data available???

CGIAR RESEARCH PROGRAM ON Fish
Led by WorldFish

Aquaculture Nutrition: Nutrient requirements of fish

Lot of Data !!!

Quality Assurance on Data?

Ingredients
- Conventional (maize, soybean, fishmeal, etc.)
- Non-conventional (HPSFM, concentrates, etc.)
- Novel / ”sexy” (insect meal, SCP)

Formulation
- Species + Life stage
- Digestibility
- Nutrient requirements
- Database + Software

Processing
- Pelleting
- Extrusion
- Commercial Vs farm made

No regulatory framework for the certification of aquaculturist (fish nutritionist versus human nutritionist)

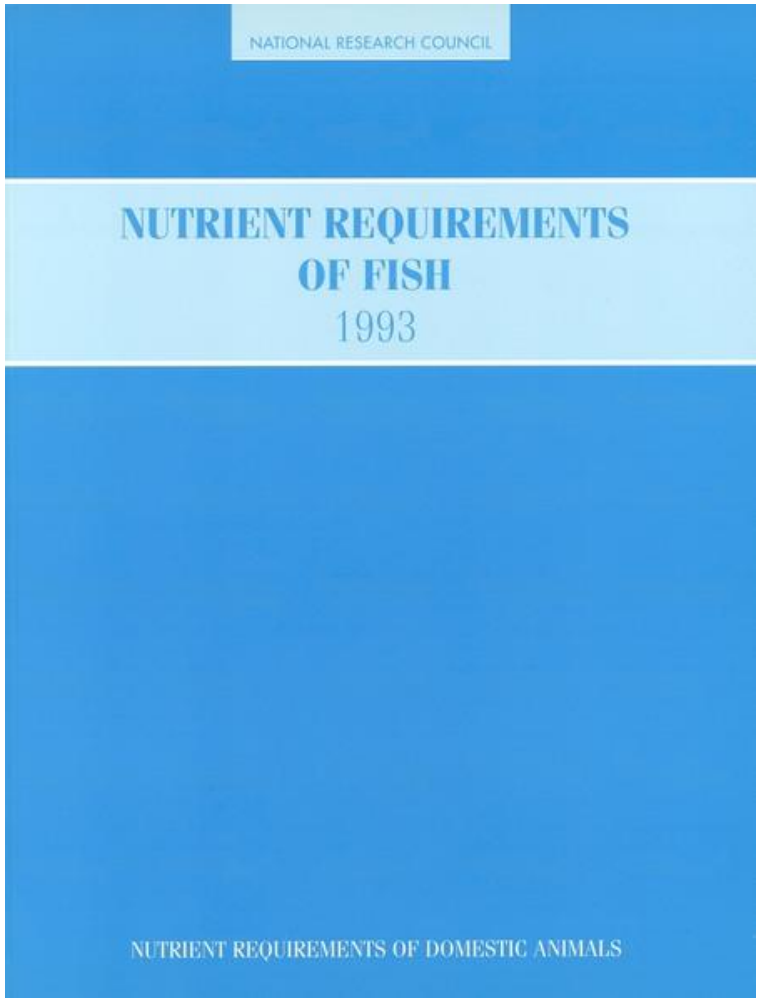
Predatory publications (industry, scientists, journals)

Non optimum statistics

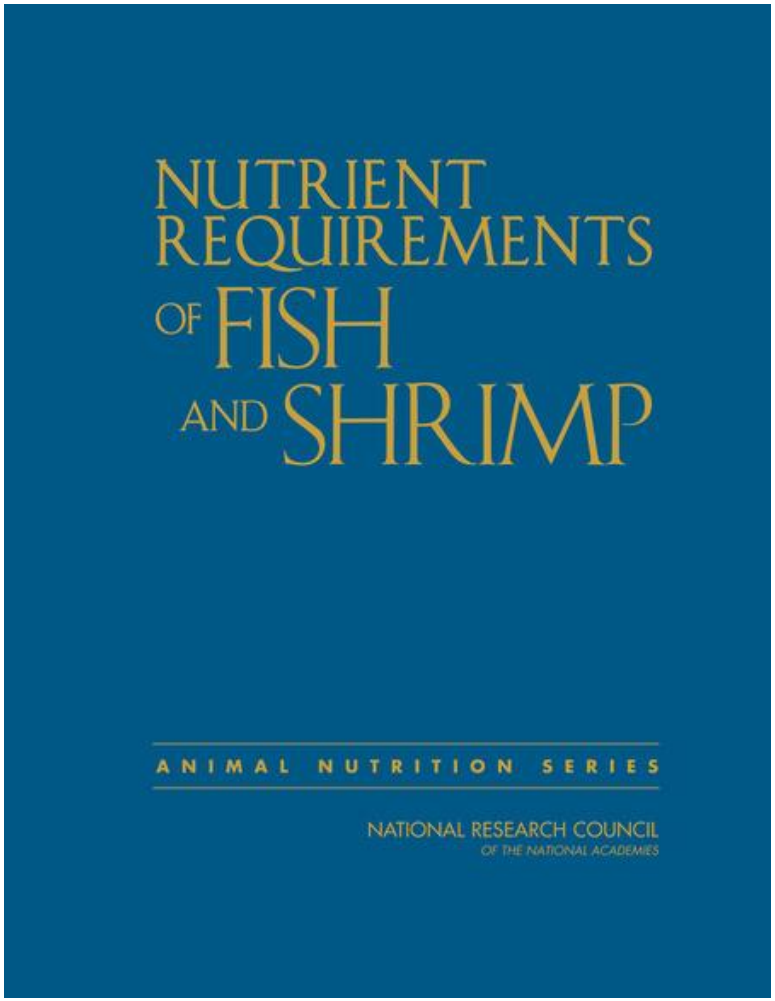
→ Exaggerated conclusions

CGIAR RESEARCH PROGRAM ON Fish Led by WorldFish

Aquaculture Nutrition: Nutrient requirements of fish



18 years



CGIAR RESEARCH PROGRAM ON Fish
Led by WorldFish

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

Short communication

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

Rodrigue Yossa [a,*], Marc Verdegem [b]

[a] Department of Biology, Gus R. Douglass Institute, WV State University, Institute, WV, USA
[b] Aquaculture and Fisheries Group, Wageningen University, Wageningen, The Netherlands

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

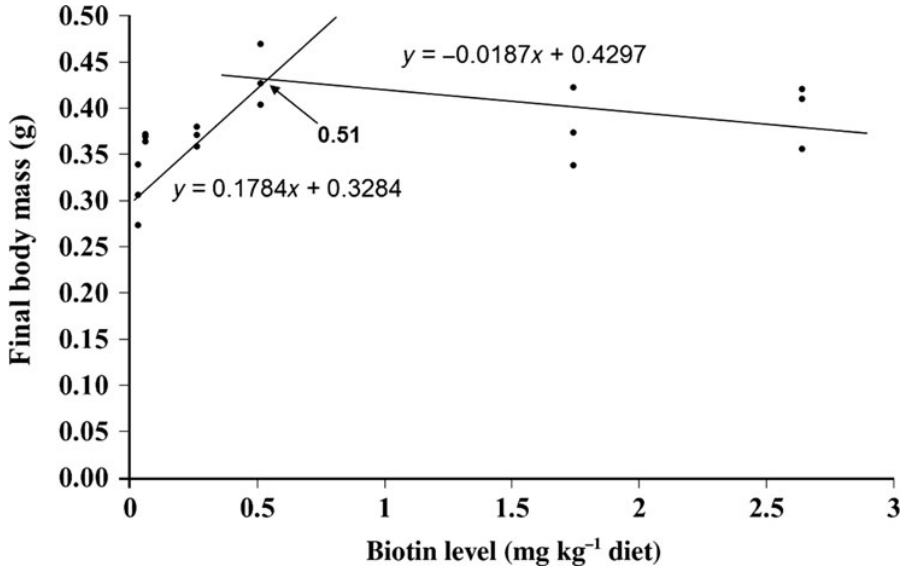
Table 2 Final mass, p… efficiency ratio (PER) and feed conversion ratio (FCR) of zeb… *Danio rerio* fed diets sup-plemented with vario… …in for 12 weeks*.

Parameters	0.031					*P-value*	Pooled SEM
Initial mass (g)	0.136	0.138			0.136		
Final mass (g)	0.306[c]				0.395[ab]	0.0058	0.017
PER (g g^{-1})†	0.44[b]					0.0257	3.537
FCR‡			1.88			0001	0.052

*Means with different s… …n a row are significantly different ($P <$ …

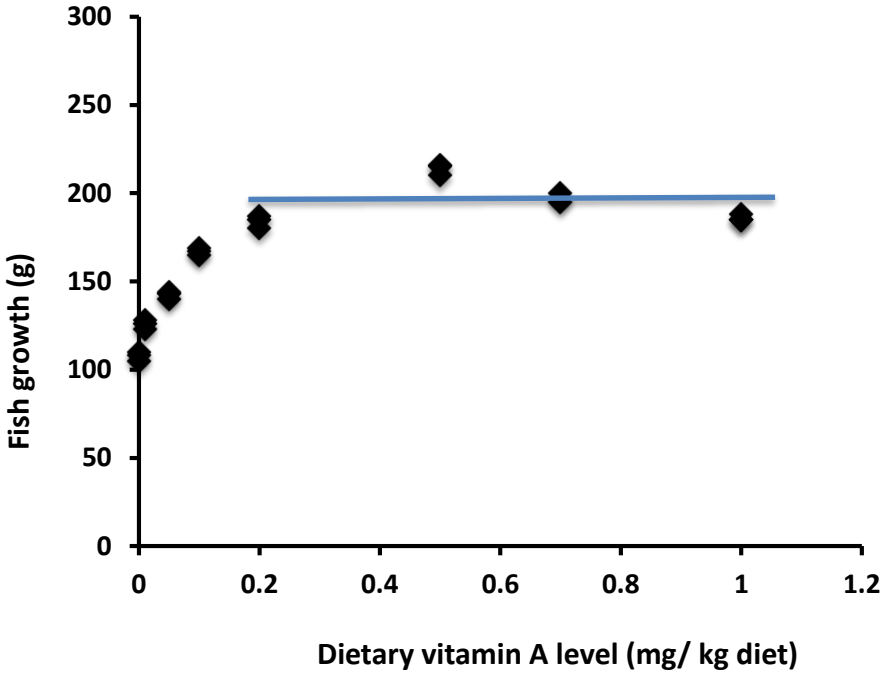
†Protein efficiency ratio … (final wet mass (g) - initial wet mass (g)) / (Quantity … …ted (g) × protein content of the feed (g g^{-1}))

‡Feed conversion ratio FCR (g g^{-1}) = (Ingested feed (g) × Dry matter content of feed) / (final wet mass (g) - initial wet mass (g))

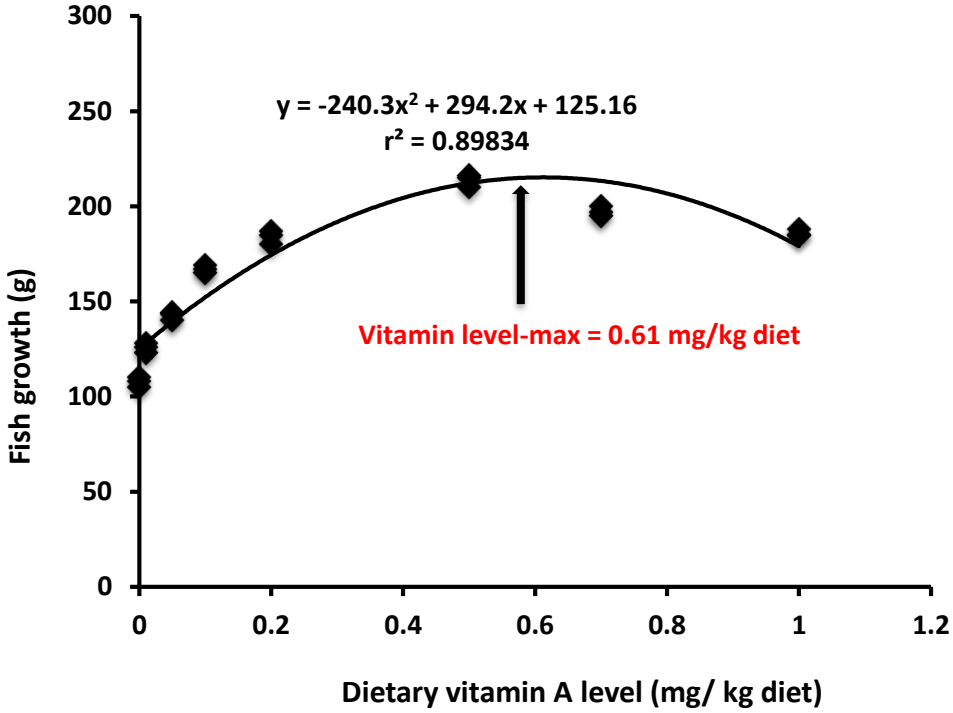


CGIAR RESEARCH PROGRAM ON Fish Led by WorldFish

Aquaculture Nutrition: Nutrient requirements of fish



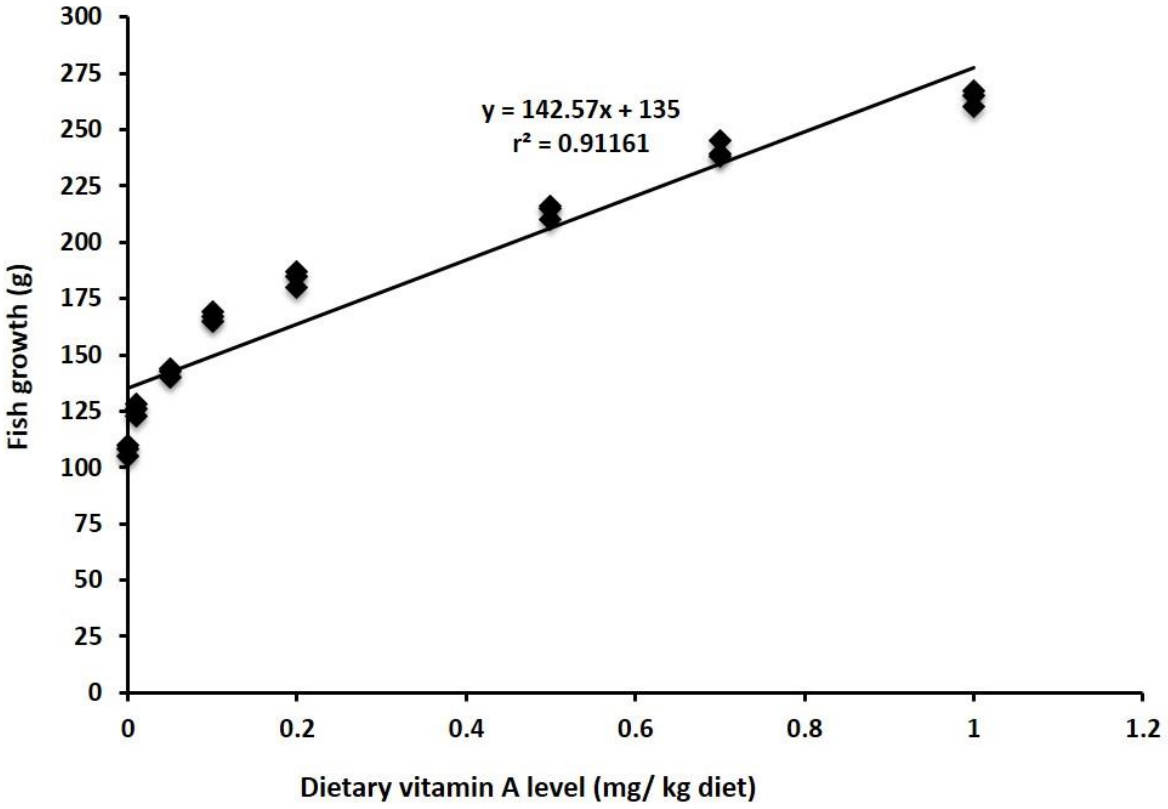
Multiple comparison test



Regression analysis

CGIAR RESEARCH PROGRAM ON Fish Led by WorldFish

Aquaculture Nutrition: Nutrient requirements of fish



Regression analysis

CGIAR RESEARCH PROGRAM ON Fish
Led by WorldFish

Aquaculture Nutrition: Nutrient requirements of fish

A lot of Data is very good !

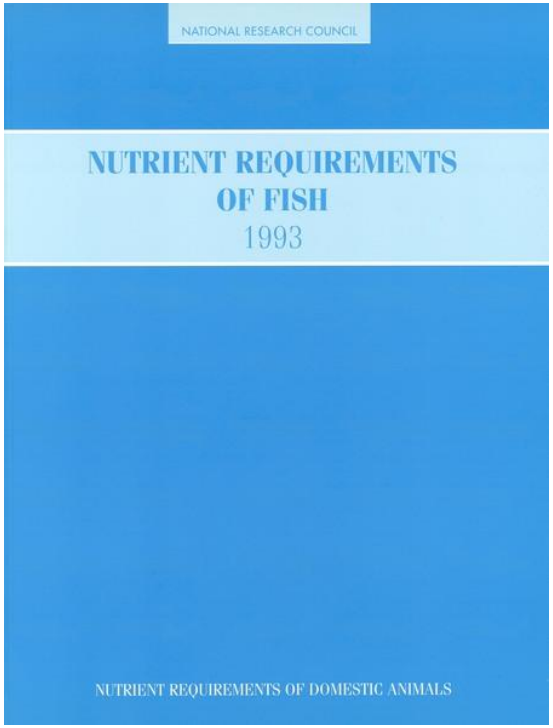
But need to know how to sort them out !

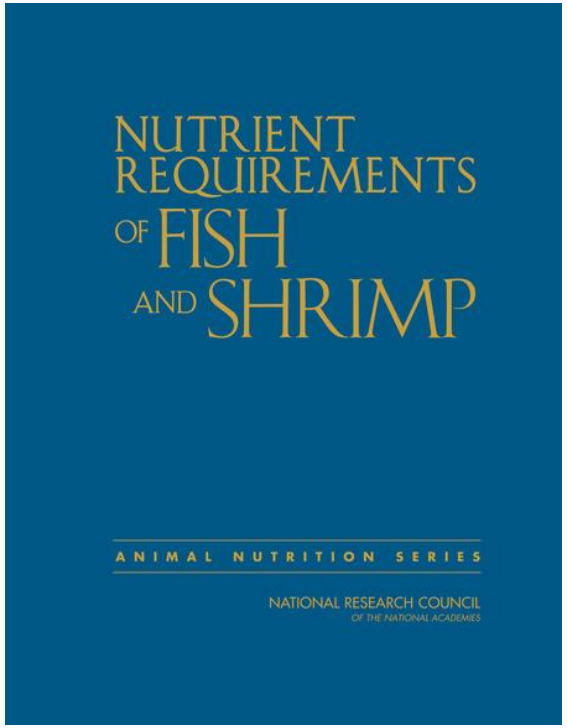
Consider “Quality Data & Relevant Information”!

CGIAR RESEARCH PROGRAM ON Fish Led by WorldFish

Aquaculture Nutrition: Nutrient requirements of fish

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





Annual (and not every 2 decades)

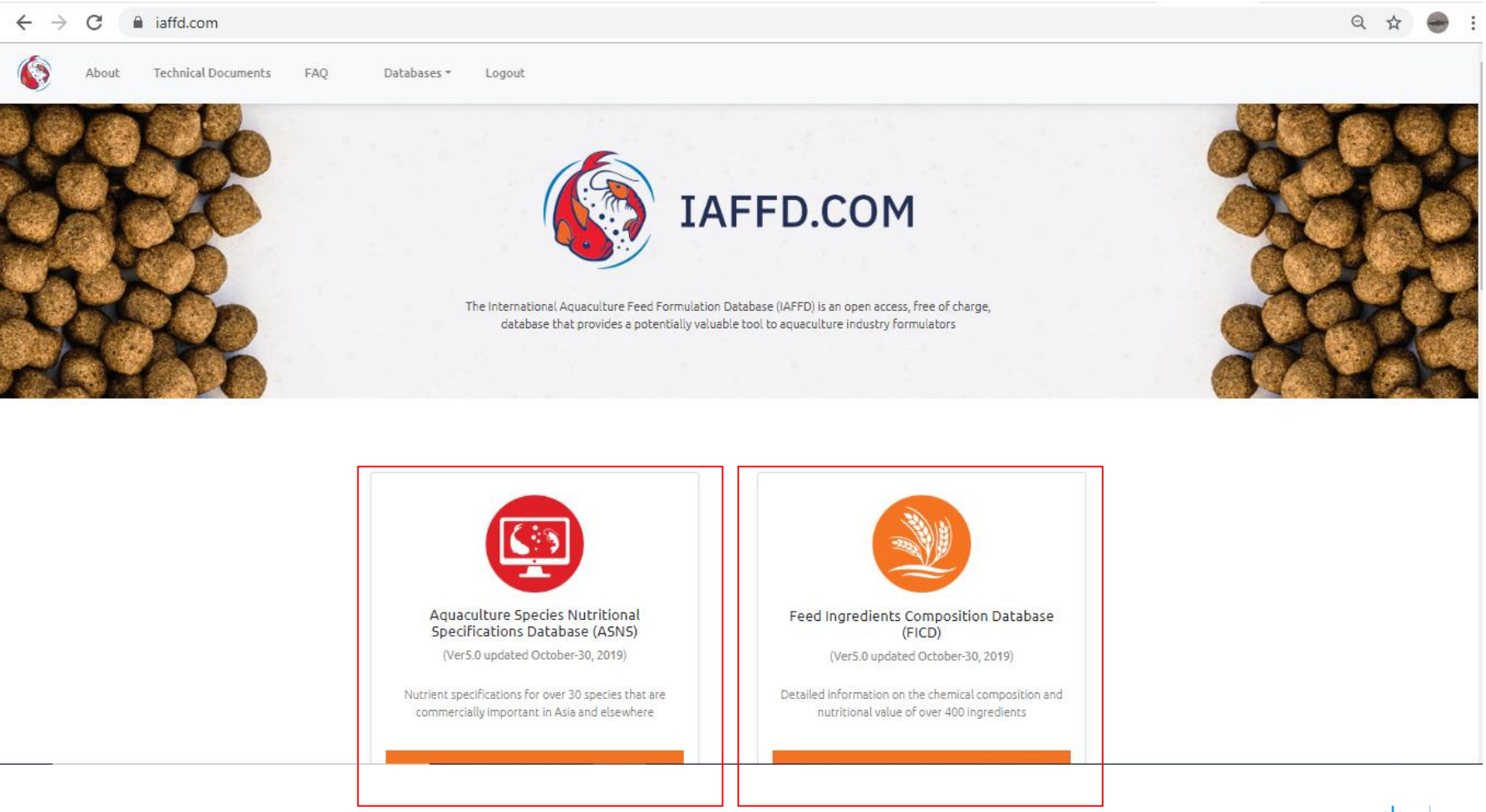
National or regional (not just the US)

ISFNF should have a data section with metadada

More nutritional modeling

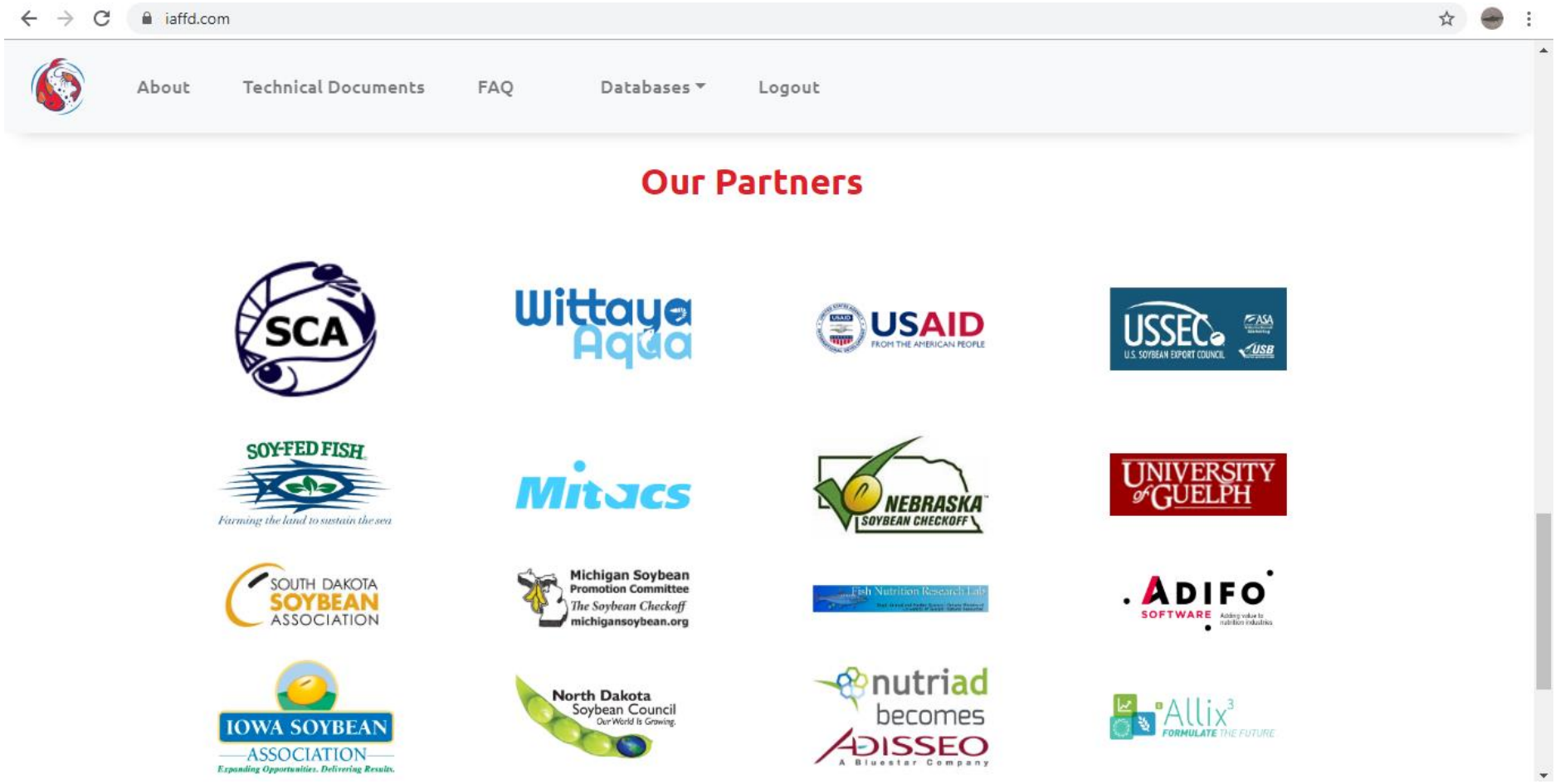
CGIAR RESEARCH PROGRAM ON Fish
Led by WorldFish

Databases



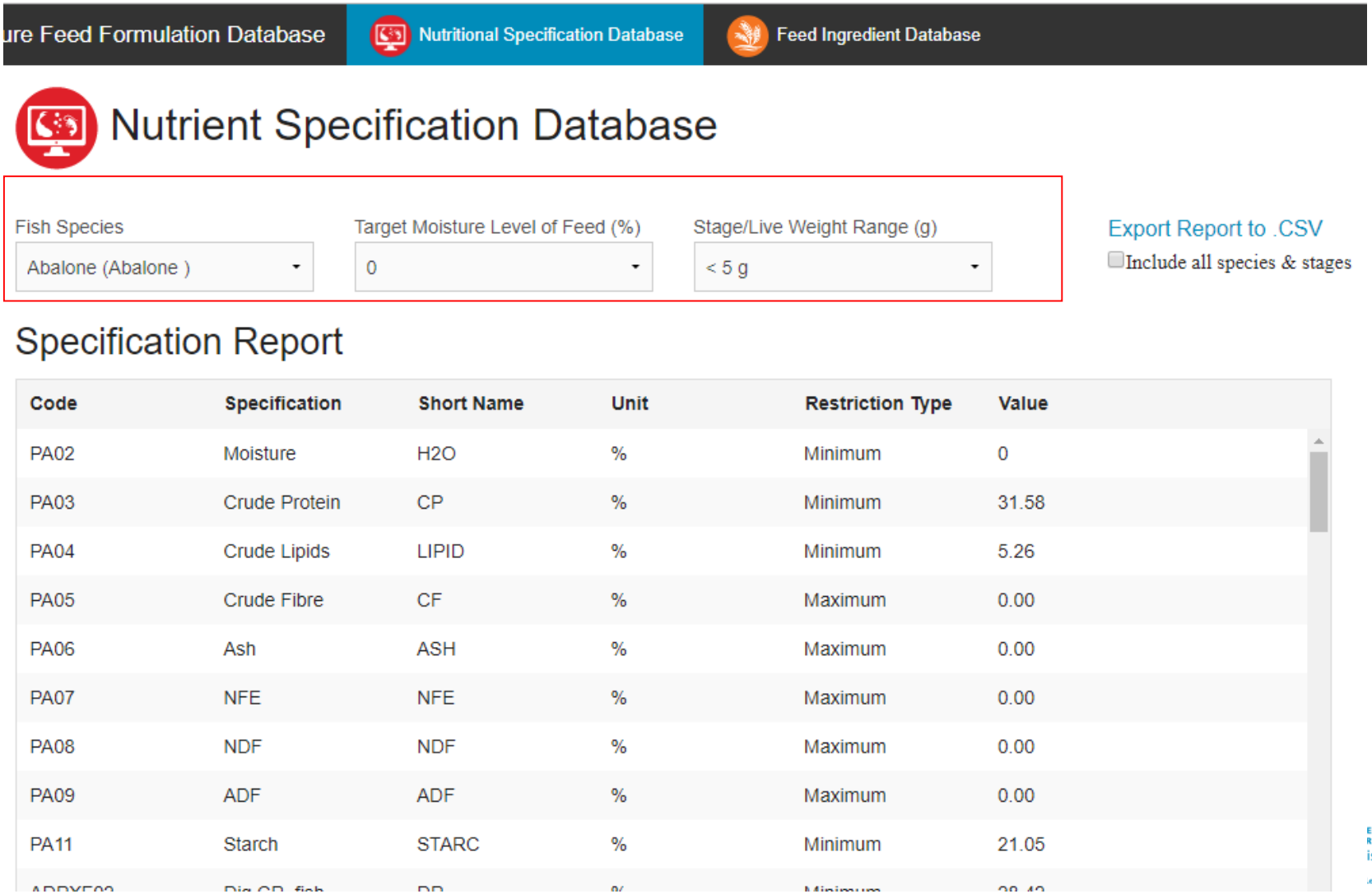
CGIAR RESEARCH PROGRAM ON Fish
Led by WorldFish

Databases



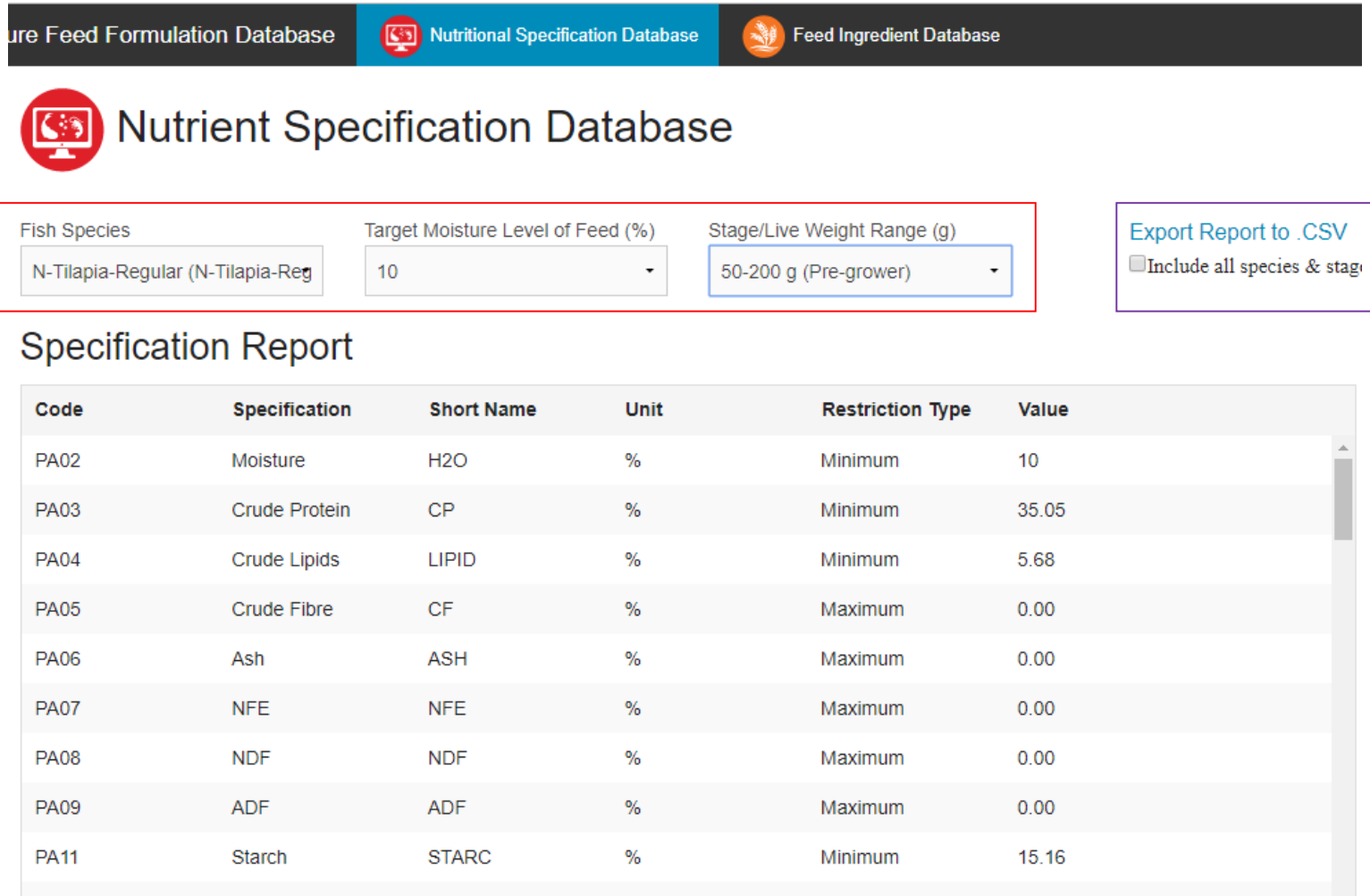
CGIAR RESEARCH PROGRAM ON Fish
Led by WorldFish

Databases



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

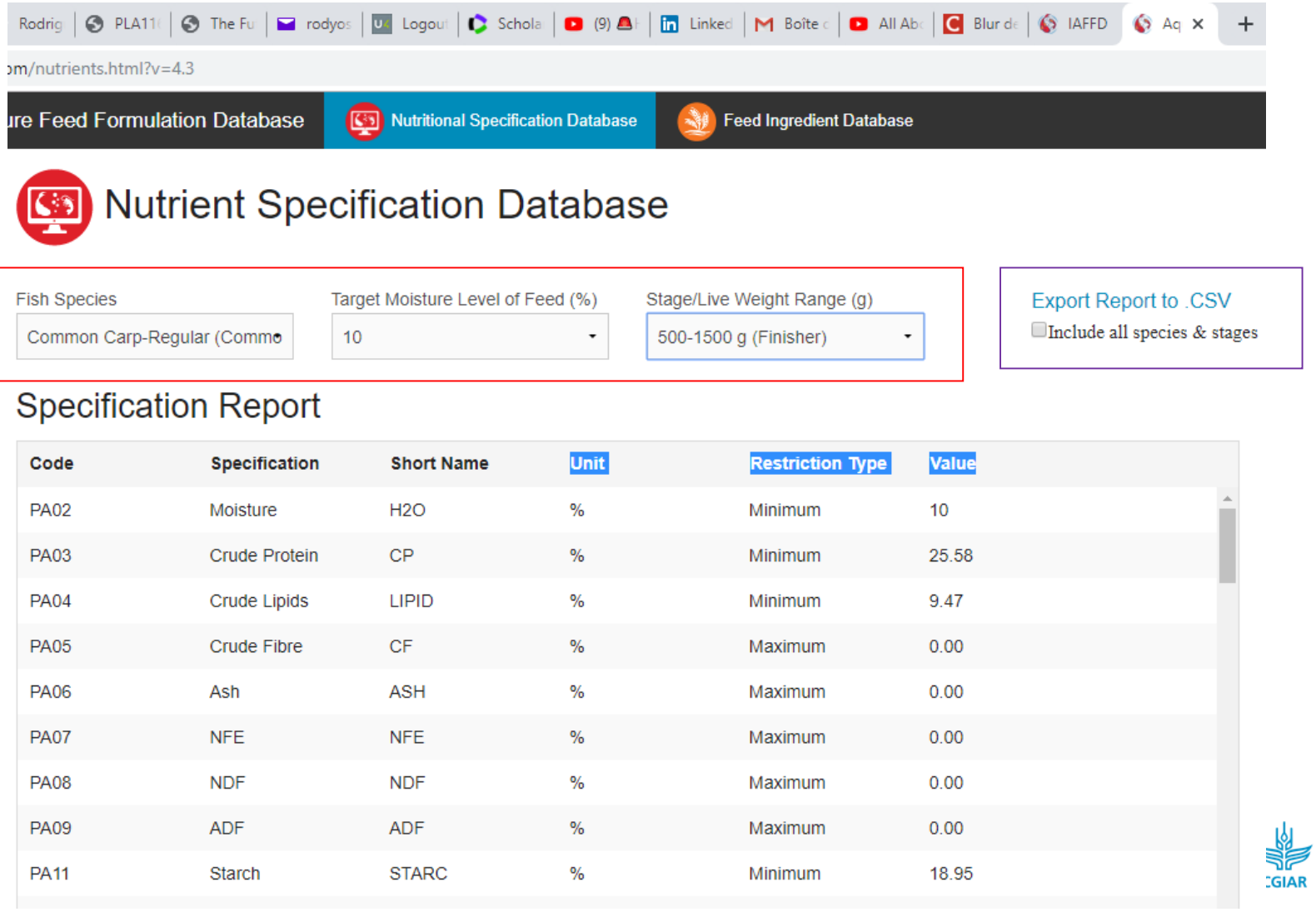
Databases



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

CGIAR RESEARCH PROGRAM ON Fish Led by WorldFish

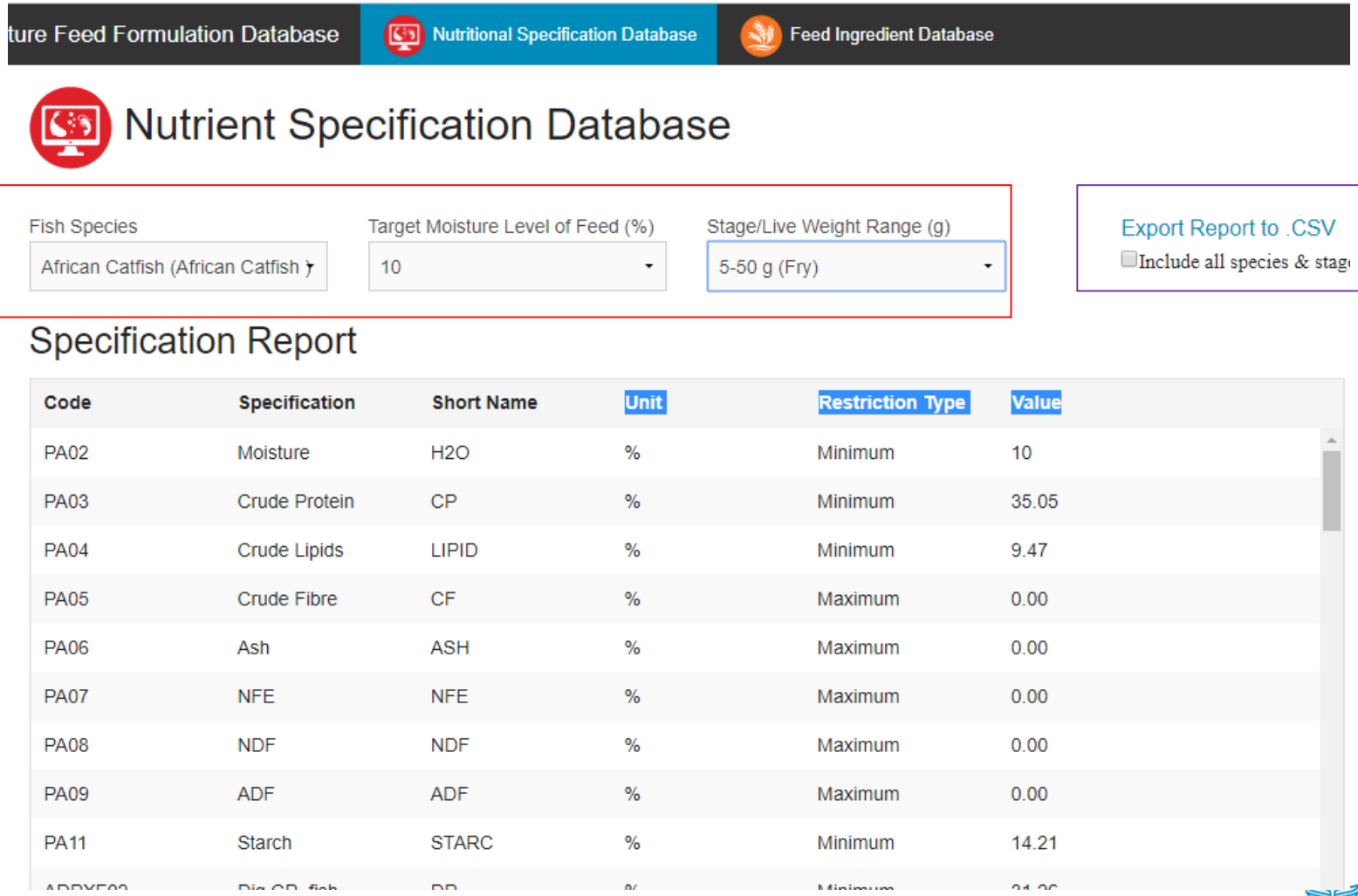
Databases



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

CGIAR RESEARCH PROGRAM ON Fish Led by WorldFish

Databases



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

CGIAR RESEARCH PROGRAM ON Fish Led by WorldFish

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

CGIAR RESEARCH PROGRAM ON Fish Led by WorldFish

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:

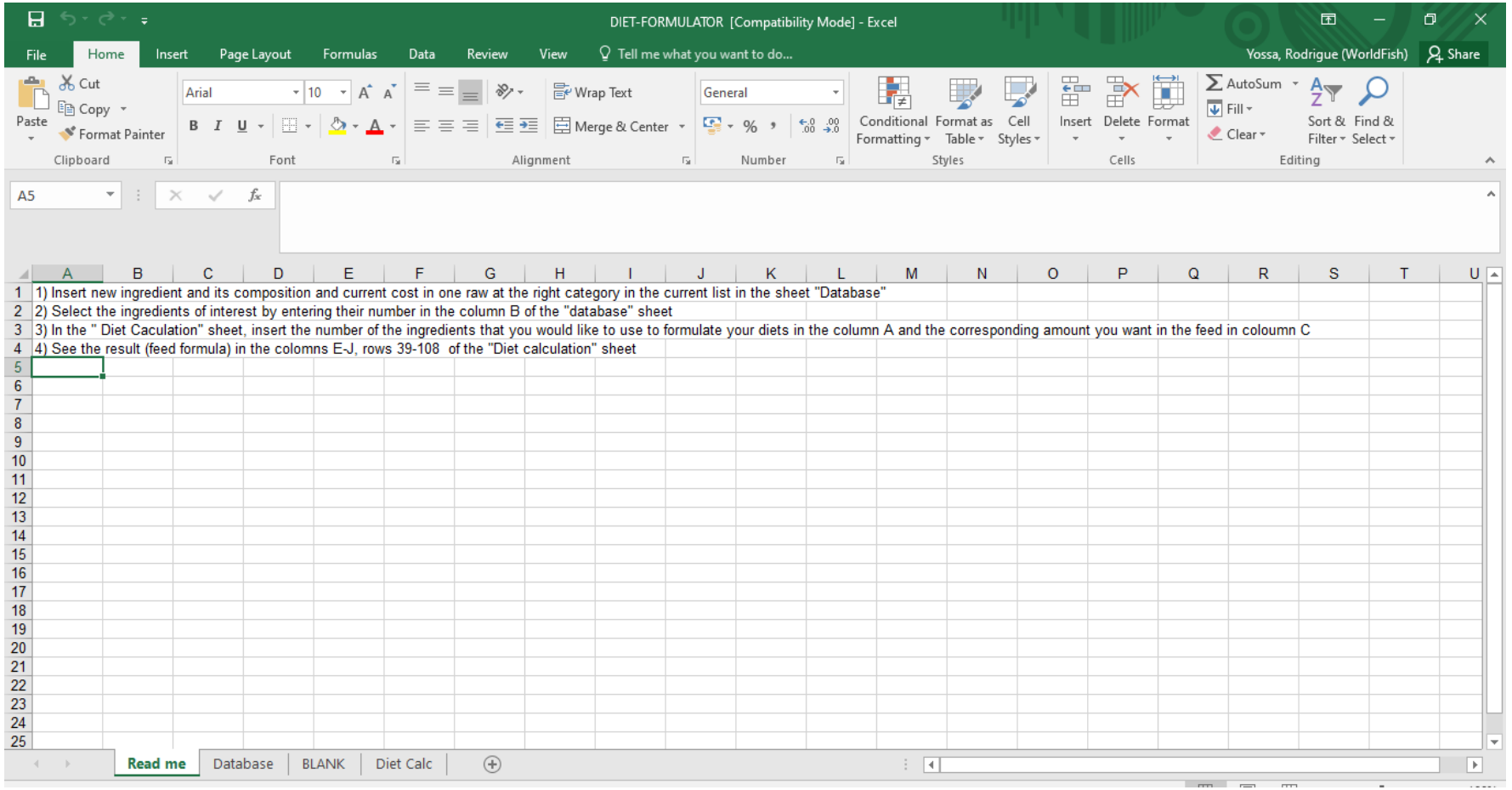
Ing_Code	Ing_Descr_E	Dry Matter(%)	Moisture(%)	Crude Protein(%)	Crude Lipids(%)	Crude Fibre(%)	Ash(%)	NFE(%)	NDF(%)	ADF(%)	Total CHO(%)	Starch(%)	Sugars(%)	Gross E
10000	Fish meal, India, 74% CP	90.80	9.20	74.16	4.97	0.50	10.00	1.17	0.00	0.00	1.67	0.00	0.00	19.72
10001	Fish meal, Chile, 64% CP	92.00	8.00	63.60	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	70.69	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	7.60	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	5.60	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	70.69	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

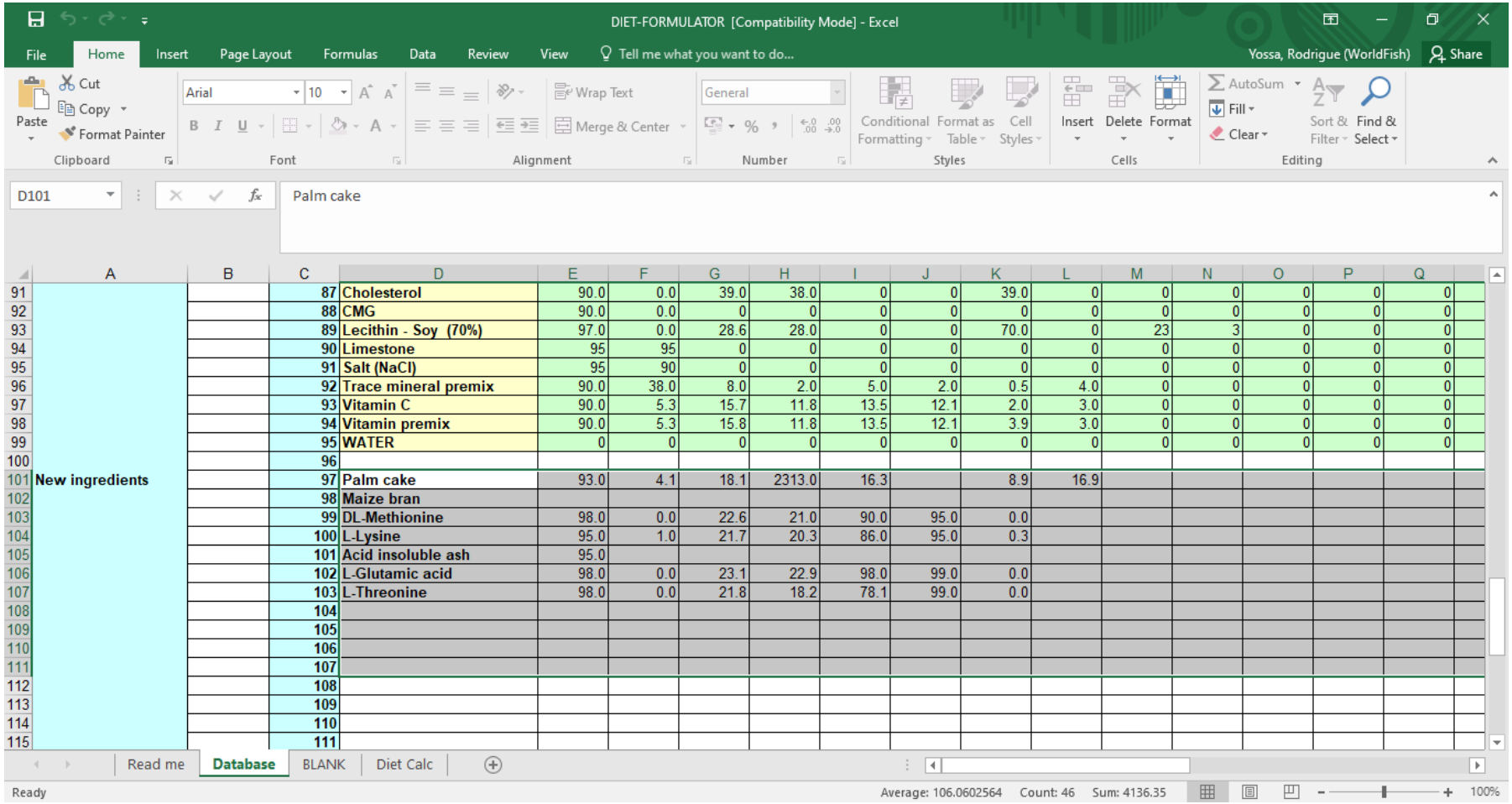
Previous 1 2 3 4 5 … 19 Next

CGIAR RESEARCH PROGRAM ON Fish Led by WorldFish

Formulation



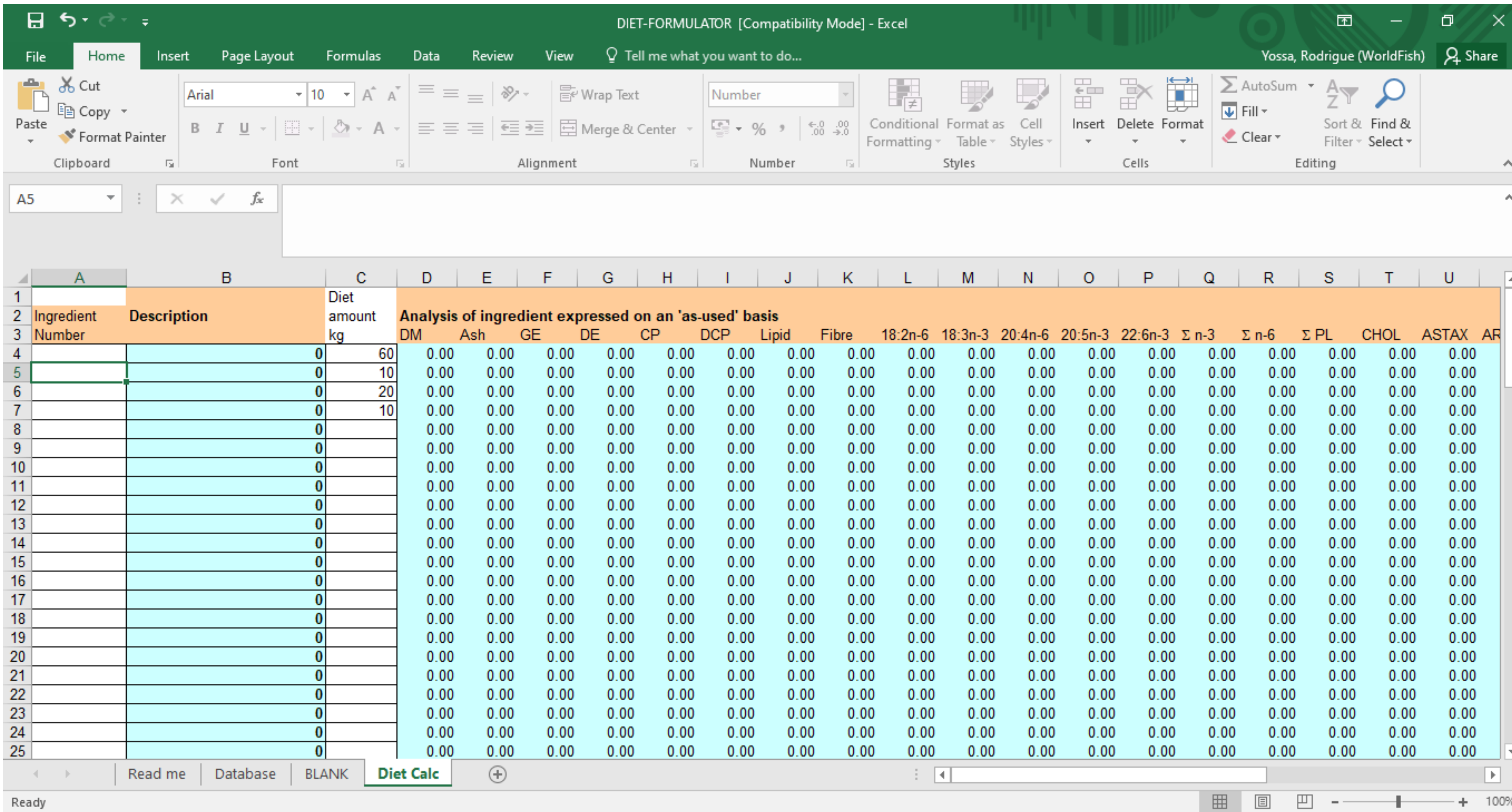
Formulation



	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														

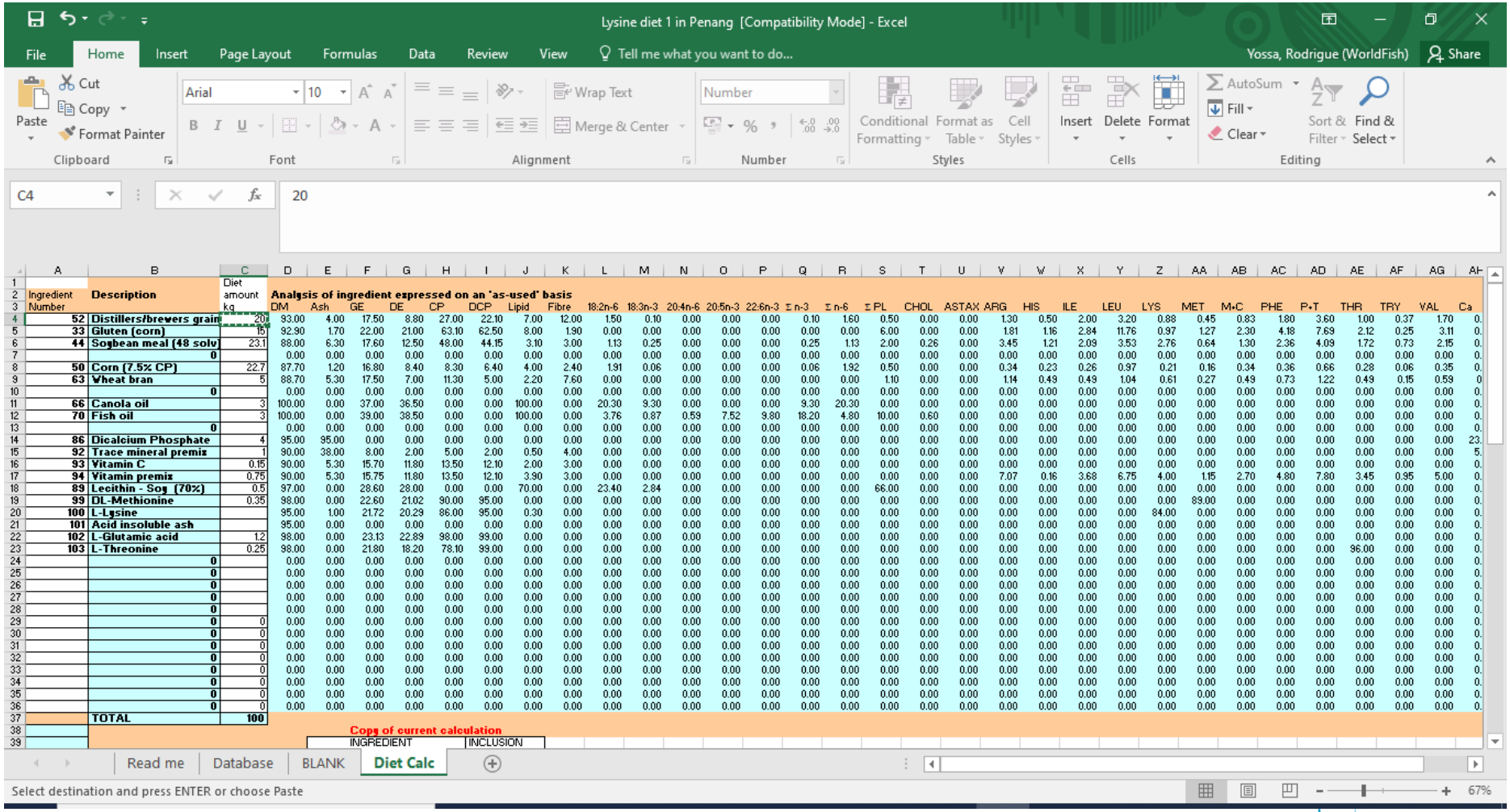
CGIAR RESEARCH PROGRAM ON Fish Led by WorldFish

Formulation



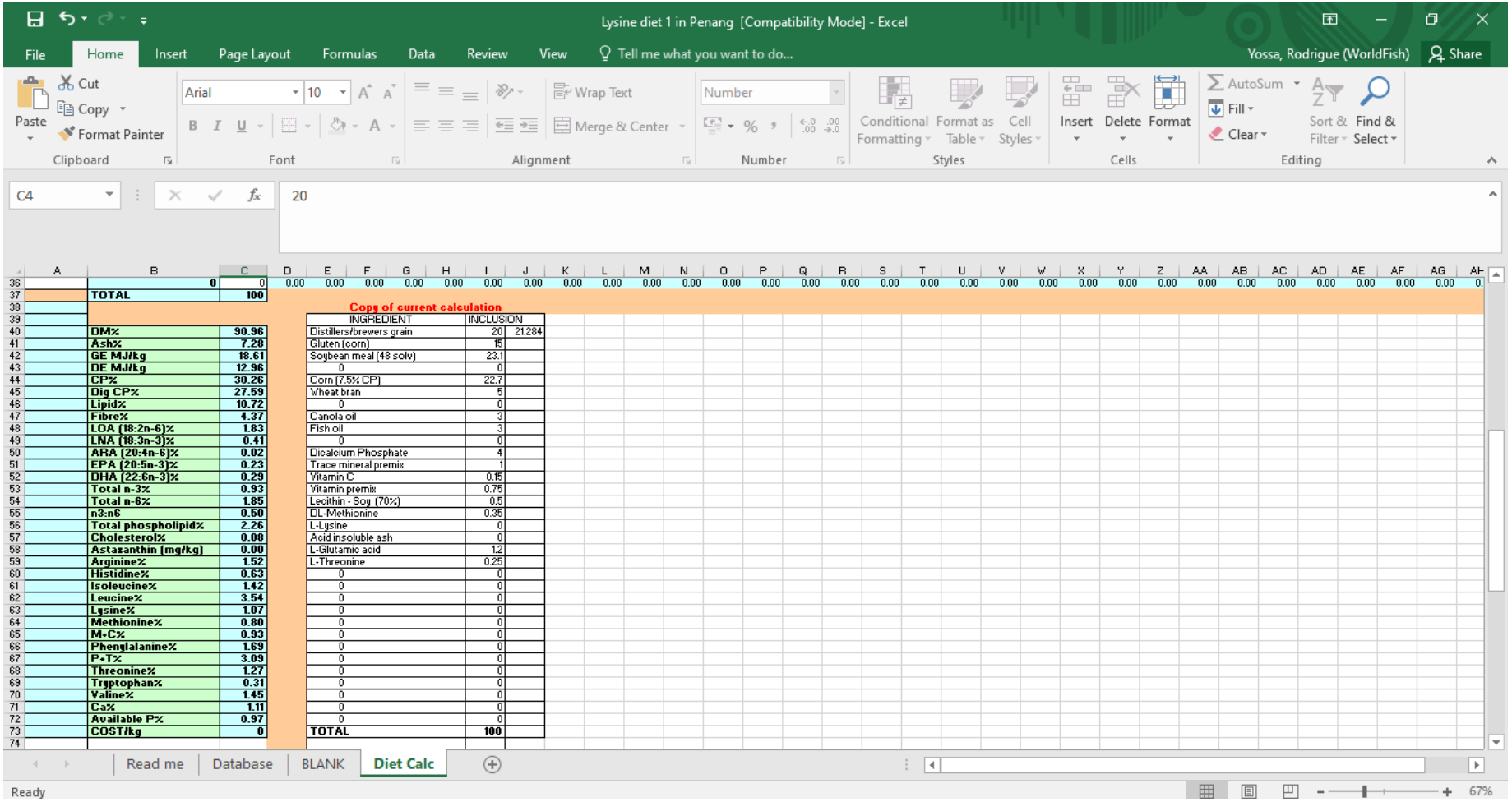
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1			Diet																		
2	Ingredient	**Description**	amount	**Analysis of ingredient expressed on an 'as-used' basis**																	
3	Number		kg	DM	Ash	GE	DE	CP	DCP	Lipid	Fibre	18:2n-6	18:3n-3	20:4n-6	20:5n-3	22:6n-3	Σ n-3	Σ n-6	Σ PL	CHOL	ASTAX
4		0	60	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

Formulation



CGIAR RESEARCH PROGRAM ON Fish Led by WorldFish

Formulation



CGIAR RESEARCH PROGRAM ON Fish Led by WorldFish

Feed Preparation

Feed Preparation

Feed Preparation

CGIAR RESEARCH PROGRAM ON Fish
Led by WorldFish

Feed Preparation

Feed Preparation

CGIAR RESEARCH PROGRAM ON Fish
Led by WorldFish

Feed Preparation

Feed Preparation

Feed Preparation

Feed Preparation

Feed Preparation

Feed Preparation

Feed Preparation

Feed Preparation

CGIAR RESEARCH PROGRAM ON Fish
Led by WorldFish

Practicals

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

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

CGIAR RESEARCH PROGRAM ON Fish

Led by WorldFish

In partnership with

IWMI International Water Management Institute

JAMES COOK UNIVERSITY AUSTRALIA

UNIVERSITY of GREENWICH

WAGENINGEN UNIVERSITY & RESEARCH

CGIAR RESEARCH PROGRAM ON Fish
Led by WorldFish