Formulating Balanced Diets for Aquaculture

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23rd September 2020

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2. Aquaculture Nutrition: Opportunities and Challenges
3. Nutrient Requirements of Fish
4. Databases
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7. Feeding

1. Introduction




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).

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1. Introduction (cont'd)

Importance of feeding

- Complement natural production
- Increase production and productivity of fish farms
- Predictability of production
- Reduction of the production cycle
- Healthier fish
- Possibility of nutritional fortification

Is the cost of feed justified for tilapia/African catfish farming?

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2. 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

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2. Aquaculture Nutrition: Opportunities and Challenges (Cont'd)

Quality Data & Relevant Information

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2. Aquaculture Nutrition: Opportunities and Challenges (Cont'd)

Quality control on data available???

2. Aquaculture Nutrition: Opportunities and Challenges (Cont'd)

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

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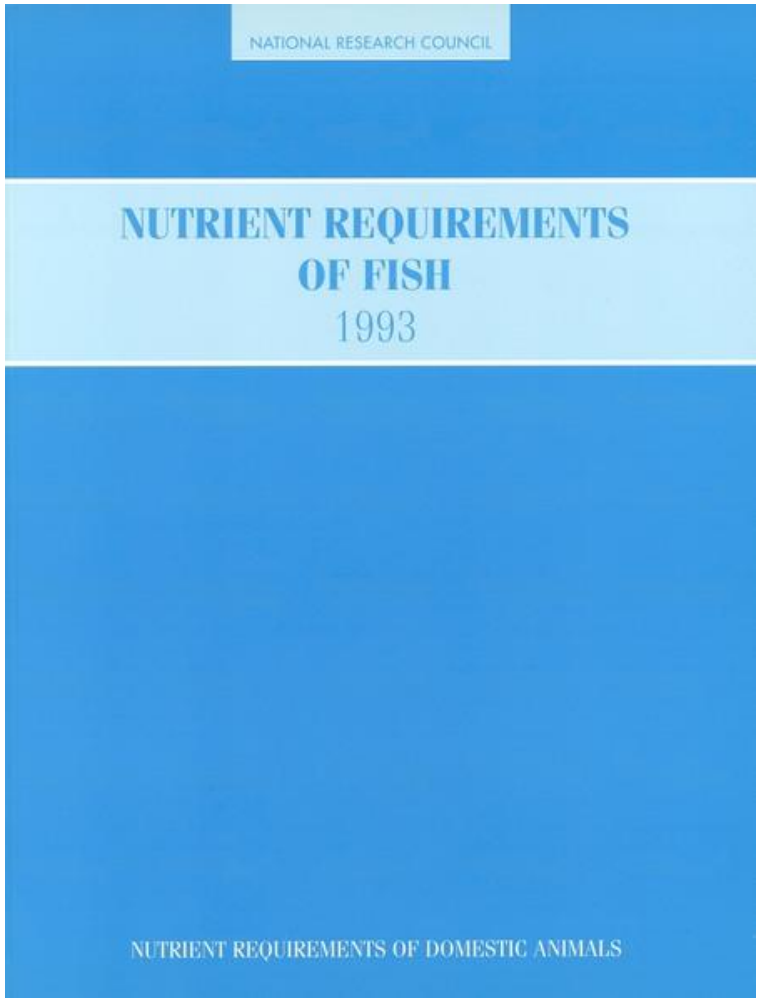
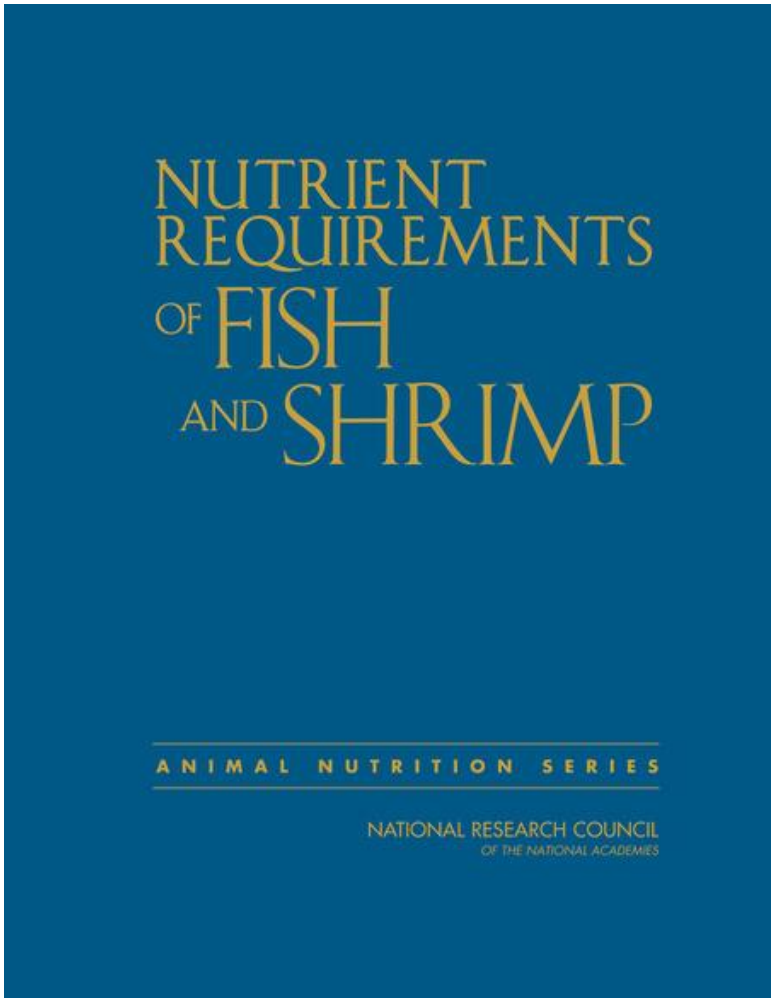
3. Nutrient requirements of fish



18 years



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3. Nutrient requirements of fish (cond't)

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

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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

3. Nutrient requirements of fish (cond't)

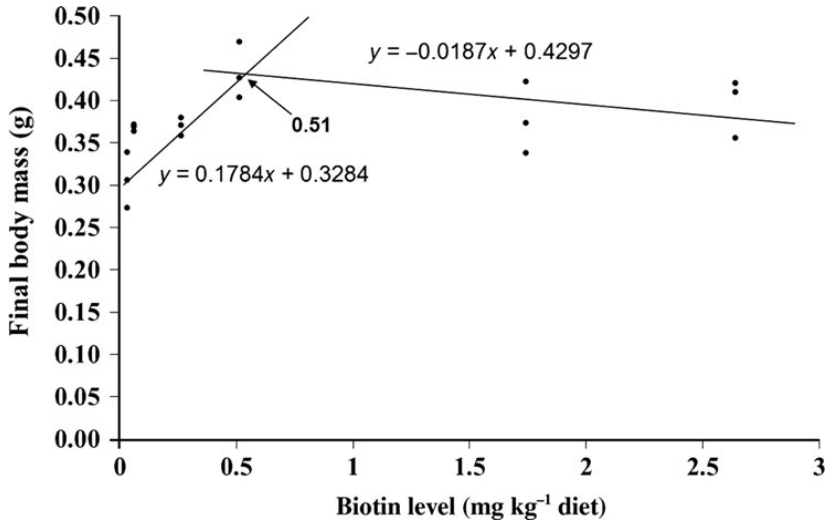
Table 2 Final mass, protein efficiency ratio (PER) and feed conversion ratio (FCR) of zebrafish *Danio rerio* fed diets supplemented with various levels of biotin for 12 weeks*.

Parameters	0.03†					*P-value*	Pooled SEM
Initial mass (g)	0.136	0.136			0.136		
Final mass (g)	0.306[c]	0.369[b]			0.395[ab]	0.0058	0.017
PER (g g^{-1})†	0.44[b]				[a]	0.0257	3.537
FCR‡	2.86					<.0001	0.052

*Means with different [illegible] are significantly different

†Protein efficiency ratio = (final wet mass (g) - initial wet mass (g)) / (Quantity of feed (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))



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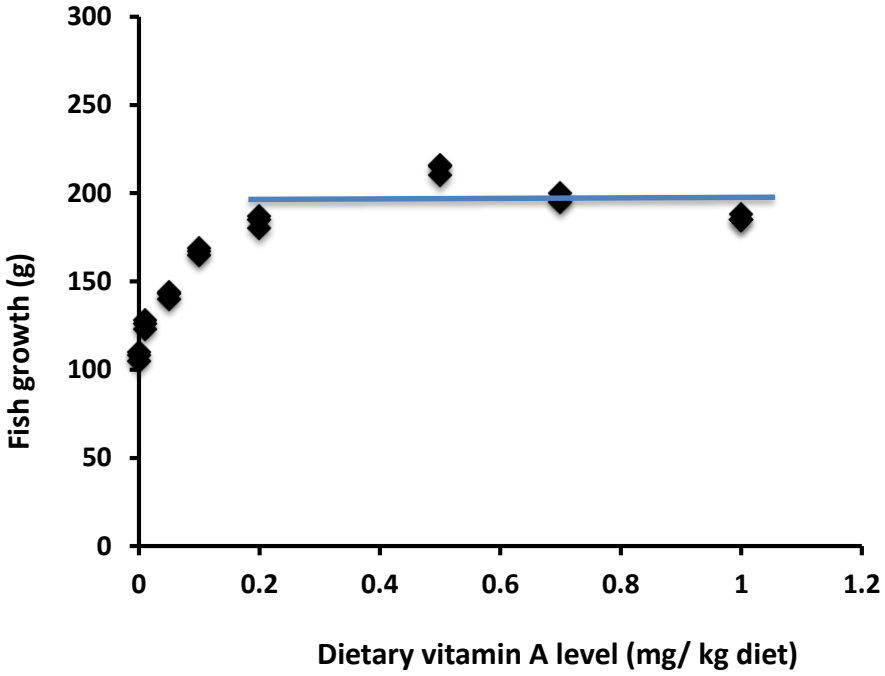
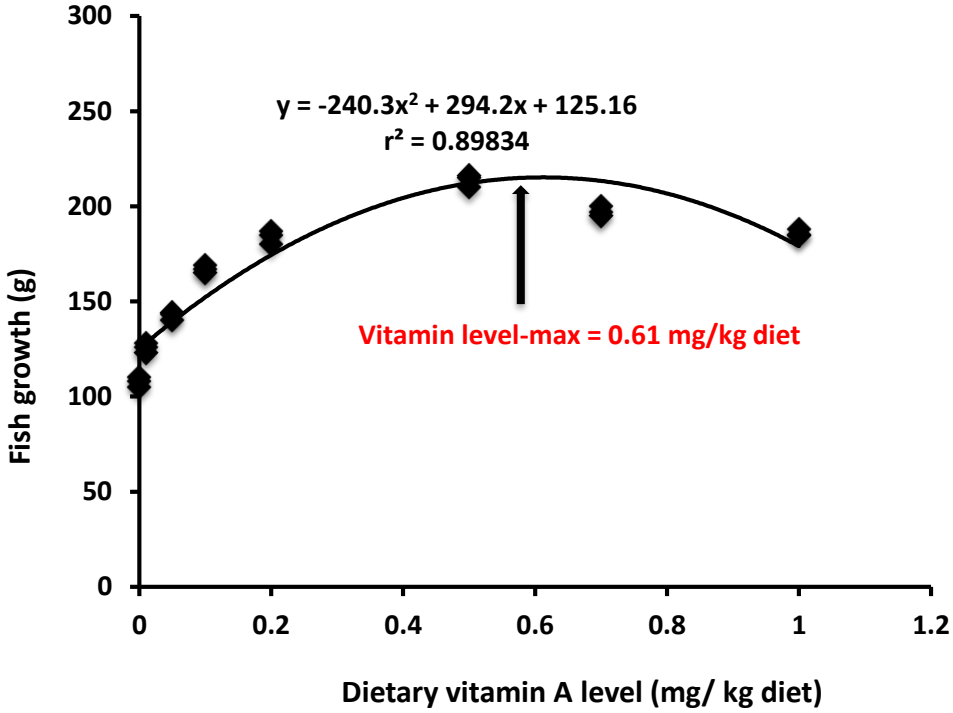
3. Nutrient requirements of fish (cond't)



Multiple comparison test



Regression analysis

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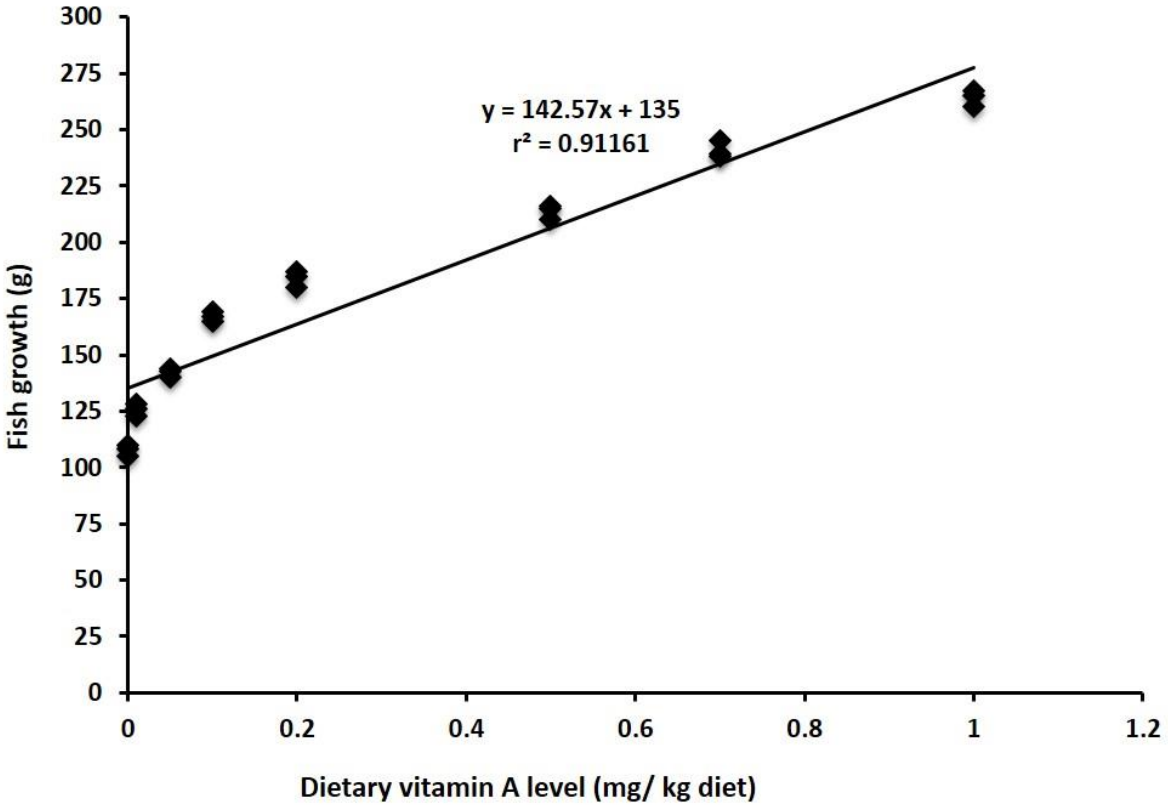
3. Nutrient requirements of fish (cond't)



Regression analysis

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3. Nutrient requirements of fish (cond't)

A lot of Data is very good !

But need to know how to sort them out !

Consider "Quality Data & Relevant Information"!

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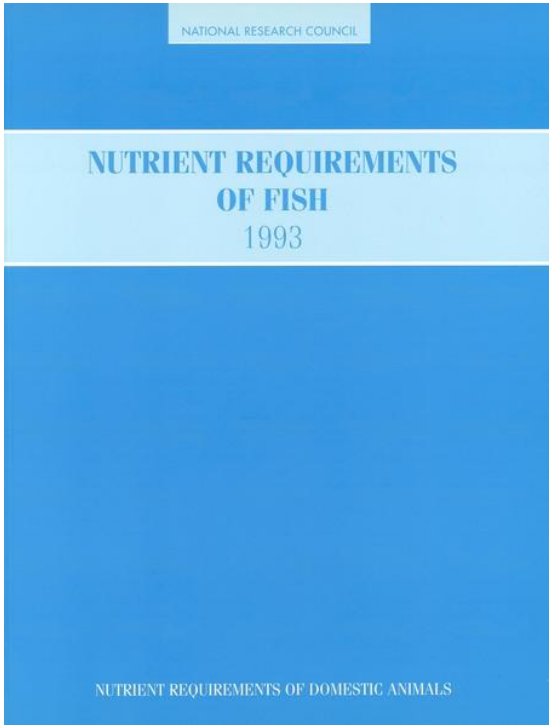
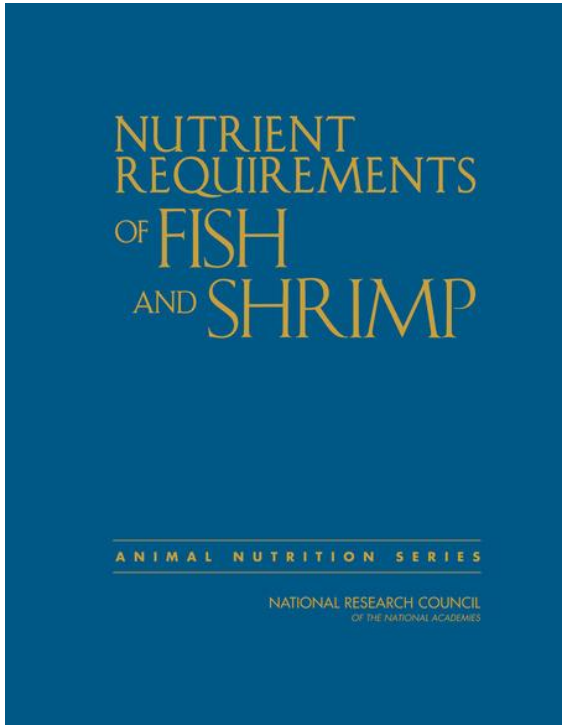
3. Nutrient requirements of fish (cond't)

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

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3. Nutrient requirements of fish (cond't)

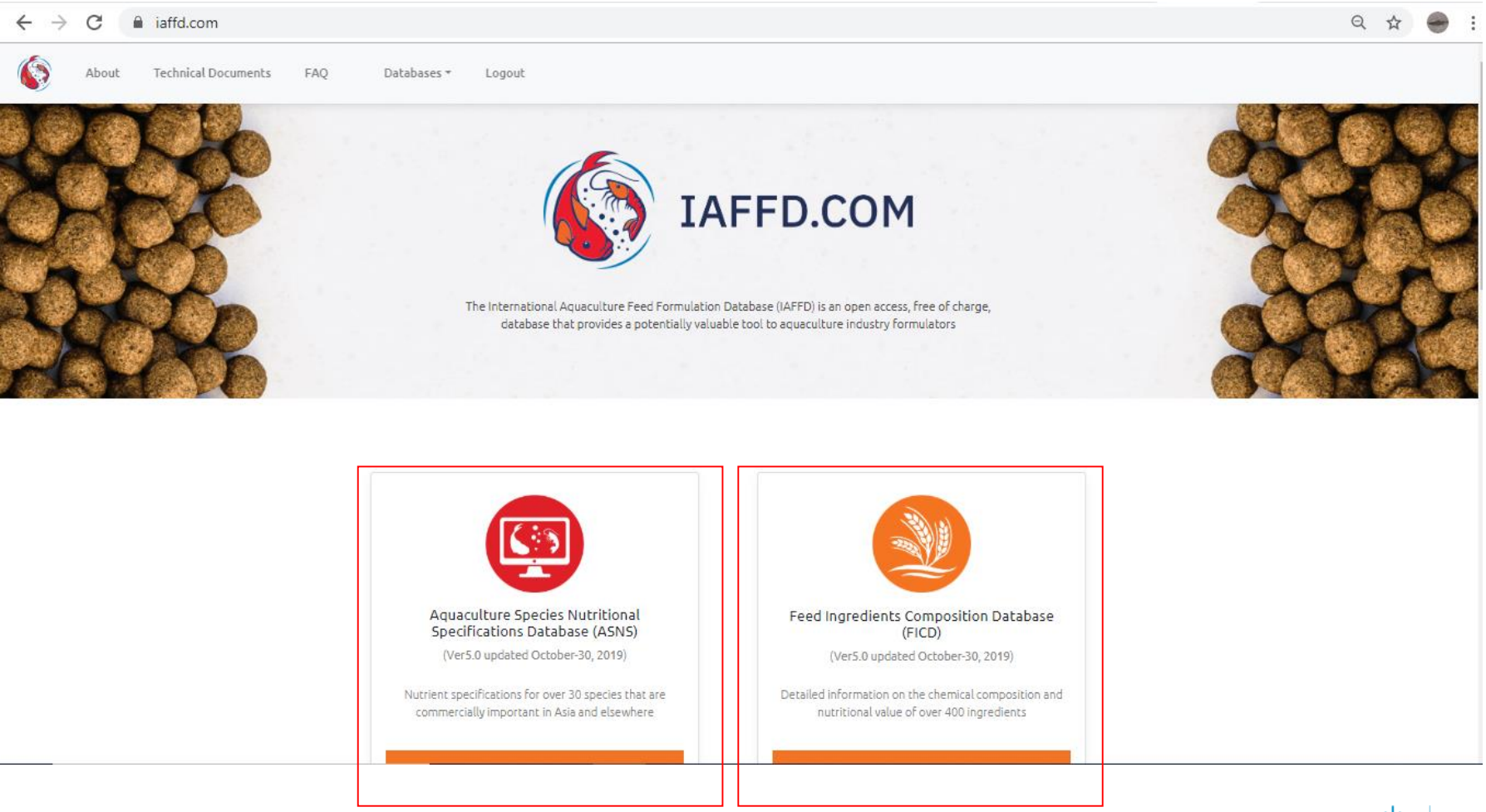
Team Work 1 (3 min)

For each group:

From where do you get the data you use for feed formulation?

4. Databases

Nutrient requirements of fish



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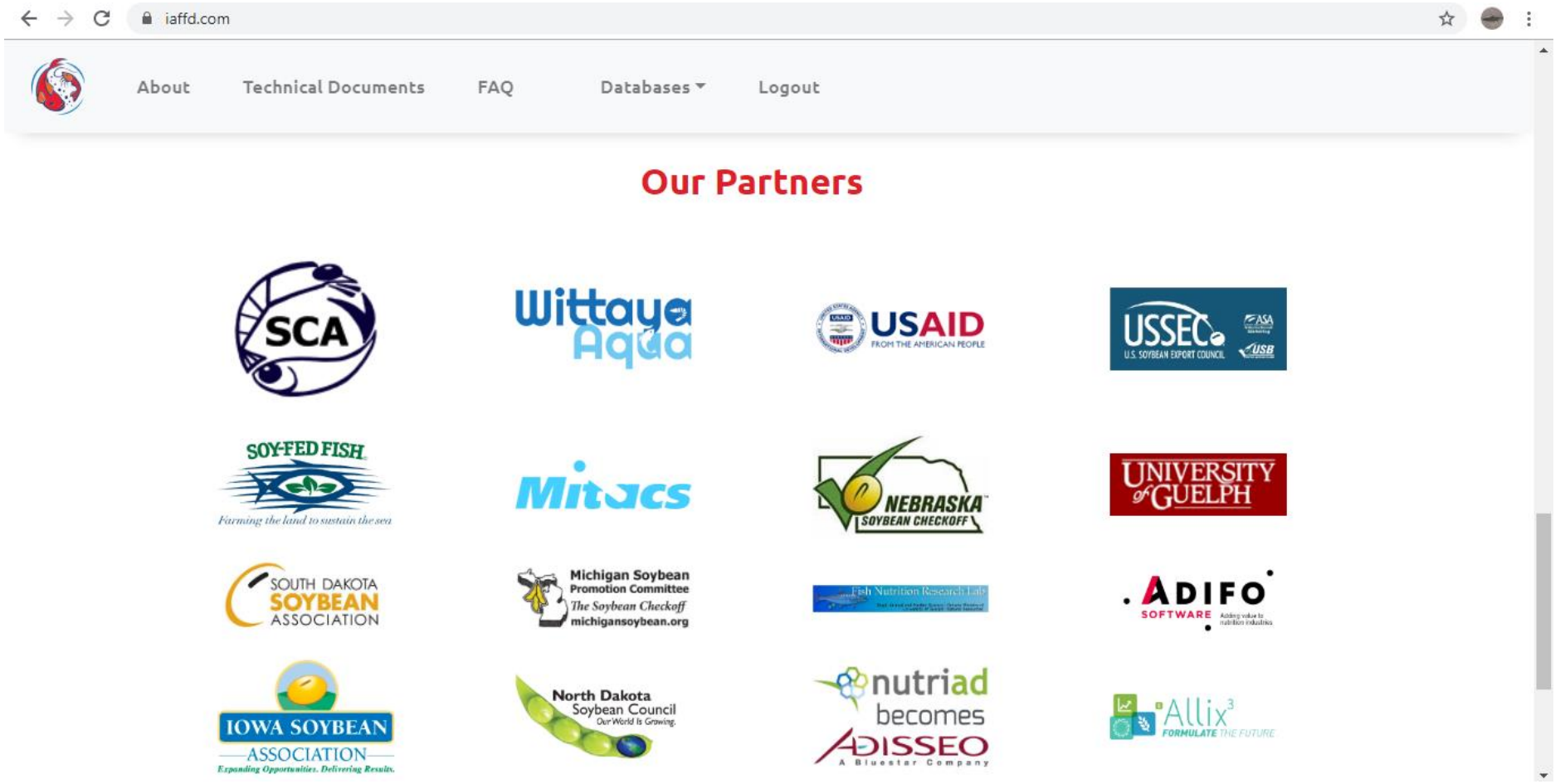
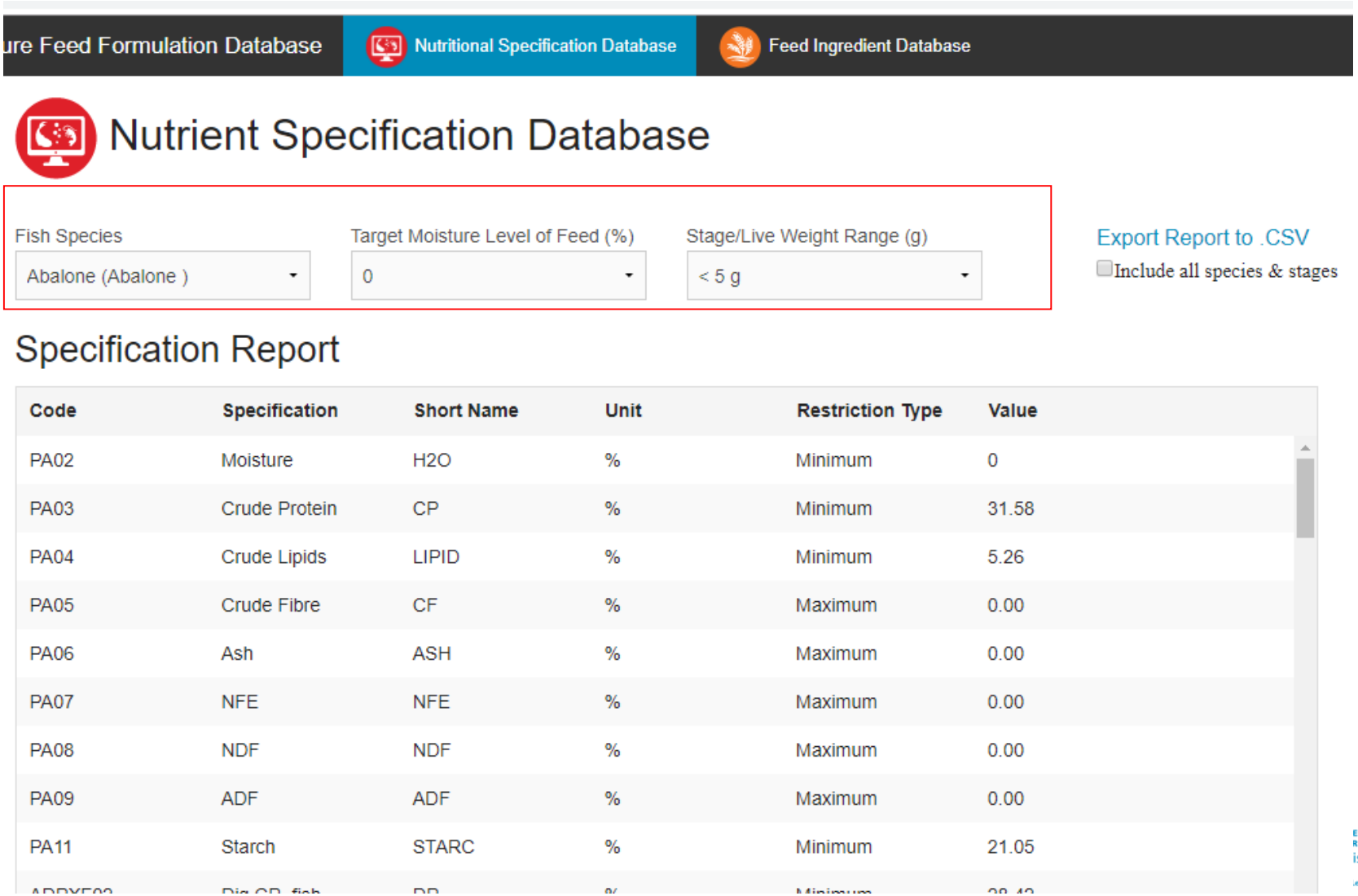
4. Databases

Nutrient requirements of fish (cont'd)



4. Databases

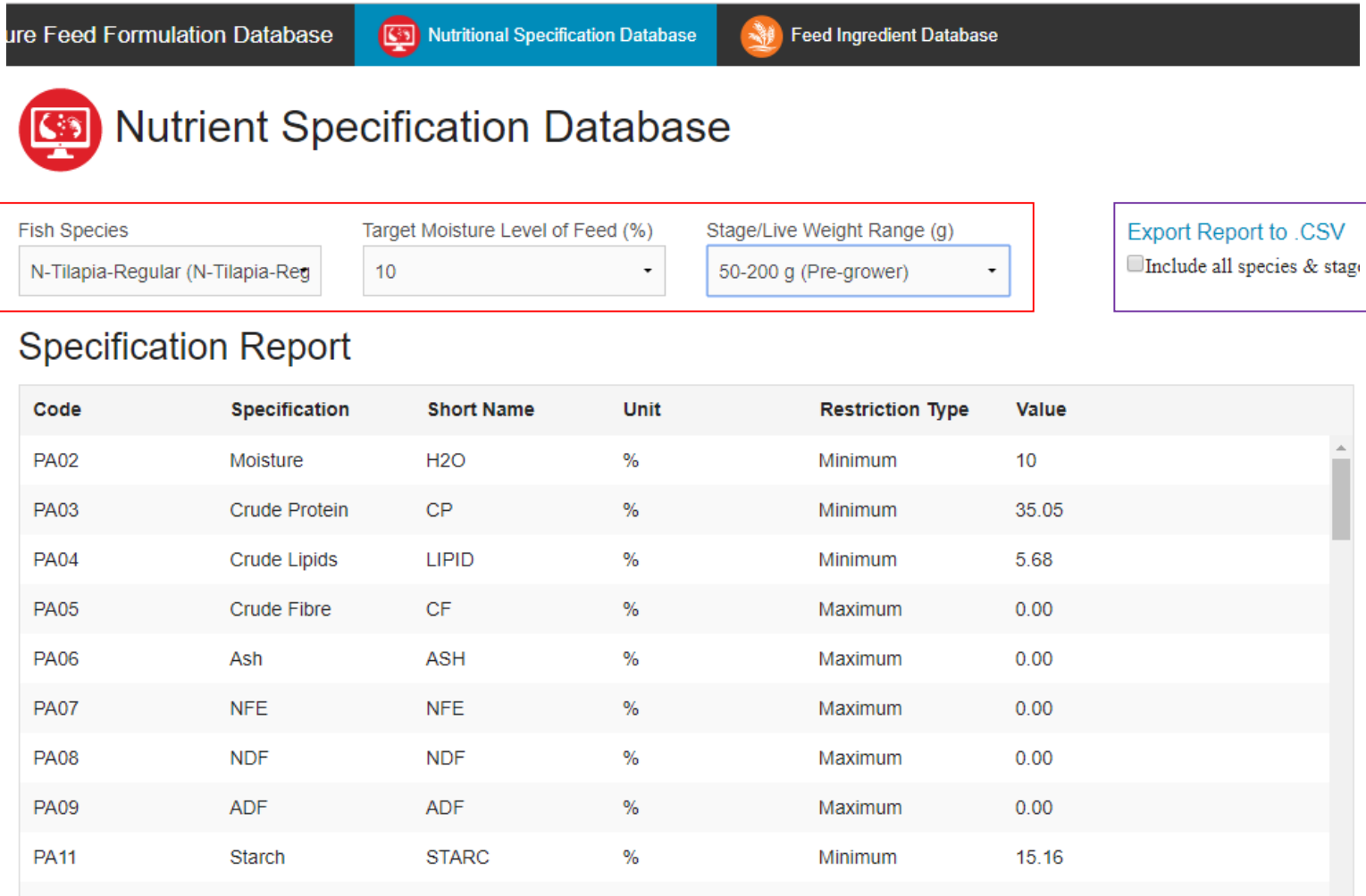
Nutrient requirements of fish (cont'd)



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

4. Databases

Nutrient requirements of fish (cont'd)



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

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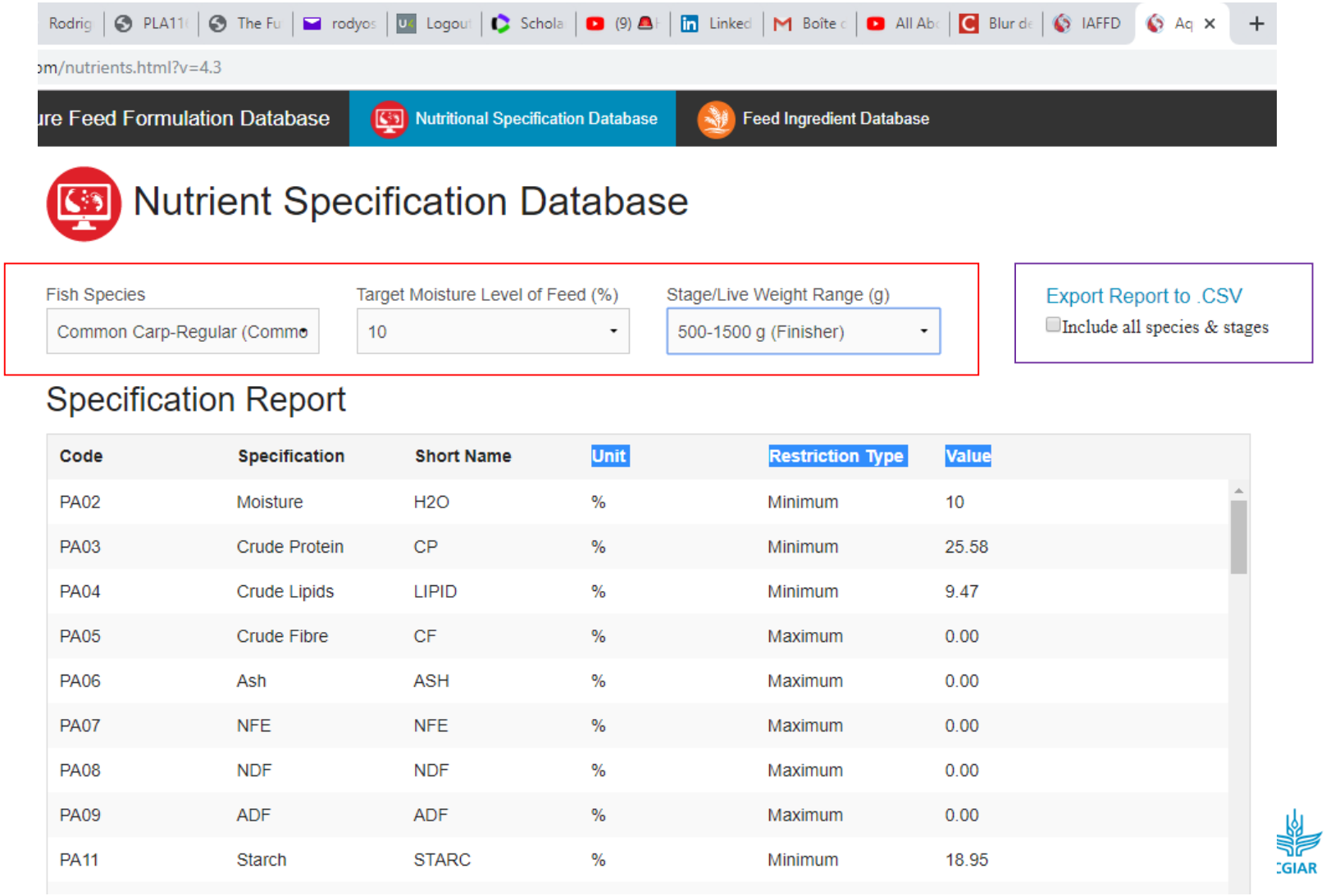
4. Databases

Nutrient requirements of fish (cont'd)



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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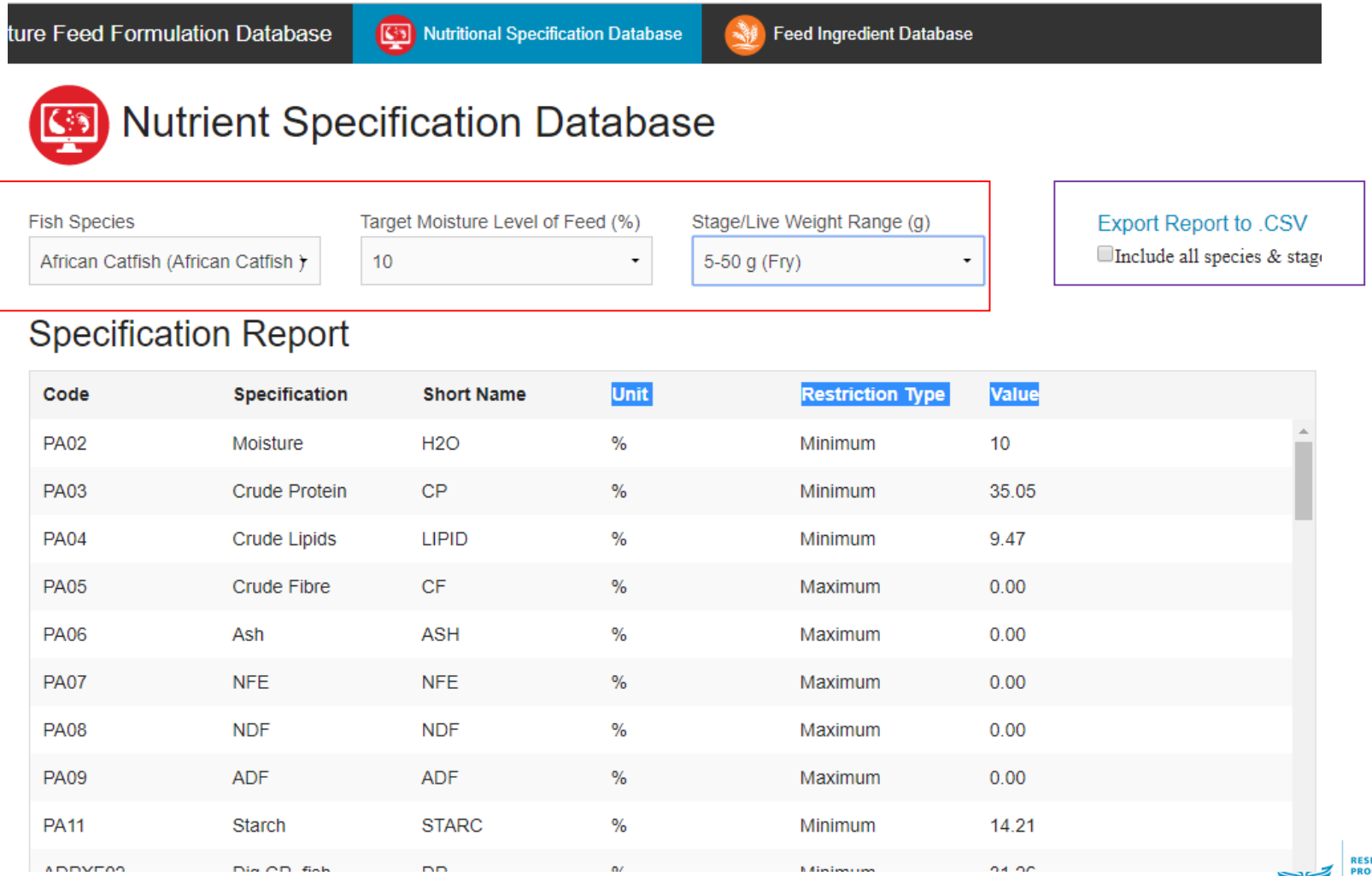
4. Databases

Nutrient requirements of fish (cont'd)



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

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4. Databases

Nutrient requirements of fish (cont'd)

Team Work 2 (15 min)

What are the nutrient requirements of tilapia at different stages?

I. Starter (group 1)
II. Fry (group 2)
III. Pre-grower (group 3)
IV. Grower (group 4)
V. Finisher (group 5)
VI. Broodstock (group 6)

Expected results

1. Crude protein
2. Digestible crude protein (DP)
3. Crude lipid
4. Digestible crude lipid
5. Digestible crude lipid
6. Gross energy
7. Digestible energy
8. DP/DE ratio
9. Lysine
10. Methionine

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4. Databases

Ingredient composition

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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4. Databases

Ingredient composition (cont'd)

Team Work 3 (10 min)

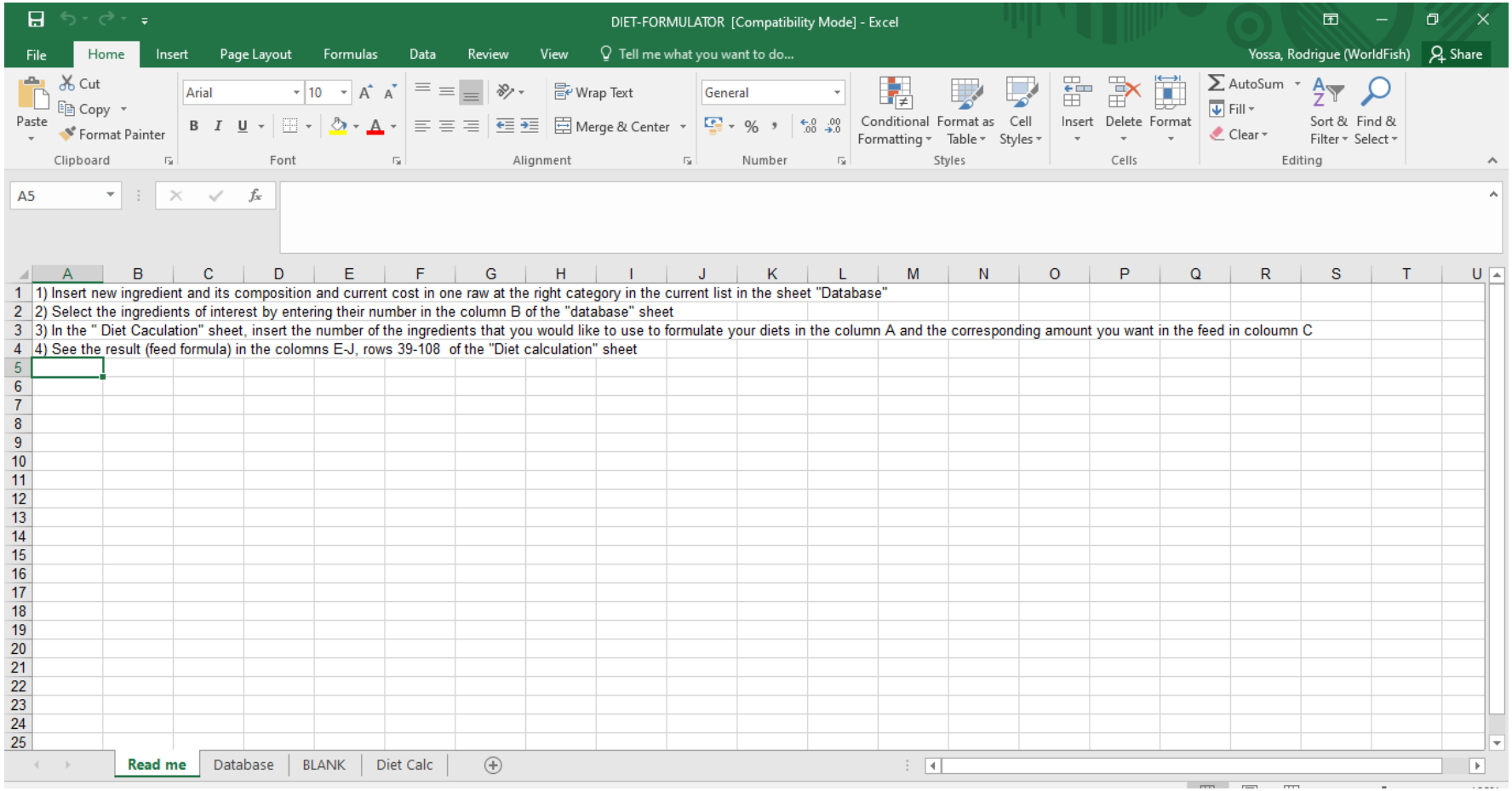
Each group:

Choose an ingredient abundant in your country and provide its nutrient composition

Expected results

1) Crude protein
2) Digestible crude protein (DP)
3) Crude lipid
4) Digestible crude lipid
5) Gross energy
6) Digestible energy
7) Lysine
8) Methionine

5. Fish Feed Formulation



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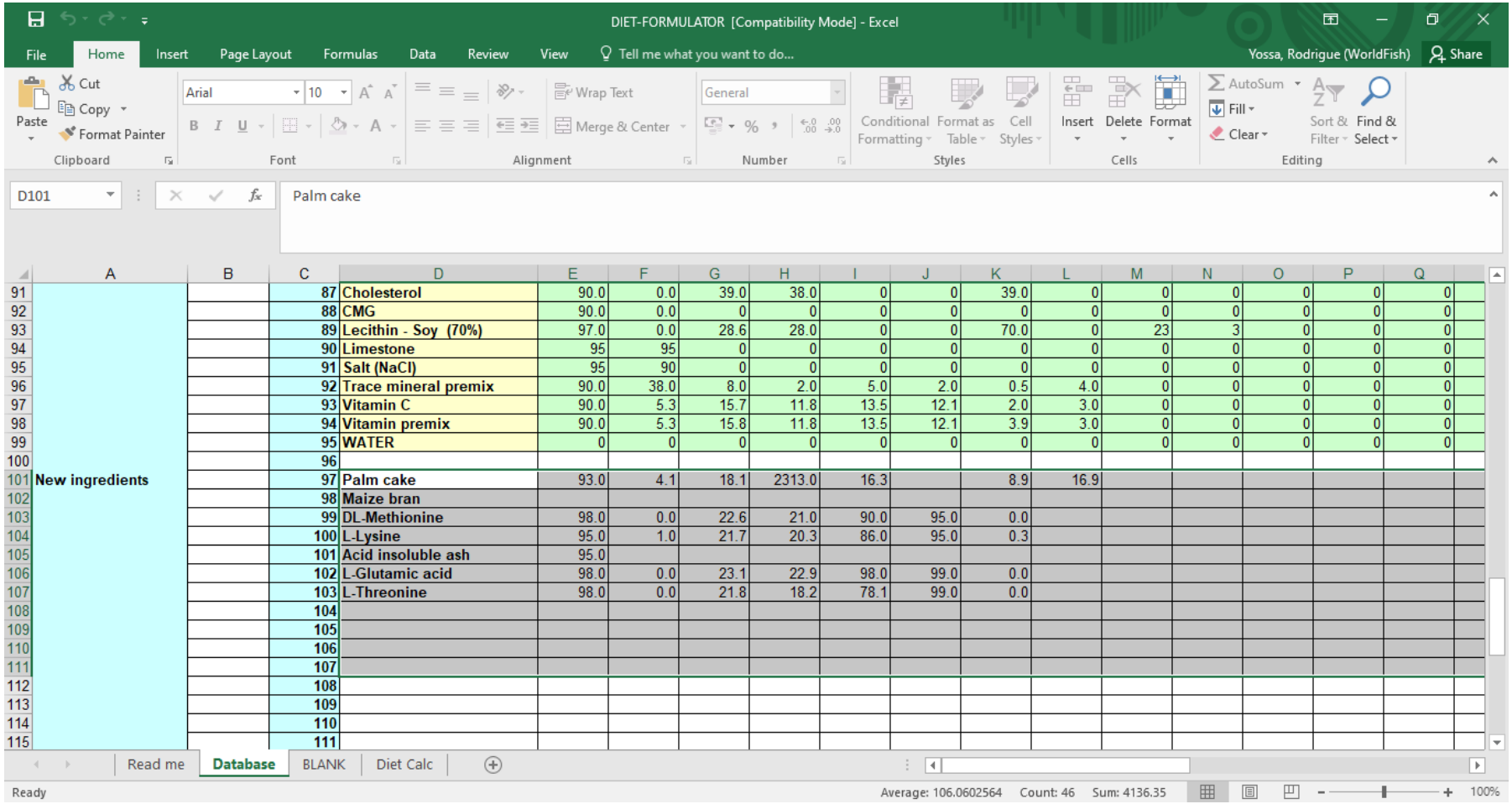
5. Fish Feed Formulation (cont'd)



	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														

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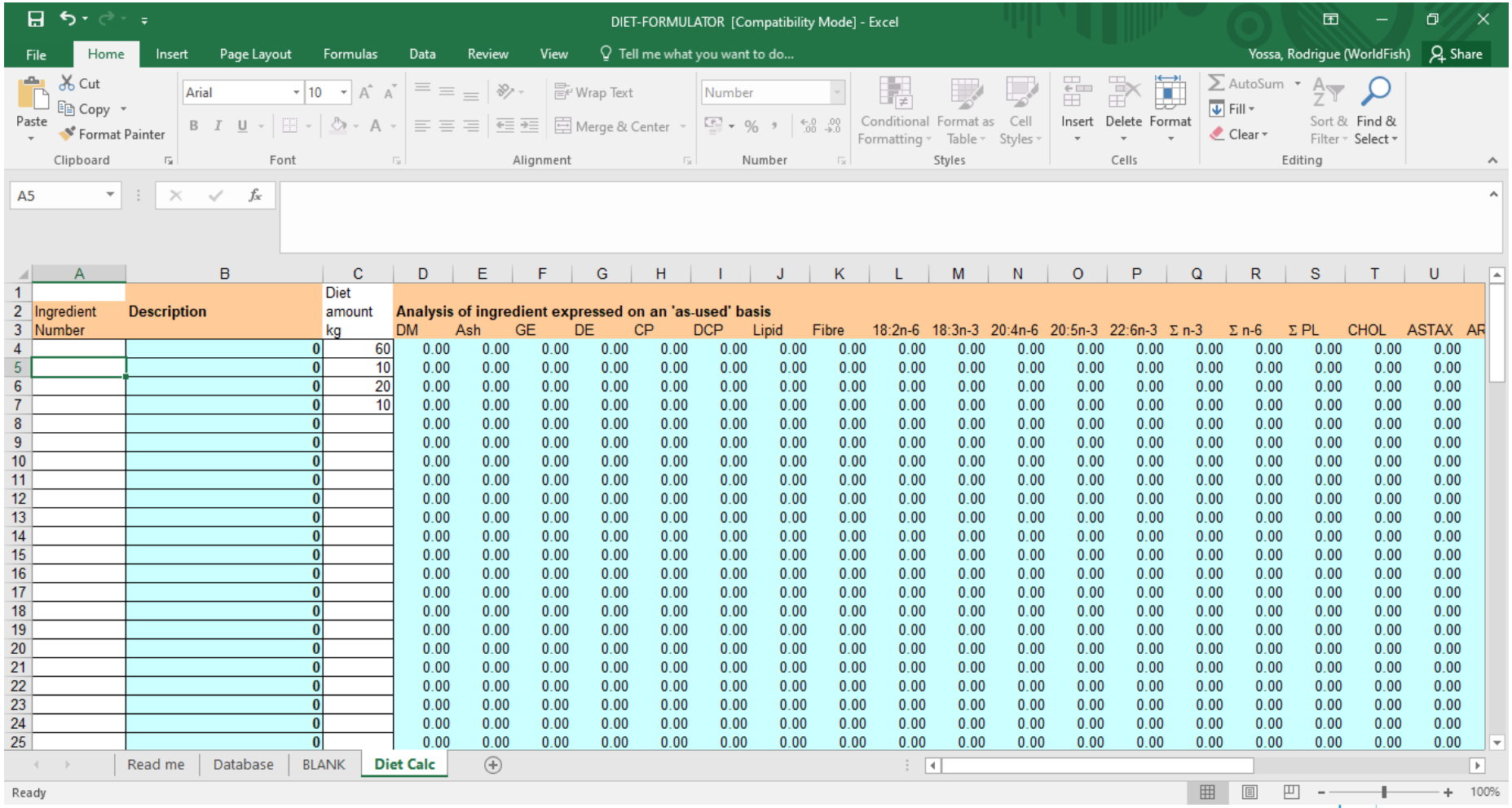
5. Fish Feed Formulation (cont'd)



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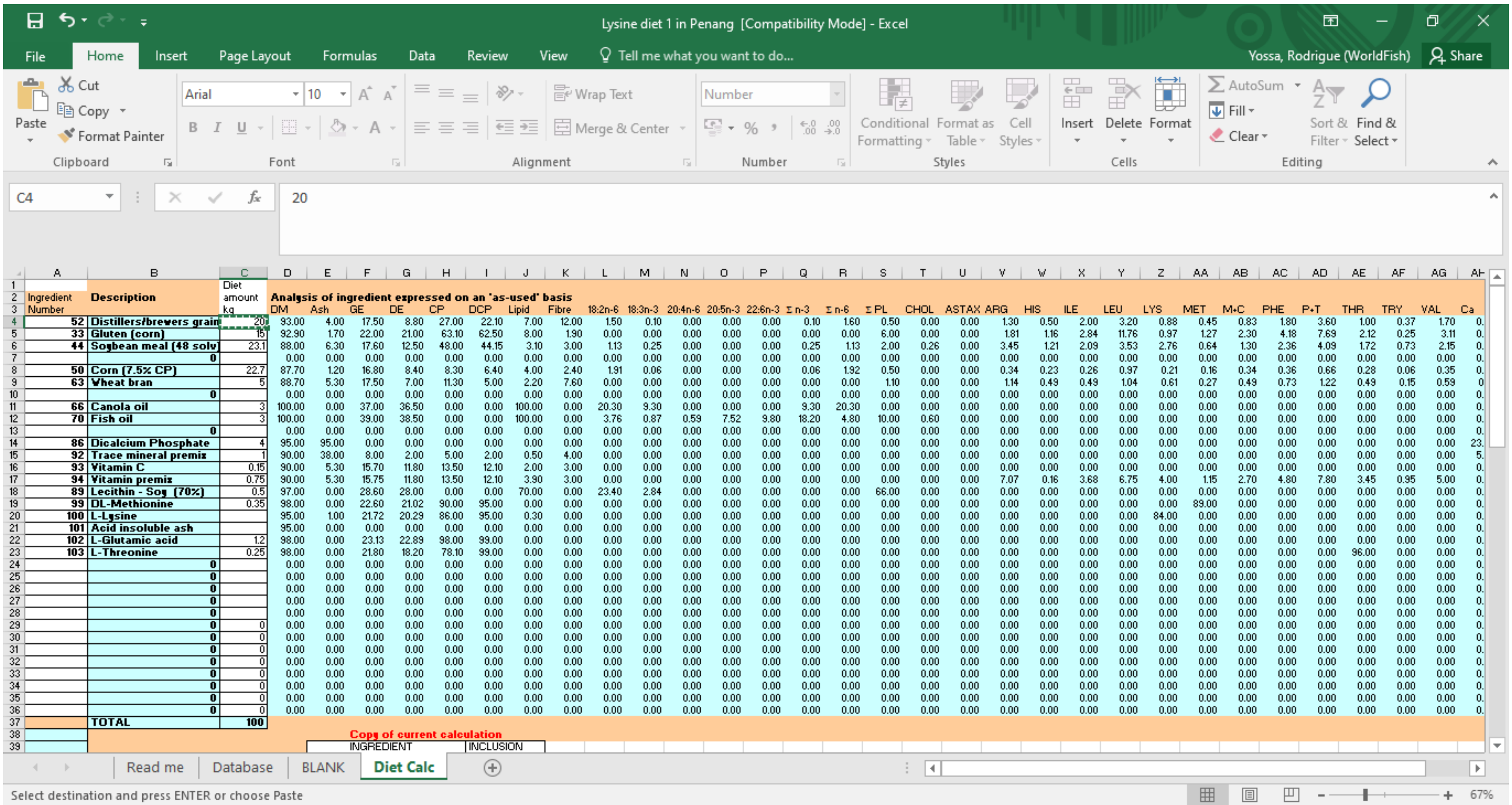
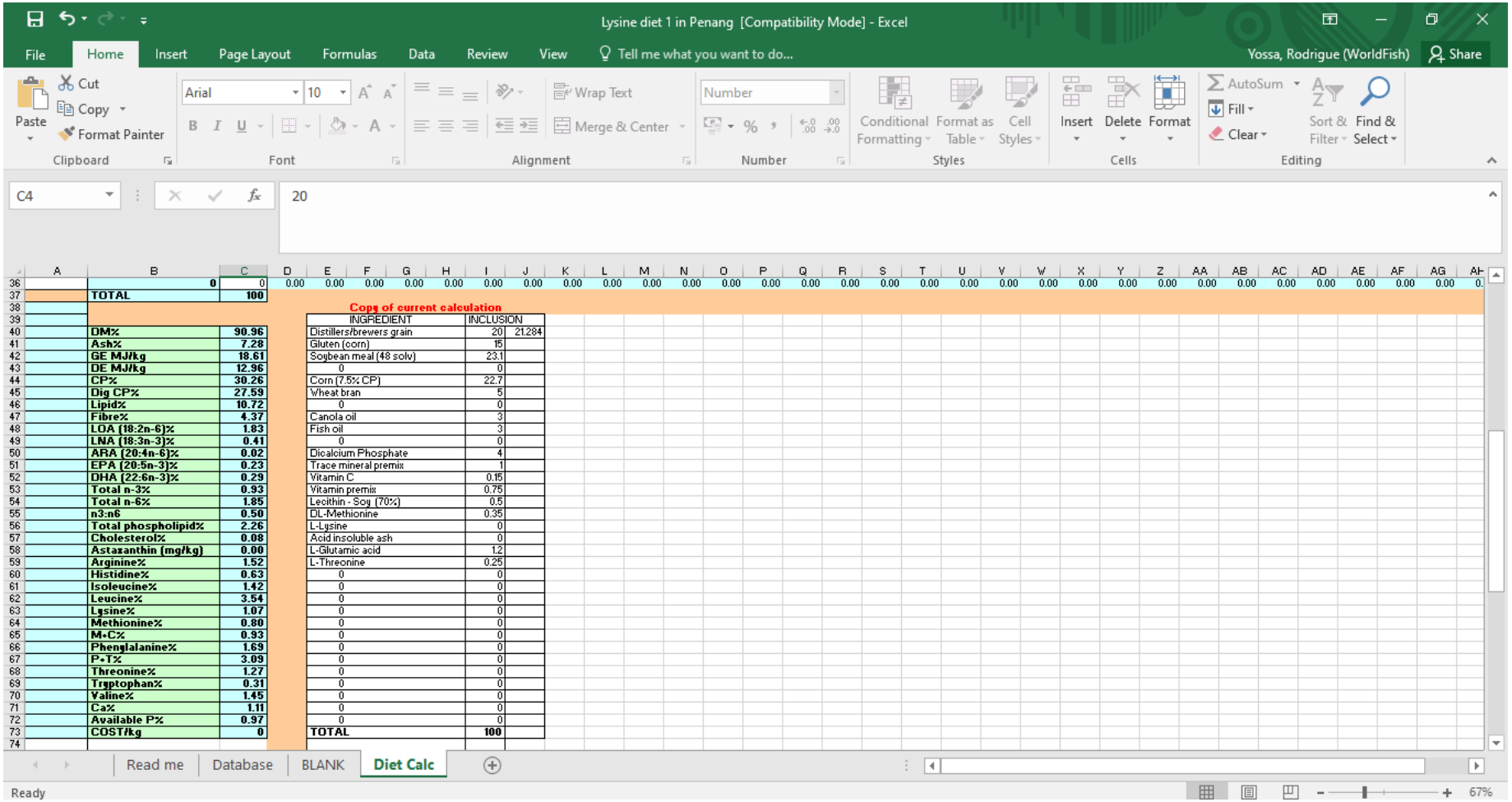
5. Fish Feed Formulation (cont'd)



Row	A: Ingredient Number	B: Description	C: Diet amount kg	D: DM	E: Ash	F: GE	G: DE	H: CP	I: DCP	J: Lipid	K: Fibre	L: 18:2n-6	M: 18:3n-3	N: 20:4n-6	O: 20:5n-3	P: 22:6n-3
1																
2				Analysis of ingredient expressed on an 'as-used' basis												
4	52	Distillers/brewers grain	20	93.00	4.00	17.50	8.80	27.00	22.10	7.00	12.00	1.50	0.10	0.00	0.00	0.00
5	33	Gluten (corn)	15	92.90	1.70	22.00	21.00	63.10	62.50	8.00	1.90	0.00	0.00	0.00	0.00	0.00
6	44	Soybean meal (48 solv)	23.1	88.00	6.30	17.60	12.50	48.00	44.15	3.10	3.00	1.13	0.25	0.00	0.00	0.00
7		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
8	50	Corn (7.5% CP)	22.7	87.70	1.20	16.80	8.40	8.30	6.40	4.00	2.40	1.91	0.06	0.00	0.00	0.00
9	63	Wheat bran	5	88.70	5.30	17.50	7.00	11.30	5.00	2.20	7.60	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
11	66	Canola oil	3	100.00	0.00	37.00	36.50	0.00	0.00	100.00	0.00	20.30	9.30	0.00	0.00	0.00
12	70	Fish oil	3	100.00	0.00	39.00	38.50	0.00	0.00	100.00	0.00	3.76	0.87	0.59	7.52	9.80
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
14	86	Dicalcium Phosphate	4	95.00	95.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	92	Trace mineral premix	1	90.00	38.00	8.00	2.00	5.00	2.00	0.50	4.00	0.00	0.00	0.00	0.00	0.00
16	93	Vitamin C	0.15	90.00	5.30	15.70	11.80	13.50	12.10	2.00	3.00	0.00	0.00	0.00	0.00	0.00
17	94	Vitamin premix	0.75	90.00	5.30	15.75	11.80	13.50	12.10	3.90	3.00	0.00	0.00	0.00	0.00	0.00
18	89	Lecithin - Soy (70%)	0.5	97.00	0.00	28.60	28.00	0.00	0.00	70.00	0.00	23.40	2.84	0.00	0.00	0.00
19	99	DL-Methionine	0.35	98.00	0.00	22.60	21.02	90.00	95.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	100	L-Lysine		95.00	1.00	21.72	20.29	86.00	95.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00
21	101	Acid insoluble ash		95.00	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	102	L-Glutamic acid	1.2	98.00	0.00	23.13	22.89	98.00	99.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	103	L-Threonine	0.25	98.00	0.00	21.80	18.20	78.10	99.00	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
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
26		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
27		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
28		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
29		0	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
30		0	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
31		0	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
32		0	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
33		0	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
34		0	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
35		0	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
36		0	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
37		TOTAL	100													
38						Copy of current calculation										
39						INGREDIENT			INCLUSION							

Row	Q: Σ n-3	R: Σ n-6	S: Σ PL	T: CHOL	U: ASTAX	V: ARG	W: HIS	X: ILE	Y: LEU	Z: LYS	AA: MET	AB: M+C	AC: PHE	AD: P+T	AE: THR	AF: TRY	AG: VAL	AH: Ca
4	0.10	1.60	0.50	0.00	0.00	1.30	0.50	2.00	3.20	0.88	0.45	0.83	1.80	3.60	1.00	0.37	1.70	0.
5	0.00	0.00	6.00	0.00	0.00	1.81	1.16	2.84	11.76	0.97	1.27	2.30	4.18	7.69	2.12	0.25	3.11	0.
6	0.25	1.13	2.00	0.26	0.00	3.45	1.21	2.09	3.53	2.76	0.64	1.30	2.36	4.09	1.72	0.73	2.15	0.
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
8	0.06	1.92	0.50	0.00	0.00	0.34	0.23	0.26	0.97	0.21	0.16	0.34	0.36	0.66	0.28	0.06	0.35	0.
9	0.00	0.00	1.10	0.00	0.00	1.14	0.49	0.49	1.04	0.61	0.27	0.49	0.73	1.22	0.49	0.15	0.59	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.
11	9.30	20.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
12	18.20	4.80	10.00	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.
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
14	0.00	0.00	0.00	0.00	0.00	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.
15	0.00	0.00	0.00	0.00	0.00	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.
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
17	0.00	0.00	0.00	0.00	0.00	7.07	0.16	3.68	6.75	4.00	1.15	2.70	4.80	7.80	3.45	0.95	5.00	0.
18	0.00	0.00	66.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	89.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	84.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00	0.00	0.00	0.
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.

5. Fish Feed Formulation (cont'd)



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5. Fish Feed Formulation (cont'd)

How to formulate tilapia diets

INGREDIENTS	INCLUSION
Fish meal (70% - Danish)	15
Gluten (corn)	8
Soybean meal (48 solv)	20.9
Corn (7.5% CP)	29.8
Wheat bran	16
Tapioca/sago flour	0
Palm oil	1
Fish oil	1.5
Dicalcium Phosphate	2
Trace mineral premix	2
Vitamin C	0.15
Vitamin premix	0.75
Lecithin - Soy (70%)	0.5
DL-Methionine	0.25
L-Lysine	0.15
TOTAL	100

DM%	89.37
Ash%	7.38
GE MJ/kg	18.12
DE MJ/kg	11.62
CP%	31.50
Dig CP%	27.60
Lipid%	7.88
Fibre%	3.21
LOA (18:2n-6)%	1.04
LNA (18:3n-3)%	0.11
ARA (20:4n-6)%	0.04
EPA (20:5n-3)%	0.21
DHA (22:6n-3)%	0.47
Total n-3%	0.78
Total n-6%	1.08
n3:n6	0.73
Total phospholipid%	2.58
Cholesterol%	0.08
Astaxanthin (mg/kg)	0.00
Arginine%	2.13
Histidine%	0.79
Isoleucine%	1.38
Leucine%	3.09
Lysine%	1.94
Methionine%	0.90
M+C%	1.12
Phenylalanine%	1.57
P+T%	2.77
Threonine%	1.29
Tryptophan%	0.35
Valine%	1.53
Ca%	1.33
Available P%	1.10
COST/kg	0

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5. Fish Feed Formulation (cont'd)

Team Work 4 (15 min)

Each group: Formulate a diet for each life stage of tilapia

I. Starter (group 1)
II. Fry (group 2)
III. Pre-grower (group 3)
IV. Grower (group 4)
V. Finisher (group 5)
VI. Broodstock (group 6)

6. Feed Preparation

6. Feed Preparation (cont'd)

6. Feed Preparation (cont'd)

6. Feed Preparation (cont'd)

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6. Feed Preparation (cont'd)

6. Feed Preparation (cont'd)

6. Feed Preparation (cont'd)

6. Feed Preparation (cont'd)

6. Feed Preparation (cont'd)

6. Feed Preparation (cont'd)

6. Feed Preparation (cont'd)

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7. Feeding

7. Feeding
Feeding table

Table 1. Suggested feed size and feeding rate of tank-cultured tilapia

Length (inches)	Estimated weight (grams)	Recommended Feed Size	Range of feeding rate (% biomass/day)
< 1	< 0.5	#00, #0, #1 Crumble	20- 15
1 - 2.5	0.5 - 5	Stage 1	15 - 10
2.5 - 4	5 - 22	Stage 2	10 - 5
4 - 6	22 - 75	Stage 3	5 - 3
6 - 8	75 - 150	Stage 4	3 - 1.5
8 -13	150 - market	Stage 4	3 - 1.5
13+	> market size	Stage 4	1

*Adapted from SRAC Publication 282 (DeLong et al., 2009)

Discussion (Q&A, comments)

Survey

Thank You

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