

LINEAR PROGRAMMING: A USEFUL TOOL FOR FOOD AID

Linear Programming & Protein Quality Tools

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Ready-to-Use Therapeutic Food (RUTF)

RUTF is a fortified lipid-based paste containing peanuts, nonfat dry milk, sugar, oil, and added vitamins and minerals used as food aid for the treatment of severe acute malnutrition (SAM).



Source: www.instagram.com/p/BR8rOCrhZ_y/

Opportunity for Impact

- Create alternative product, maintains therapeutic benefit, no degradations of nutrition all at a cost savings
- Utilize the Linear Programming Tool to formulate based on target population and nutrient requirements

Linear Programming Tool (LP Tool)

- Input variables – available ingredients, nutrient information, and price
- Constraint variables – ingredient proportion and nutrient requirements
- Optimize target attribute (ingredient inclusion, cost, nutrient profile, etc.)
- Controlling the inputs and constraints allow for versatile utilization of the tool

Impact of LP Tool

- Utilize LP Tool to produce cost savings – reduced unit costs translate to larger population treated
- Incorporate local ingredients to produce local product for local consumption
 - Economic benefit to the community
 - Increased acceptability by target population
 - Increased acceptability of governing agencies
 - Formulate to maintain nutrient requirements

Inputs: Ingredient Exclusions & Nutrient Profile

	A	B	C	D	E	F	G	H
1		Populate/Refresh			Ingredient Exclusions			
2	ID	Ingredients	USDA (5 digit) # or other number	Exclude Ingredient?	Exclude the ingredient because it is a duplicate?	Exclude the ingredient because it is unstable/has a short shelf life?	Exclude the ingredient due to insufficient nutrient information?	Exclude the ingredient for another reason?
244	1241	Milk, dry, nonfat, regular, without added vitamin A and vitamin D	1091	NO	NO	NO	NO	NO
245	1242	Milk, dry, whole, without added vitamin D	1212	NO	NO	NO	NO	NO

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1		Populate/Refresh			Nutrient Profiles (per 100g)											
2	ID	Ingredients	Nutritional Information Substituted Source (USDA (5 digit) # or other number)	Energ_Kcal	Energ_calc_kcal	Protein_(g)	Dairy_Protein_(g)	Lipid_Tot_(g)	Carbohydrt_(g)	Calcium_(mg)	Phosphorus_(mg)	Bioavail_Phosphorus_(mg)	Sodium_(mg)	n-3 Fatty Acids	n-6 Fatty Acids	
64	1241	Milk, dry, nonfat, regular, without added vitamin A and vitamin D	1091	362	359.5	36.16	36.16	0.77	51.98	1257	968	968	535	0.011	0.019	
65	1242	Milk, dry, whole, without added vitamin D	1212	496	499.4	26.32	26.32	26.71	38.42	912	776	776	371	0.204	0.46	

Constraints: Ingredients & Nutrition

	A	B	C	D
1		Populate/Refresh		
2				
3				
4	Notes: For unconstrained ingredients, leave the min and max as is. After entering desired constraints, go to the Nutrient Constraints page to populate the optimization.			
5	ID	Ingredient Constraint	Enter minimum weight (g) per serving	Enter maximum weight (g) per serving
22	1241	Milk, dry, nonfat, regular, without added vitamin A and vitamin D	0	96
23	1242	Milk, dry, whole, without added vitamin D	0	96

	B	C
	constraints	Populate Optimization Sheet

	Nutrient Constraints	Instruction	Target Value per 100g
5			
6	Food Ingredient Weight	Enter total weight from food ingredients (g)	96
7	Non-optimized Ingredient Weight*	Enter total weight of non-optimized ingredients (g)	4
8	Energy	Enter minimum total energy (kcal)	520
9		Enter maximum total energy (kcal)	550
10	Total Protein	Enter min target proportion of energy from protein	0.1
11		Enter max target proportion of energy from protein	0.12
12		Enter min target proportion of product weight from protein	0.13
13		Enter max target proportion of product weight from protein	0.16
14	Lipid	Enter min target proportion of energy from lipids	0.45
15		Enter max target proportion of energy from lipids	0.6
16		Enter min target proportion of product weight from lipids	0.268
17		Enter max target proportion of product weight from lipids	0.363
18	n-6 Fatty Acids	Enter min target proportion of energy from n-6 fatty acids	0.06
19		Enter max target proportion of energy from n-6 fatty acids	1
20	n-3 Fatty Acids	Enter min target proportion of energy from n-3 fatty acids	0.025
21		Enter max target proportion of energy from n-3 fatty acids	0.03
22	Carbohydrate	Enter min target proportion of product weight from carbohydrates	0.41
23		Enter max target proportion of product weight from carbohydrates	0.58
24	Sodium (mg)	Enter max sodium content (mg)	290
31	Dairy Protein	Enter minimum proportion of protein from dairy sources	0.5

Selected Formula

	A	B	C	D	E	F	G	H	I	J	K
1	Populate/Refresh Optimization Results										
2	ID	Ingredients List	USDA (5 digit) # or other number	Price (\$/kg)	Min Weight (g)	Max Weight (g)	Locally Available	Weight (g)	Total Cost (\$)	Water_(g)	Energ_Kcal
3	1192	Legume, Soy flour, defatted	16117	0.8279374	0	96	11.606	11.606	0.0096	0.8415	38.301
4	1241	Milk, dry, nonfat, regular, without added vitamin A and vitamin D	1091	2.3238113	0	96	12.126	12.126	0.0282	0.3832	43.896
5	1245	Milk, sweet whey powder	1115	1.4438113	0	96	16.359	16.359	0.0236	0.5219	57.747
6	1290	Oil, Soybean	4044	1.119131	0	96	20.335	20.335	0.0228	0	179.77
7	1323	Sugar, brown	19334	1.1703002	0	96	14	14	0.0164	0.1876	53.2
8	1529	Oil, soybean, high oleic, Plenish	Plenish, DuPont	1.3580459	0	96	13.344	13.344	0.0181	0	117.96
9	1534	Cereal/Grain, barley flour	20004	0.7195704	0	96	8.2295	8.2295	0.0059	0.7769	29.132
10											
11	TOTALS						96	96	0.1246	2.711	520

Optimization: Goal

	A	B	C	D
1	Populate/Refresh			
2	Populate/Refresh			
3	Populate/Refresh			
4	Notes: For unconstrained ingredients, leave the min and max as is. After entering desired constraints, go to the Nutrient Constraints page to populate the optimization.			
5	ID	Ingredient Constraint	Enter minimum weight (g) per serving	Enter maximum weight (g) per serving
22	1241	Milk, dry, nonfat, regular, without added vitamin A and vitamin D	0	96
24	1245	Milk, sweet whey powder	0	0
25	1263	Oil, Canola, Rapeseed	0	96
33	1323	Sugar, brown	0	0
34	1324	Sugar, white	0	96
46	1529	Oil, soybean, high oleic, Plenish	0	0

	D	E	F	G	H	I	J	K			
	Price (\$/kg)	Min Weight (g)	Max Weight (g)	Locally Available	Weight (g)	Total Cost (\$)	Water_(g)	Energ_Kcal			
2	ID	Ingredients List		USDA (5 digit) # or other number							
3	1241	Milk, dry, nonfat, regular, without added vitamin A and vitamin D	1091	2.3238113	0	96	5.8173	5.8173	0.0135	0.1838	21.059
4	1242	Milk, dry, whole, without added vitamin D	1212	2.3238113	0	96	26.217	26.217	0.0609	0.6476	130.04
5	1290	Oil, Soybean	4044	1.119131	0	96	24.315	24.315	0.0272	0	214.94
6	1324	Sugar, white	19335	1.3919542	0	96	14	14	0.0195	0.0028	54.18
7	1538	Cereal/Grain, Oat flour	20038	0.8966911	0	96	25.651	25.651	0.023	2.1085	99.783
8											
9	TOTALS						96	96	0.1441	2.942	520

Optimization: Result

	A	B	H	I	K
2	ID	Ingredients List	Weight (g)	Total Cost (\$)	Energ_Kcal
3	1192	Legume, Soy flour, defatted	11.61	0.01	38.3
4	1241	Milk, dry, nonfat, regular, without added vitamin A and vitamin D	12.13	0.028	43.9
5	1245	Milk, sweet whey powder	16.36	0.024	57.75
6	1290	Oil, Soybean	20.34	0.023	179.8
7	1323	Sugar, brown	14	0.016	53.2
8	1529	Oil, soybean, high oleic, Plenish	13.34	0.018	118
9	1534	Cereal/Grain, barley flour	8.229	0.006	29.13
10					
11	TOTALS		96	0.125	520

	B	H	I	K	
2	ID	Ingredients List	Weight (g)	Total Cost (\$)	Energ_Kcal
3	1241	Milk, dry, nonfat, regular, without added vitamin A and vitamin D	5.817	0.014	21.06
4	1242	Milk, dry, whole, without added vitamin D	26.22	0.061	130
5	1290	Oil, Soybean	24.31	0.027	214.9
6	1324	Sugar, white	14	0.019	54.18
7	1538	Cereal/Grain, Oat flour	25.65	0.023	99.78
8					
9	TOTALS		96	0.144	520

Linear Programming Tool Summary

- Create new and alternative formulas which deliver same nutrient requirements as standard products
- Ability to add ingredients and customize nutrient profiles, including new or locally-available commodities
- Allows for diverse application per target product or application
- Default formula will always be at maximum cost-savings
 - purpose of optimization to produce practical, acceptable formula


An excel spreadsheet calculator for protein quality: one step further in optimization

- A growing demand for cheaper, more locally available, and even superior food aid products
 - A need for a quick and easy way to ensure alternative or optimized food aid products have are meeting the recipients protein (amino acid) needs
- The calculator is based off the methodology and examples in the FAO Food and Nutrition Paper no. 92: *Dietary protein quality and evaluation in human nutrition*
- The tool allows for 1-5 protein sources to be entered
- One of the 4 different AA patterns based on population interest can also be used to assess the protein quality of a product for multiple populations

Digestible Indispensable Amino Acid Score(DIAAS) Calculator

	A	B	C	D	E	F	G	H	I	J	K
			Wheat			chickpea			soybeans		
	CVB Feed Tables (2007)	Standard Ileal digestible AA (g/kg)	Amino Acids Content: g/kg	Amino Acids Content: mean (g/16g N)	Standard Ileal digestible AA (g/kg)	Amino Acids Content: (g/kg)	Amino Acids Content: mean (g/100g protein)	Standard Ileal digestible AA (g/kg)	Amino Acids Content: g/kg	Amino Acids Content: mean (g/16g N)	
1	Histidine	5.508	6.48	12.2	2.7	2.9	22	10.5	11.7	27	
2	Isoleucine	11.2014	12.6	26.7	4.3	4.8	37	17.6	20	46	
3	Leucine	18.8256	21.2	42.3	8.6	9.6	73	29	33.5	77	
4	Lysine	15.3813	17.7	34.6	4.6	5.4	41	23.9	27	62	
5	Threonine	8.5143	10.1	21.1	3.7	4.6	35	14.5	17	39	
6	Valine	13.4075	15.5	33.3	6	6.8	52	18.1	20.9	48	
7	Cysteine	4.20553	5.11	11	3.2	3.9	30	5.4	6.5	15	
8	Methionine	5.6978	6.2	15.6	2	2.2	17	5.5	6.1	14	
9	Sulfur A.A.'s	9.90333	11.31	26.6	5.2	6.1	47	10.9	12.6	29	
10	Tyrosine	7.57264	8.48	18.5	3.9	4.3	33	14.2	16.1	37	
11	Tryptophan	3.0883	3.47	8.37	1.3	1.6	12	4.9	5.7	13	
12	Phenylalanine	11.7876	13.2	15.6	5.8	6.3	48	20	22.6	52	
13	Aromatic A.A.'s	22.44854	25.15	42.47	11	12.2	93	39.1	44.4	102	
14	Arginine	14.352	16	30.1	8.2	8.5	65	30.5	32.6	75	
15	Alanine	10.9824	12.8	26.4	5.1	6.3	48	16.4	19.1	44	
16	Aspartic Acid	19.552	23.5	46.7	8.8	10.7	8.2	44	50.5	116	
17	Glutarric Acid	38.5636	42.1	54.3	22.5	25.2	192	69.8	77.4	178	
18	Glycine	8.2416	10.1	15.9	5.3	6.4	4.9	16.1	18.7	43	
19	Proline	13.1846	14.3	18.1	6.4	6.9	53	20.4	22.2	51	
20	Serine	9.588	12	26.3	5.4	6.3	48	19.7	22.2	51	
21	Total AA g/kg	471				122.7			435		
22	Weight (g)		3.77			20.6			33.63		
23	Protein Content in Mix		1.77567			2.52762			14.62905		Total (g) 18.932

Amino Acid Scoring Patterns for 4 different physiological states

AA Scoring Pattern (mg/g protein)	His	Ile	Leu	Lys	SAA	AAA	Thr	Trp	Val
1-3 y healthy	18	31	63	52	25	46	27	7	41
1-3 y living in developing world	21	36	72	60	29	53	31	8	47
 1-3 y malnourished	24	35	74	67	32	64	37	10	48
1-3 y infected	28	45	84	78	35	81	44	12	58

Amino Acid Reference Pattern

Amino Acid	soybeans			True Ileal IAA Digestibility			True Ileal Content (g/kg)	
	Amino Acids Content: g/kg	Amino Acids Content: mean (g/16g N)			True Ileal IAA Digestibility			
					Wheat	Pea		Milk
10.5	11.7	27						
17.6	20	46	His:	0.85	0.93	0.90	18.41	
29	33.5	77	Ile:	0.89	0.90	0.88	42.15	
23.9	27	62	Leu:	0.89	0.90	0.87	66.70	
14.5	17	39	Lys:	0.87	0.85	0.89	53.39	
18.1	20.9	48	Thr:	0.84	0.80	0.85	31.58	
5.4	6.5	15	Val:	0.87	0.88	0.87	51.15	
5.5	6.1	14	Cys:	0.82	0.82	0.83	16.08	
10.9	12.6	29	Met:	0.92	0.91	0.90	25.46	
14.2	16.1	37	SAA:	0.88	0.85	0.87	41.36	
4.9	5.7	13	Tyr:	0.89	0.91	0.88	29.33	
20	22.6	52	Trp:	0.89	0.81	0.86	13.23	
39.1	44.4	102	Phe:	0.89	0.92	0.88	24.74	
30.5	32.6	75	AAA:	0.89	0.90	0.88	67.31	
16.4	19.1	44						
44	50.5	116						
59.8	77.4	178						
16.1	18.7	43						
20.4	22.2	51						
19.7	22.2	51						
435								

W	X	Y
A.A Reference Pattern for malnourished child (1-3 years)		
His:	24	
Ile:	35	
Leu:	74	
Lys:	67	
Thr:	37	
Val:	48	
Cys:	-	
Met:	-	
SAA:	32	
Tyr:	-	
Trp:	10	
Phe:	-	
AAA:	64	

The DIAAS score is....

The screenshot shows an Excel spreadsheet with the following data:

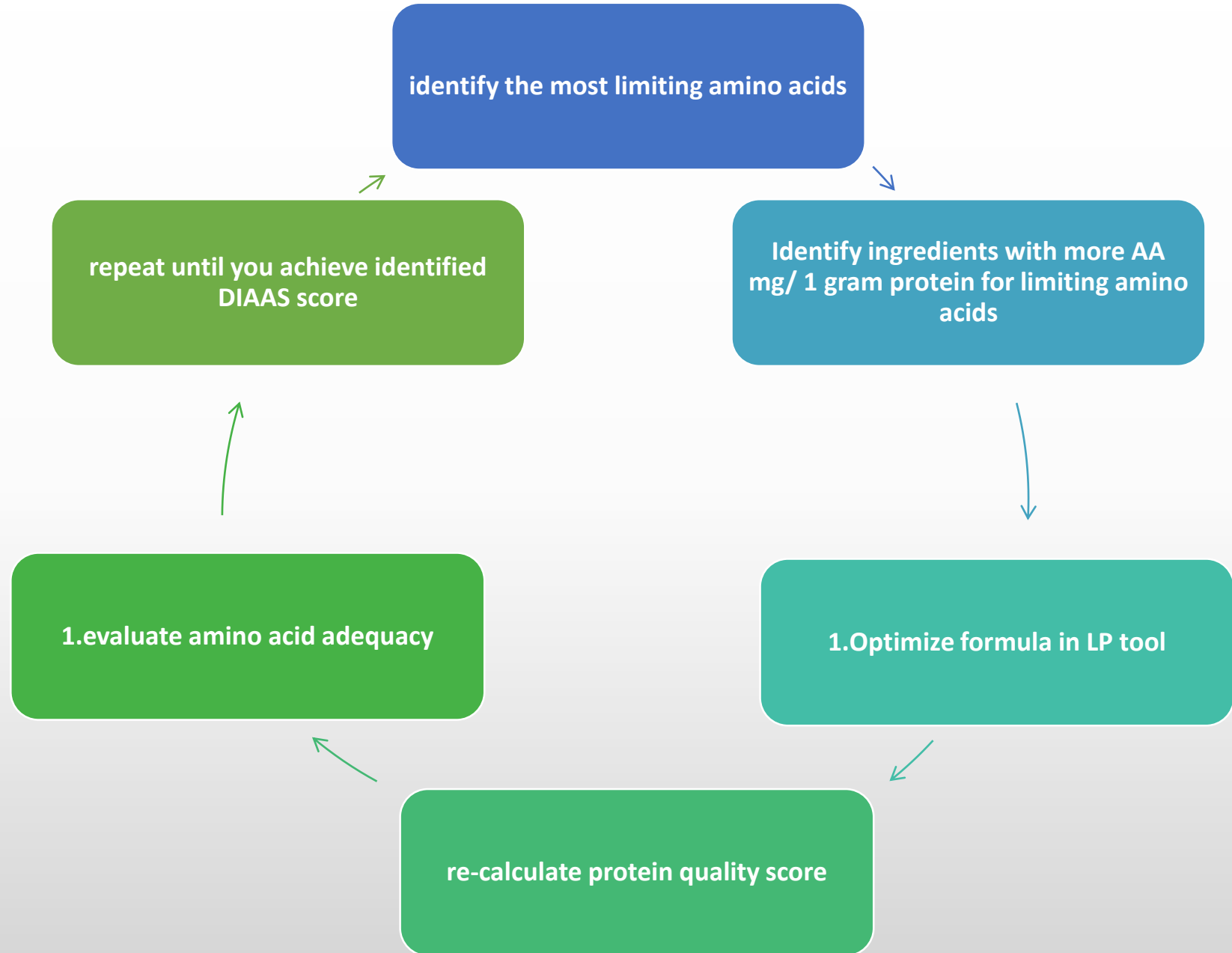
	Wheat	chickpea	soybeans						
CVB Feed Tables (2007)	Standard Ileal digestible AA (g/kg)	Amino Acids Content: g/kg	Amino Acids Content: mean (g/16g N)	Standard Ileal digestible AA (g/kg)	Amino Acids Content: (g/kg)	Amino Acids Content: mean (g/100g protein)	Standard Ileal digestible AA (g/kg)	Amino Acids Content: g/kg	Amino Acids Content: mean (g/16g N)
Histidine	5.508	26						11.7	27
Isoleucine	11.2014	27						20	46
Leucine	18.8256	27	Weight (g)			3.77		33.5	77
Lysine	15.3813	28						27	62
Threonine	8.5143	28						17	39
Valine	13.4075	29	Protein Content in Mixture			1.77567		20.9	48
Cysteine	4.20553	30						6.5	15
Methionine	5.6978	30						6.1	14
Sulfur A.A.'s	9.90333	31						12.6	29
Tyrosine	7.57264	31	DIAAS			74.4625875		16.1	37
Tryptophan	3.0883	32						5.7	13
Phenylalanine	11.7876	33						22.6	52
Aromatic AAs		34						44.4	102
Arginine	2.7922	35						32.6	75
Alanine	10.9824	36						19.1	44
Aspartic Acid	19.552	37						50.5	116
Glutamic Acid	38.5636	38						77.4	178
Glycine	8.2416	39						18.7	43
Proline	13.1846							22.2	51
Serine	9.588							22.2	51
Total AA g/kg	471							435	
Weight (g)								33.63	
Protein Content in Mixture								14.62905	Total (g) 18.932
DIAAS	79.19037081								

Evaluating Adequacy

soybeans		True ileal IAA Digestibility			
Real AA	Amino Acids Content: g/kg	Amino Acids Content: mean (g/16g N)	Wheat	Pea	Milk
10.5	11.7	27	His: 0.85	0.93	0.9
17.6	20	46	Ile: 0.89	0.90	0.8
29	26			0.90	0.8
23.9	27	Weight (g)		0.85	0.8
14.5	28			0.80	0.8
18.1	29	Protein Content in Mixture		0.88	0.8
5.4	30			0.82	0.8
5.5	31			0.91	0.9
10.9	32	DIAAS		0.85	0.8
14.2	33			0.91	0.8
4.9	34			0.81	0.8
20	35			0.92	0.8
39.1	36			0.90	0.8
30.5	37				
16.4	38				
44	39				
59.8					
16.1					
20.4					
19.7					

U	V	W	X	Y	Z	AA
	Amino Acids: mg/g protein		A.A Reference Pattern for malnourished child (1-3 years)		Digestible IAA Reference Ratio	
	22.4303738	His: 24		His: 0.9345989		
	37.9304329	Ile: 35		Ile: 1.0837267		
	63.7596135	Leu: 74		Leu: 0.8616164		
	49.8899335	Lys: 67		Lys: 0.7446259		
	31.130511	Thr: 37		Thr: 0.8413652		
	40.9479731	Val: 48		Val: 0.8530828		
	13.764487	Cys: -		Cys: -		
	13.1616965	Met: -		Met: -		
	26.9186071	SAA: 32		SAA: 0.8412065		
	30.76138	Tyr: -		Tyr: -		
	10.6356554	Trp: 10		Trp: 1.0635655		
	42.76431	Phe: -		Phe: -		
	84.1577964	AAA: 64		AAA: 1.3149656		

Protein Optimization Summary





Thank you!

Feel free to contact us with questions:

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