Practical Feed Formulation

"Understanding the Basics"

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SOY EXCELLENCE CENTER
A USSOY program

Things to know:

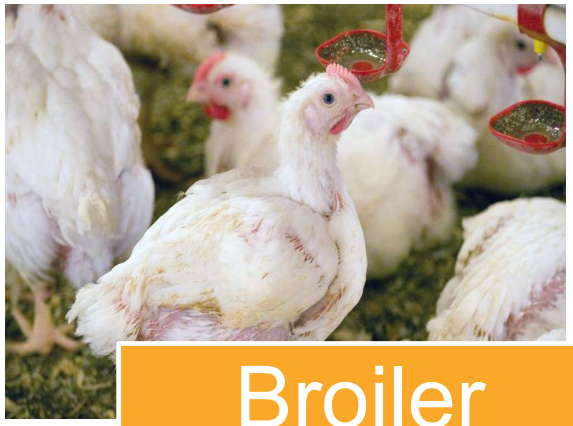
- Animal
- Nutrient requirements/ diet specifications
- Raw materials available
- Raw material prices
- Other considerations
- Formulation tool

What is FEED FORMULATION?

Feed formulation is the process of matching the **nutrient requirements** of a class of **animal** with the nutrient contents of the **available ingredients** (raw materials) in an **economic** manner.

ANIMAL AND NUTRIENT REQUIREMENTS

Each animal has different nutrient requirements

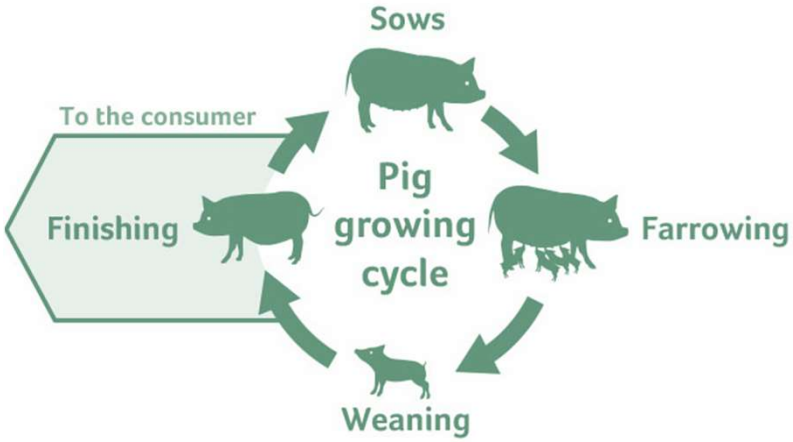


Broiler

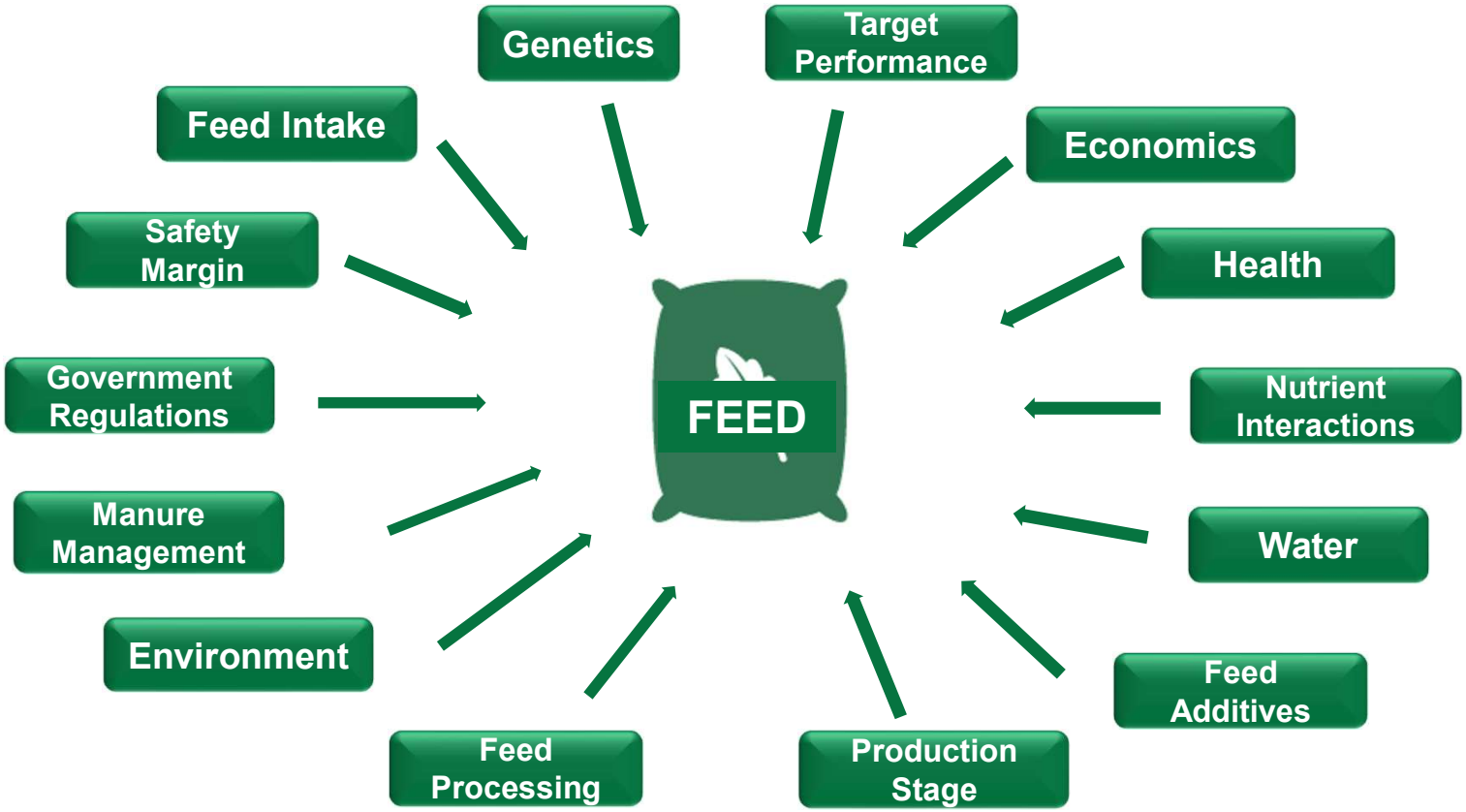
Layer

Pigs

Each production stage also has different nutrient requirements



Different factors should be considered in establishing nutrient requirements and diet specifications



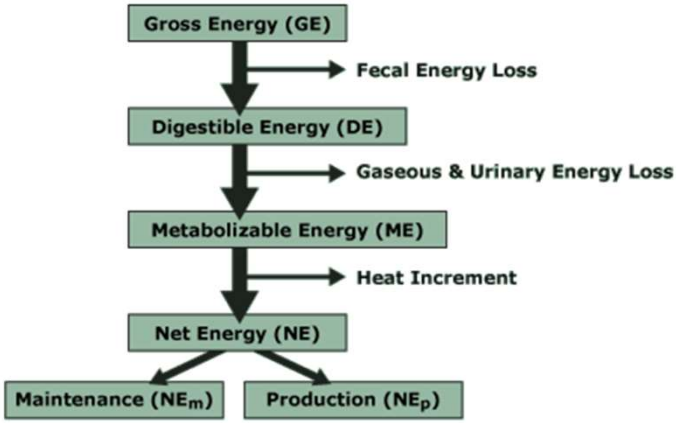
What are the nutrients?

Nutrients – compounds in food essential to life and health which provides energy, building blocks for repair and growth, and substances necessary to regulate chemical processes

- **Carbohydrates** – compounds composed of C, H, O and come in simple forms such as sugars and complex forms such as starches and fiber
- **Lipids (fat)** – chemically defined as substances insoluble in water and soluble in alcohol, ether and chloroform. Includes fatty acids, neutral fats, waxes and steroids
- **Protein** – large molecules composed of one or more chains of **amino acids** and are essential components of muscles, skin, bones and the body as whole
- **Vitamins** – complex organic compounds that are needed in small amounts for normal growth and metabolism. Classified as either fat-soluble vitamins (Vitamin A, D, E, K) or water-soluble vitamins (Vitamin C and B-complex vitamins)
- **Minerals** – inorganic substances that must be ingested and absorbed in adequate amounts to satisfy a wide variety of essential metabolic and/or structural functions in the body. Categorized according to amount required in the diet (macrominerals and trace minerals)
- **Water** – an essential nutrient because it is required in amounts that exceed the body's ability to produce it

Choose an energy system that can better predict animal performance

Energy Partitioning



DE vs ME vs NE

Performance of growing-finishing pigs according to energy system and diet characteristics[a,b]

Energy system	DE	ME	NE
Trial 1: Added fat (%)			
0	***100***	***100***	***100***
2	100	100	100
4	99	99	100
6	98	98	100
Trial 2: crude protein content (30-100 kg)			
Normal	***100***	***100***	***100***
Low	96	97	100
Trial 3: crude protein content (90-120 kg)			
Normal	***100***	***100***	***100***
Low	97	98	100

[a] Energy requirements (or energy cost of BW gain) for similar daily BW gain and composition of BW gain; values are expressed relative to the energy requirement (or energy cost of BW gain) in the control treatment (considered as 100; values in bold characters); from Noblet (2006), Wu et al. (2007) and unpublished data.

The ability of NE system to predict performance of pigs is greater than DE and ME system

[b]Noblet (2013)

Select a more accurate measure of amino acid digestibility

Total AA vs Digestible AA

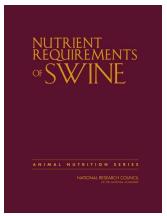
TABLE 4. Broiler performance as affected by diet composition

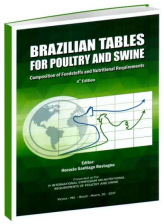
	TREATMENT			SEM
	HD	LD	LD + AA	
GROWTH DATA, 1–21 DAYS OF AGE[A]				
Weight gain (g)	697[a]	673[b]	706[a]	7.7
Feed intake (g)	1026[a]	1030[a]	1060[a]	13.5
Feed/gain	1.473[a]	1.532[b]	1.502[ab]	0.016
GROWTH DATA, 1–42 DAYS OF AGE[A]				
Weight gain (g)	2333[a]	2241[b]	2330[a]	18.5
Feed intake (g)	4165[a]	4140[a]	4190[a]	29.8
Feed/gain	1.786[a]	1.848[b]	1.799[a]	0.011

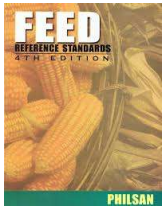
Rostagno et al. (1995)

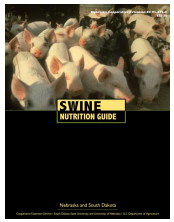
How to set nutrient specifications?

- **Check nutrient recommendations**
  - From organizations and institutions

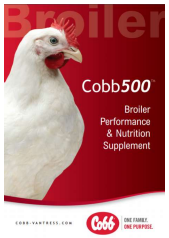


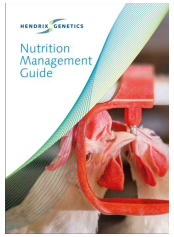






  - From breeding/private companies





- **Use prediction models**
  - ME (pig) = 106 × $BW^{0.75}$
  - Lys requirement of nursery pigs = 19g SID Lys/kg weight gain

Nutrient Recommendation for Cobb 500 Broiler Chicken

Nutrient Recommendations

		Starter	Grower	Finisher 1	Finisher 2*
FEEDING AMOUNT/bird		180 g 0.40 lb	700 g 1.54 lb	1350 g 3.0 lb	
FEEDING PERIOD days		0 - 8	9 - 18	19 - 28	> 29
FEED STRUCTURE		Crumble	Crumble / Pellet	Pellet	Pellet
Crude Protein	%	21-22	19-20	18-19	17-18
Metabolizable energy (AMEn')	MJ/kg Kcal/kg Kcal/lb	12.45 2,975 1,349	12.66 3,025 1,372	12.97 3,100 1,406	13.18 3,150 1,429
Digestible Lysine	%	1.22	1.12	1.02	0.97
Digestible Methionine	%	0.46	0.45	0.42	0.40
Digestible Met + Cys	%	0.91	0.85	0.80	0.76
Digestible Tryptophan	%	0.20	0.18	0.18	0.17
Digestible Threonine	%	0.83	0.73	0.66	0.63
Digestible Arginine	%	1.28	1.18	1.07	1.02
Digestible Valine	%	0.89	0.85	0.76	0.73
Digestible Isoleucine	%	0.77	0.72	0.67	0.64
Calcium	%	0.90	0.84	0.76	0.76
Available Phosphorus	%	0.45	0.42	0.38	0.38
Sodium	%	0.16-0.23	0.16-0.23	0.16-0.23	0.16-0.23
Chloride	%	0.16-0.30	0.16-0.30	0.16-0.30	0.16-0.30
Potassium	%	0.60-0.95	0.60-0.95	0.60-0.95	0.60-0.95
Linoleic Acid	%	1.00	1.00	1.00	1.00

† Energy system is based on the Apparent Metabolizable Energy corrected by Nitrogen (AMEn).

* Should withdrawal feed be required use same finisher specification.

Supplementary levels of vitamins and trace elements (per tonne)

		Starter	Grower	Finisher 1 & 2
Vitamin A	(MIU)	10-13	10	10
Vitamin D3	(MIU)	5	5	5
Vitamin E	(KIU)	80	50	50
Vitamin K	(g)	3	3	3
Vitamin B1 (thiamine)	(g)	3	2	2
Vitamin B2 (riboflavin)	(g)	9	8	6
Vitamin B6 (pyridoxine)	(g)	4	3	3
Vitamin B12	(mg)	20	15	15
Biotin (Maize Diets)	(mg)	150	120	120
Biotin (Wheat Diets)	(mg)	200	180	180
Choline*	(g)	500	400	350
Folic Acid	(g)	2	2	1.5
Nicotinic Acid	(g)	60	50	50
Pantothenic Acid	(g)	15	12	10
Manganese	(g)	100	100	100
Zinc	(g)	100	100	100
Iron	(g)	40	40	40
Copper	(g)	15	15	15
Iodine	(g)	1	1	1
Selenium	(g)	0.35	0.35	0.35

* Preferably Choline is added directly into the mixer rather than via a premix because of its hygroscopic nature.

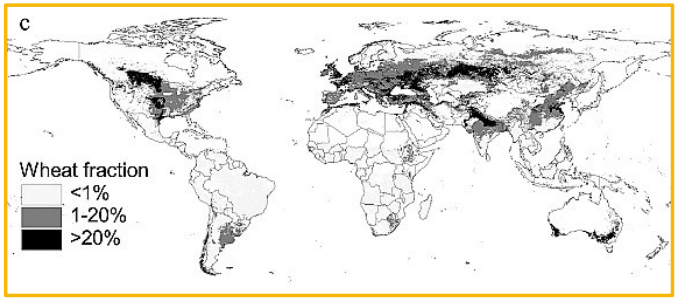
Vitamin and trace mineral levels may vary depending on the source and supplier. The numbers above refers to e.g. usage of inorganic minerals and a vitamin D3 source.

MIU = million international units
KIU = thousand international units
g = grams
mg = milligrams

Supplementary levels of trace elements should always be reviewed to ensure total levels do not exceed those set in local legislation (e.g. EU 1334/2003).

RAW MATERIALS (RM)

Survey raw materials available locally



Global Biogeochemical Cycles (2004)

Commonly Used Raw Materials

Cereals

Corn

Wheat

Broken rice

Plant and Animal Protein Sources

Soybean meal

Fish meal

Oils

Coconut oil

Soybean oil

Palm oil

Commonly Used Raw Materials

Co-products

Rice bran

Wheat pollard

Copra meal

Supplements

Limestone

Phosphates

Salt

Sodium bicarbonate

Amino acids

Choline chloride

Vitamin premix

Mineral premix

Additives

Enzymes

Toxin binders

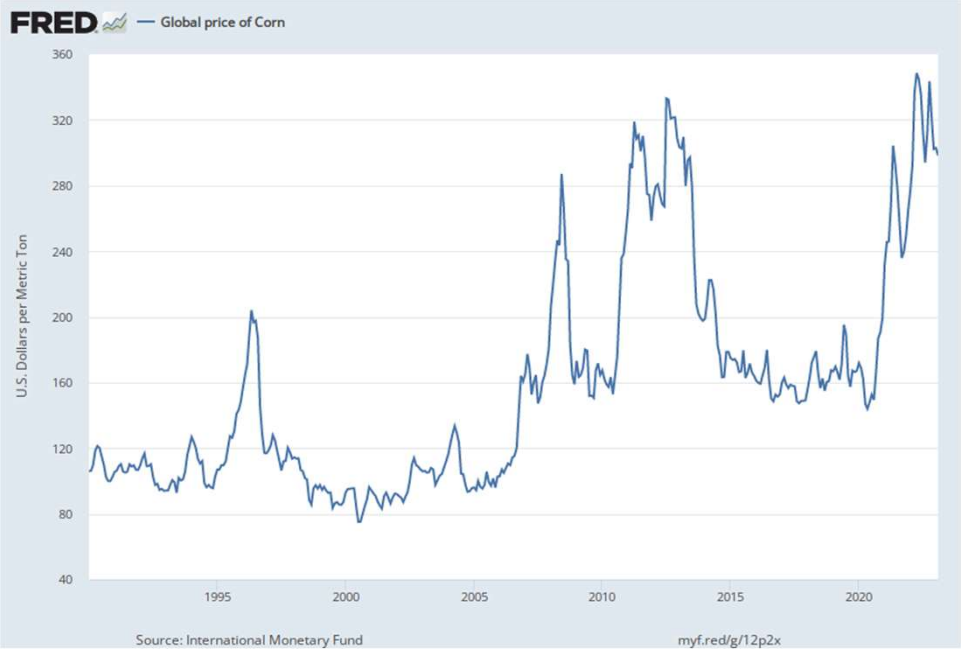
Acidifiers

Flavor and sweeteners

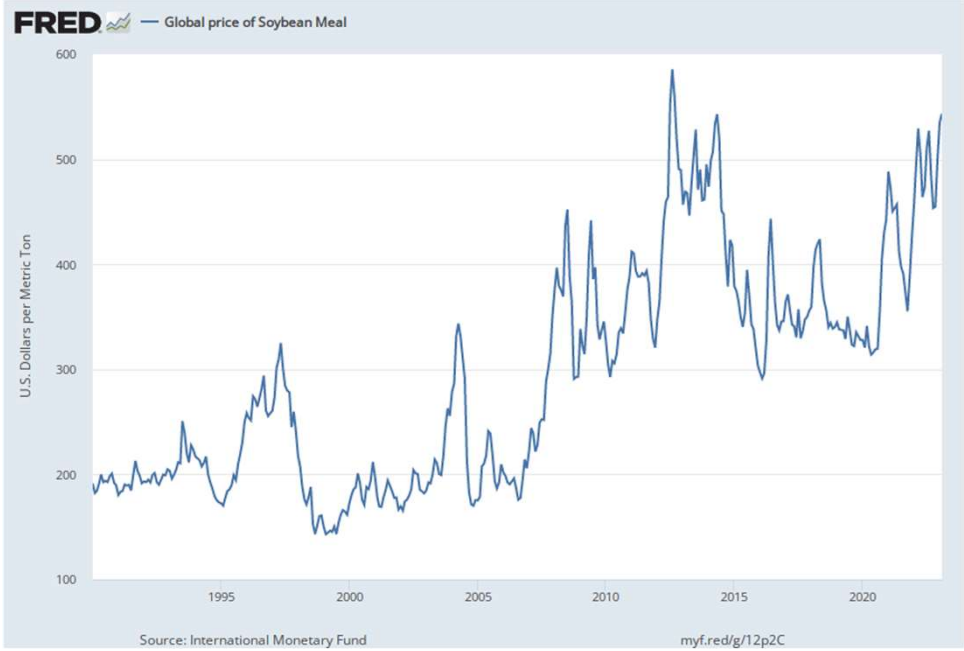
Performance enhancers

Mold inhibitor

Check updated RM prices



Corn



Soybean meal

Analyze RM Quality

Physical

Chemical

- Proximate analysis
- Fiber (NDF, ADF)
- Amino acid content
- Minerals (Ca, P, Na)
- Mycotoxin contamination

Know energy and nutrient composition of RM

Corn, Grain 7.86% CP (Mean)

Main Components (%)						
	Mean	n	SD		Mean	n	SD
Dry Matter	88.9	245	2.35	Organic Matter (OM)	87.8	-	-
Crude Protein	7.86	402	0.94	Coef. Dig. OM Swine	86.0	-	-
Starch	63.4	148	2.51	Digestible OM Swine	75.5	-	-
Crude Fiber (CF)	1.73	151	0.19	Non Dig. OM Swine	12.3	-	-
Coef. Dig. CF Swine	41.4	1	-	Ether Extract (EE)	3.81	157	0.29
NDF	13.8	3	1.20	Coef. Dig. EE Poultry	92.0	1	-
Coef. Dig. NDF Swine	66.4	1	-	Digestible EE Poultry	3.50	-	-
ADF	3.16	3	0.29	Coef. Dig. EE Swine	90.0	1	-
Coef. Dig. ADF Swine	68.2	1	-	Digestible EE Swine	3.43	-	-
Nitrogen Free Ext (NFE)	74.4	-	-	Linoleic Acid	1.91	1	-
Coef. Dig. NFE Poultry	89.0	-	-	Linolenic Acid	0.03	1	-
Digestible NFE Poultry	66.2	-	-				
Non Dig. NFE + CF Poultry	9.91	-	-				

Energy (kcal/kg)							
	Mean	n	SD		Mean	n	SD
Gross Energy	3901	6	35	***Swine***			
Poultry				Digestible Energy	3442	7	27
Metabolizable Energy	3364	14	100	Metabolizable Energy	3360	4	30
Std. Metab. Energy	3481	1	-	Net Energy	2668	-	-
Net Energy	2713	-	-	***Sows***			
Hens				Digestible Energy	3565	-	-
Std. Metab. Energy	3394	-	-	Metabolizable Energy	3452	-	-
Net Energy	2742	-	-	Net Energy	2735	-	-

Minerals							
	Mean	n	SD		Mean	N	SD
Ash, %	1.11	18	0.23	***Trace Minerals, mg/kg***			
				Manganese (Mn)	5.30	1	-
Macro Minerals (%)				Iron (Fe)	23.5	1	-
Potassium (K)	0.32	4	0.04	Copper (Cu)	2.10	1	-
Sodium (Na)	0.01	4	0.01	Zinc (Zn)	21.5	1	-
Chlorine (Cl)	0.09	3	0.04	Selenium (Se)	0.07	1	-
Sulfur (S)	0.08	2	0.04	Iodine (I)	-	-	-
Magnesium (Mg)	0.11	4	0.02				
Total Calcium (Ca)	0.02	7	0.01				
Total Phosphorus (P)	0.24	9	0.05				
Phytate P	0.18	70	0.03				
Available P (Pav)	0.03	-	-				
Coef. Dig. P Poultry	40.8	1	-				
Std. Dig. P Poultry	0.10	-	-				
Coef. Dig. P Swine	44.0	1	-				
Std. Dig. P Swine	0.11	-	-				

Pav = Non Phytate P (Total P – Phytate P).

Corn, Grain 7.86% CP (Mean)

Amino Acid Content and Digestibility						
	Total	% CP	Poultry		Swine	
			SID[1]	Coef.	SID[1]	Coef.
Crude Protein, %	7.86	100	6.83	87.0	6.50	82.7
Lysine, %	0.23	2.93	0.19	82.5	0.18	78.9
Methionine, %	0.16	2.04	0.15	93.4	0.14	86.4
Met + Cys, %	0.33	4.20	0.29	88.4	0.29	88.1
Threonine, %	0.31	3.94	0.29	93.9	0.24	78.8
Tryptophan, %	0.06	0.76	0.06	95.2	0.05	75.7
Arginine, %	0.37	4.71	0.34	91.0	0.33	89.6
Gly + Ser, %	0.72	9.16	0.57	78.9	-	-
Valine, %	0.36	4.58	0.31	87.3	0.32	88.5
Isoleucine, %	0.26	3.31	0.24	94.0	0.23	89.9
Leucine, %	0.95	12.1	0.91	95.4	0.85	89.5
Histidine, %	0.24	3.05	0.22	93.3	0.21	86.5
Phenylalanine, %	0.37	4.71	0.33	90.5	0.33	89.7
Phe + Tyr, %	0.65	8.27	0.60	92.6	0.59	90.9
Alanine, %	0.61	7.76	0.49	81.0	0.52	85.6
Cystine, %	0.17	2.16	0.14	83.6	0.15	89.7
Tyrosine, %	0.28	3.56	0.27	95.4	0.26	92.6
Glycine, %	0.32	4.07	0.24	76.0	0.25	79.2
Serine, %	0.40	5.09	0.32	81.2	0.34	83.8
Proline, %	0.80	10.2	0.76	94.5	0.66	82.7
Glutamine[2], %	0.93	11.8	0.88	94.4	0.81	87.6
Glutamic acid[2], %	0.59	7.51	0.56	94.4	0.52	87.6
Asparagine[2], %	0.24	3.05	0.20	82.4	0.20	81.7
Aspartic acid[2], %	0.30	3.82	0.25	82.4	0.25	81.7
Total Nitrogen (CP/6.25) %	1.26	16.0	1.10	87.0	1.04	82.7
Essential Nitrogen Poultry, %	0.61	48.5*	0.55	89.5	-	-
Essential Nitrogen Swine,%	0.49	38.9*	-	-	0.42	85.3

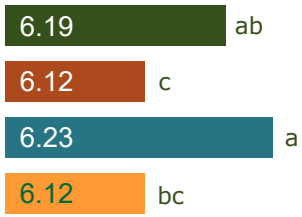
[1]SID = Standardized Ileal Digestibility.
[2]Values estimated based on data of Li *et al.*, (2011).
* Essential Nitrogen for Poultry and Swine calculated as a percentage of Total Nitrogen.

Recommended Inclusion Levels of Poultry and Swine Feeds (%)					
	Broilers			***Hens***	
	Starter		Grower		
Practical	65		65	65	
Maximum	65		65	65	
	Growing Pigs			***Sows***	
	Starter	Grower	Finisher	Gestation	Lactation
Practical	60	65	70	65	70
Maximum	60	65	70	65	70

Understand variability in nutrient composition

AA Profile (% of CP) of Soybean Meal from Different Origin

LYSINE



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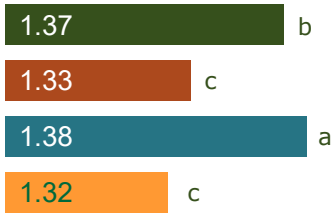
METHIONINE



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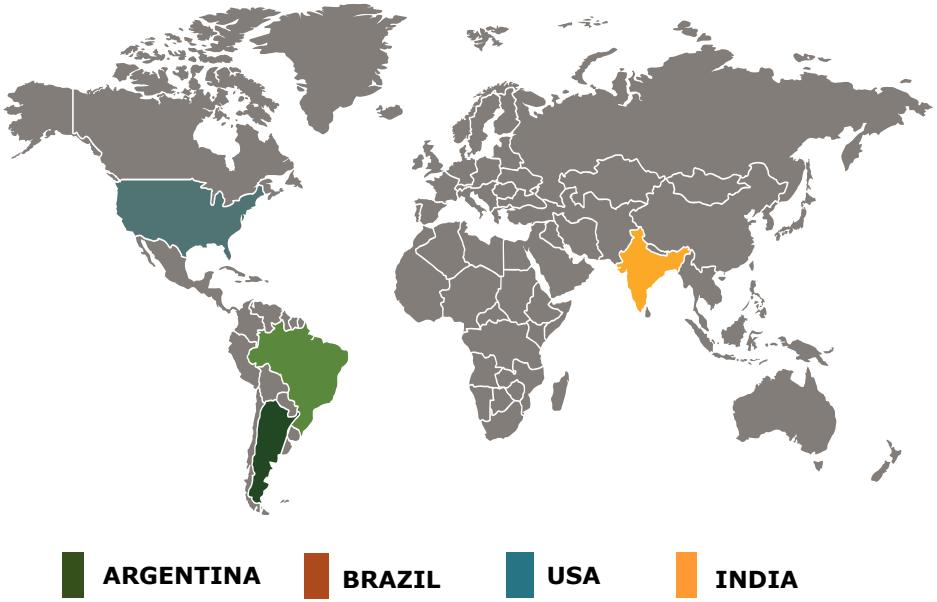
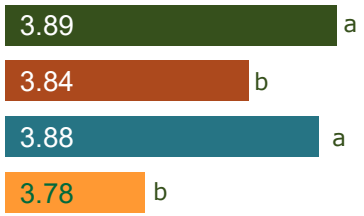


THREONINE



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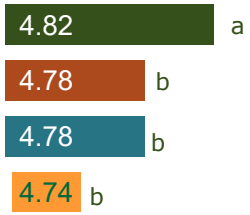
VALINE



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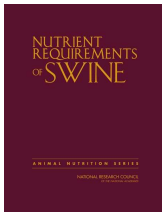
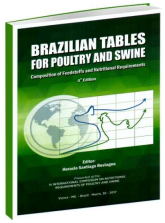
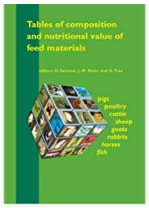
Ibáñez et al. (2020)

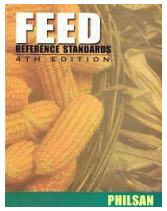
Some Reference RM Nutrient Tables

- **From organizations and institutions**









- **Online**

Study RM characteristics that can impact feed intake and nutrient digestibility

- Palatability
- Presence of anti-nutritional factors
- Level of mycotoxin
- Heat stability
- Buffering capacity
- Shelf life

Feed mill Considerations when Formulating a Diet

For pelleted feeds

- **minimum and maximum oil content**
- **minimum starch**
- **maximum co-products**

FEED FORMULATION

Formulation Tools

MANUAL CALCULATION

EXCEL

FORMULATION SOFTWARE

What makes up a feed formula?

Ingredients for USSEC / BS01 — Broiler Grower Cobb 500

Code	Name	Price	Solution Amount	Minimum	Maximum
1ERG04	Yellow Corn	450.00	670.44180		
2PPS01A	US Soybean Meal	684.00	270.74020		
6FO03	Coconut Oil	1,080.00	21.39970		30.00000
7MS03	Limestone	90.00	10.53894		
7MS07	Monodicalcium phosphate	918.00	9.57550		
7SAA02	L-Lysine	1,998.00	3.53086		
7SAA01	DL-Methionine	3,204.00	3.48665		
7MS01	Salt	90.00	2.88106		
7SAA03	L-Threonine	2,088.00	1.40812		
7SAA08	L-Valine	6,300.00	1.29718		
7MS14	Sodium bicarbonate	630.00	1.00000	1.00000	
7TM01	Trace Mineral Premix	3,600.00	1.00000	1.00000	1.00000
8NNA09	Toxin binder	3,600.00	1.00000	1.00000	1.00000
7VIT02	Choline chloride 60%	1,548.00	0.80000	0.80000	0.80000
8NNA11	NSP Enzyme (broiler)	5,040.00	0.50000	0.50000	0.50000
7VIT01	Vitamin Premix	21,600.00	0.30000	0.30000	0.30000
8NN10	Phytase (broiler)	9,000.00	0.10000	0.10000	0.10000
4MFP26A	Rice bran	421.00			50.00000
7SAA04	L-Tryptophan	9,000.00			

1000.00 | 1 Nutritionist's Copy | Feasible

1.00000

568.30

Code	Name	Solution Amount	Minimum	Maximum
1	Weight (Kgs)	1.0000	1.0000	1.0000
2	Dry Matter (%)	87.9007		
3	Moisture Content (%)	12.0993		
4	Crude Protein (%)	19.0000	19.0000	20.0000
5	Crude Fat (%)	5.0513		
7	Crude Fiber (%)	2.3243		
8	Ash (%)	2.7119		
21	ME-Poultry (kcal/kg)	3,025.0000	3,025.0000	
25	Calcium (%)	0.8400	0.8400	
27	Available Phosphorus (%)	0.4200	0.4200	
29	Sodium (%)	0.1600	0.1600	0.2300
30	Chloride (%)	0.2135	0.1600	0.3000
33	Linoleic Acid (%)	1.3194	1.0000	
59	Lysine-Dig-Po (%)	1.1200	1.1200	
61	Methionine-Dig-Po (%)	0.6141	0.4500	
65	M+C-Dig-Po (%)	0.8500	0.8500	
67	Threonine-Dig-Po (%)	0.7300	0.7300	
69	Tryptophan-Dig-Po (%)	0.2023	0.1800	
77	Valine-Dig-Po (%)	0.8500	0.8500	
117	Potassium (%)	0.8129	0.6000	0.9500

Sample formulation only.

Feed formulation is a process that needs thorough understanding of animal requirements, available raw materials and economic goals.

Thank you!

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