

BASICS OF ANIMAL NUTRITION AND FEED FORMULATION

Concepts and Practical Aspects

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What is the Difference Between Feed Business and a Restaurant?

- A good recipe – famous with competitive.
- A good head cook.
- A good team of waitress/waiter.
- A stead customer base.
- **A win-win relation between company and customers.**

Feed Formulation- What need to know?

1. Objectives.
2. Nutrient requirements.
3. Nutrient limitations and interactions.
4. Availability of raw materials.
5. Cost and quality of raw materials.
6. Customer requirement and market potential.

Feed Formulation- What need to know?

Objectives

- **Maximize:**
 - Profit per farm unit
 - Product quality and quantity
 - Profit for feed manufacturer
- **Minimize:**
 - Impact on environment
 - Stress on animal well-being

Feed Formulation- What need to know?

Nutrient Requirement

Nutrient and ingredient ?

- An ingredient is a raw material that provides the required nutrients.
- Nutrient is a chemical substance having specific nutritional function in animal body.

Examples:

- Corn, rice hulls, soybean meal, fish meal, wheat bran.
- Protein, Carbohydrate , Fat , Mineral, Vitamin, Water

Function of nutrients in body

Nutrient
functions

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graph TD; A[Nutrient functions] --- B[Maintenance]; A --- C[Growth]; A --- D[Production]; A --- E[Reproduction]; A --- F[Work];
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Maintenance

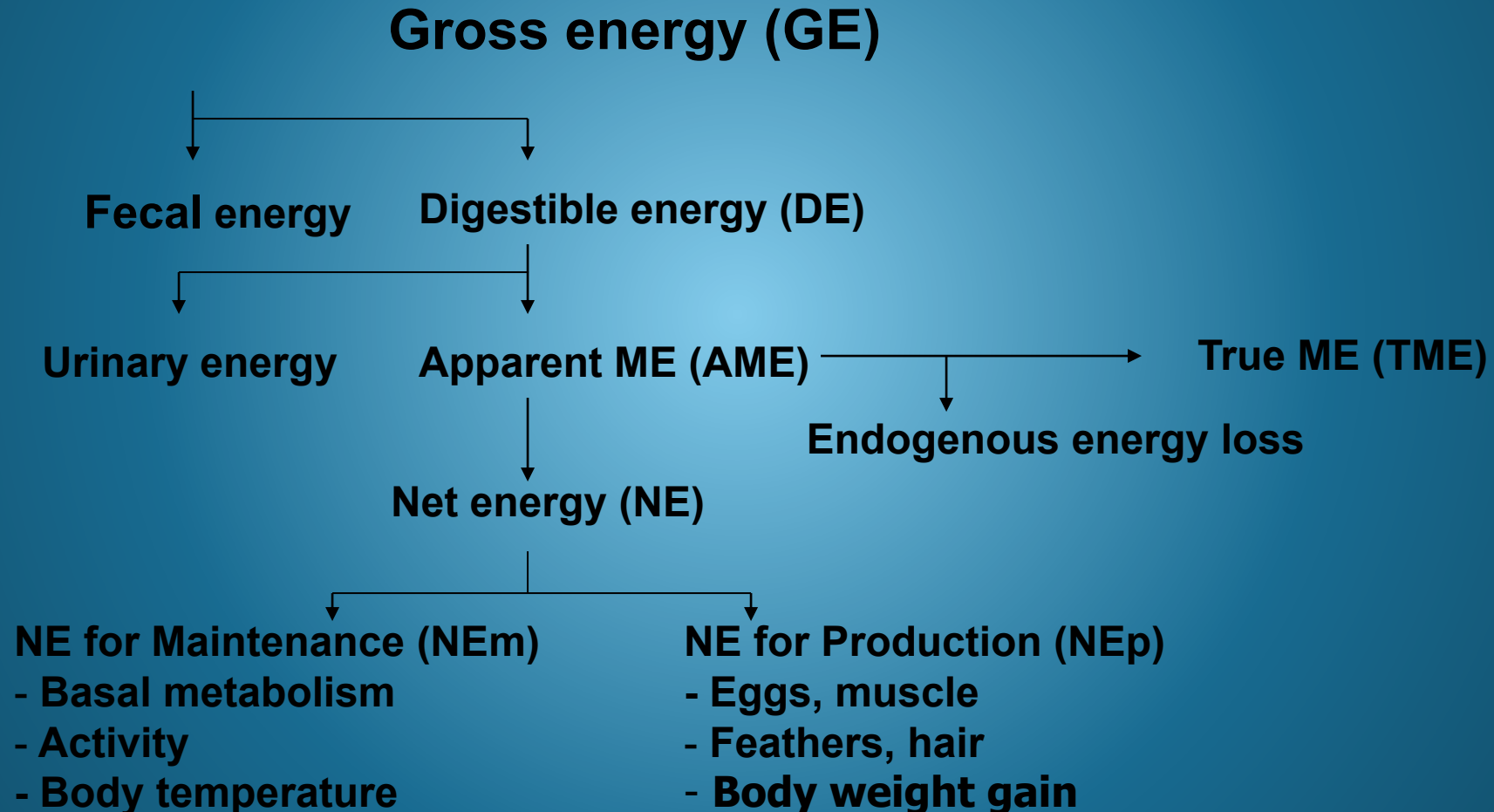
Growth

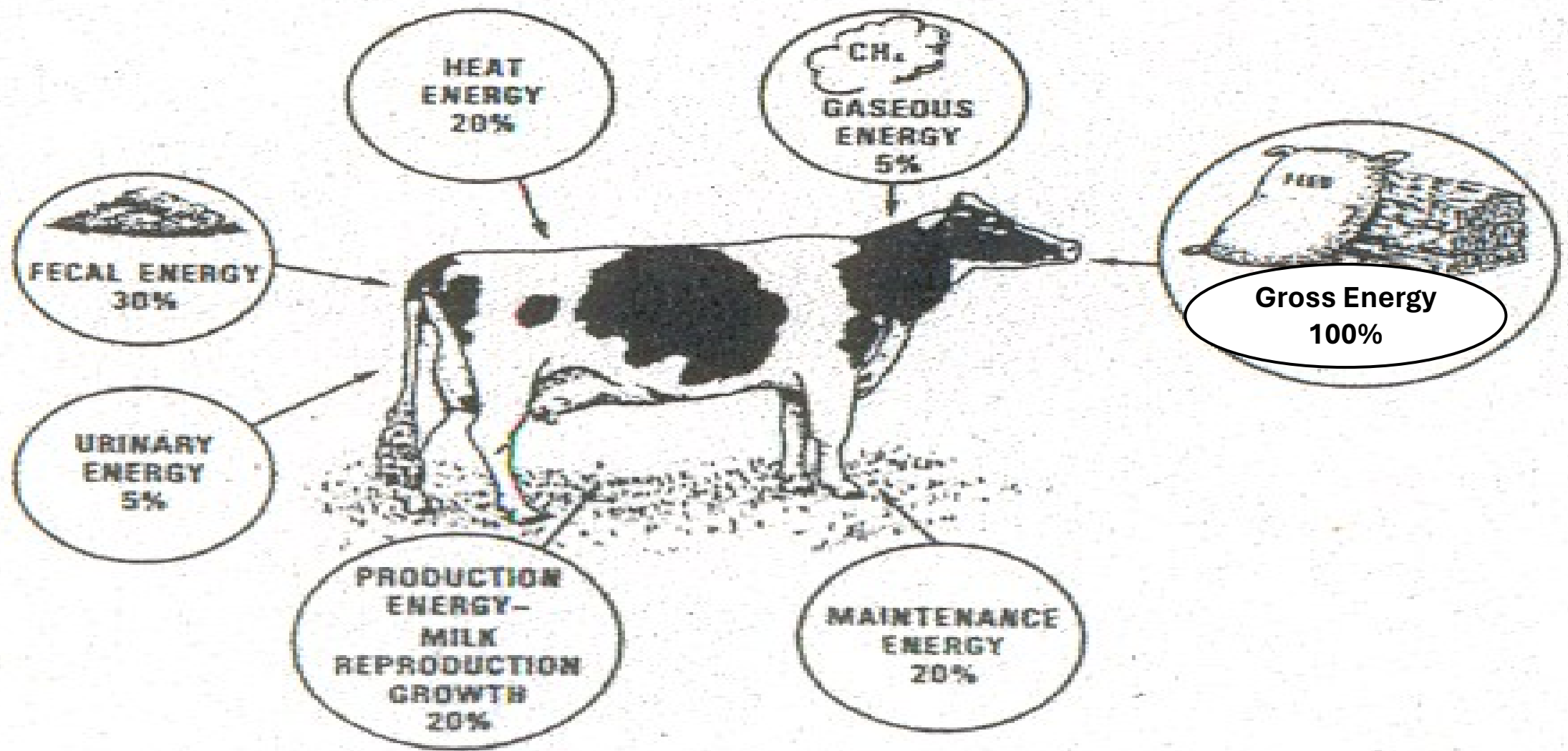
Production

Reproduction

Work

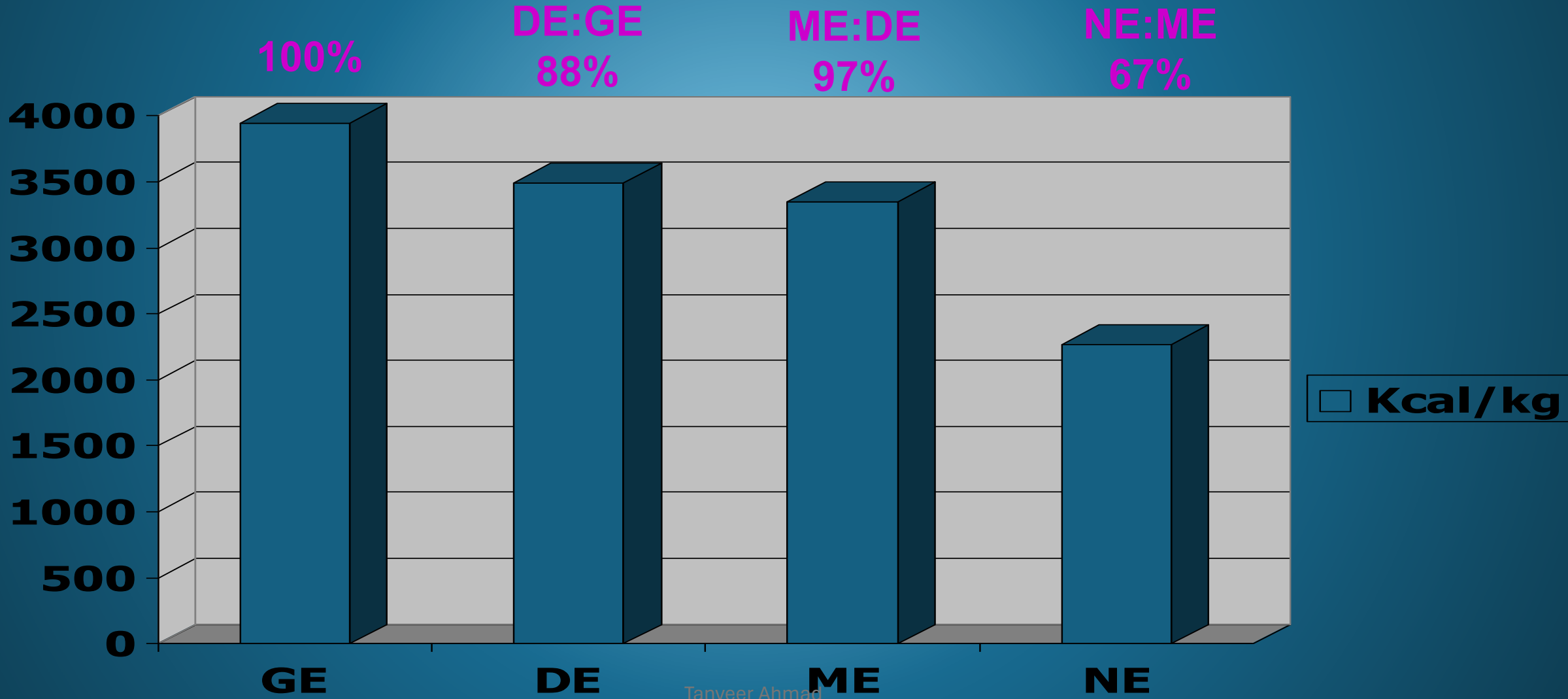
Energy Partitioning in an Animal Body





Energy utilization by a lactating cow showing average partition of feed energy by the animal

Proportion of Energy in Corn



Protein Concept-Amino Acids

- **Essential AA**
Indispensable, must be supplied from feed.
- **Non-essential AA**
dispensable, can be converted from carbohydrates or fat in the body.
- **Semi-essential AA**
can be synthesized from limited substrates or amino acids.

- | • Essential AA (Indispensable) | | Non-essential AA (dispensable) | • Semi-essential AA (semi-dispensable) |
|---------------------------------------|---------------|---------------------------------------|---|
| Methionine | Arginine | • AIA | • CYS |
| Threonine | Tryptofan | • ASP | • TYR |
| Histidine | Isoleucine | • GLU | • Hydroxy-LYS |
| Leucine | Lysine | • PRO | |
| Valine | Phenylalanine | • GLY | |
| | | • SER | |
| | | • Hydroxy-PRO | |
- MATT VIL PHLy
- Tanveer Ahmad

How Many Types of Animal Feed?

- ✓ **Complete/Compound Feed**

A complete feed provides all nutrient requirements for designated class of animals.

It is ready to use, do not need to add any more ingredients on farm.

- ✓ **Semi complete feed**

A semi-complete feed provides most nutrients.

It needs to add only one major ingredient (grain) on farm.

Inclusion rate 45-55% in a complete feed.

- ✓ **Concentrate**

- ✓ **Premix**

- ✓ **Base mix**

Concentrate

A concentrate provides most parts of:

- **Protein, amino acids.**
 - **Macro- and micro-minerals.**
 - **Vitamins.**
 - **Very limited energy.**
-
- **Inclusion rate 30- 45% in a complete feed.**

Vitamin/Mineral Premix

Provides the required:

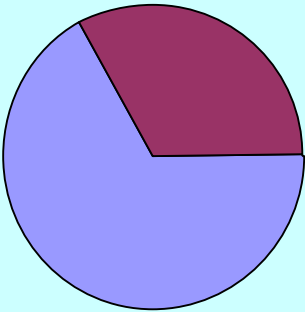
- **Micro-minerals**
- **Vitamins**
- **Partial energy, protein, amino acids**
and micro-minerals from the carrier.

- **0.05% 0.5kg/T complete feed.**
- **0.1%, 1 kg/T complete feed.**
- **0.5%, 5 kg/T complete feed.**
- **1.0%, 10 kg/T complete feed.**
- **4.0%, 40 kg/T complete feed.**
- **5.0%, 50 kg/T complete feed.**

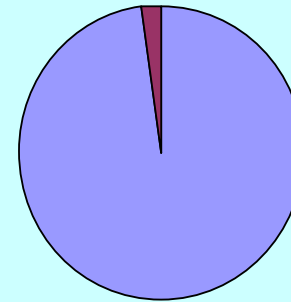
The higher the inclusion rate, the lower nutrient content and cost per unit weight of premix.

Vitamins - Micronutrients With Macro-responsibility

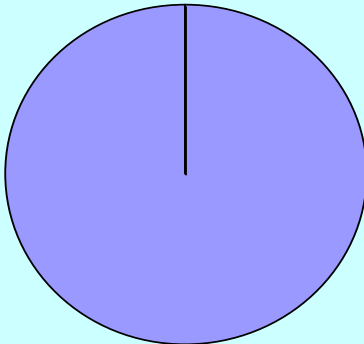
33% of No. of Feed Ingredients



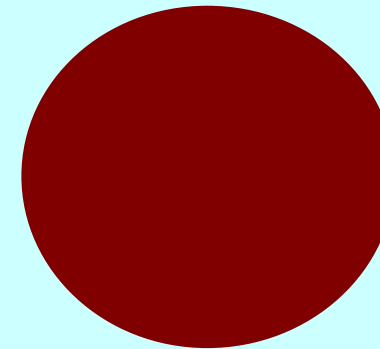
2% of Feed Cost



0.08% of Feed Weight



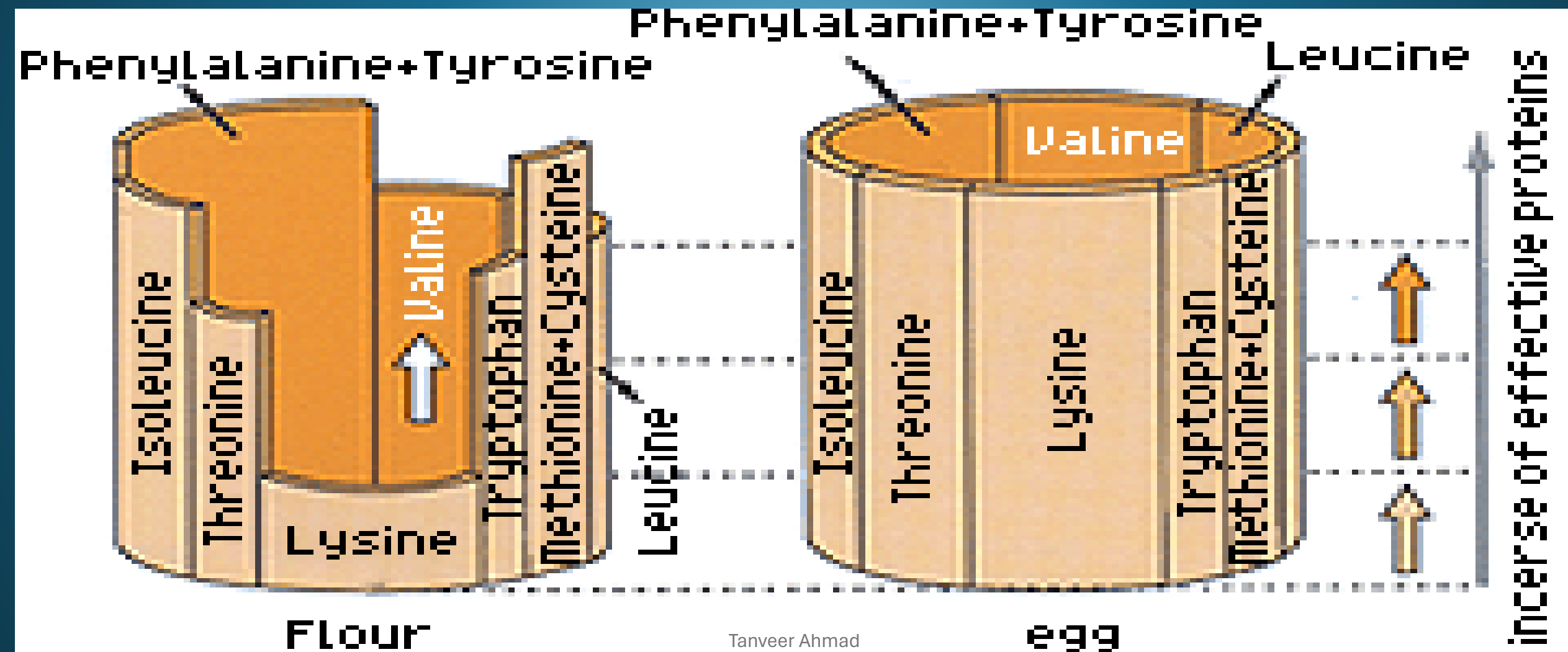
100% of Metabolic Functions



Factors Affecting Nutrient Requirement

- **Genetics of farm animals**
- **Interrelationships of nutrients**
- **Health status (Disease and stress)**
- **Management and environmental conditions**

Ideal Protein Concept



Interrelationships of nutrients

■	Energy	↔	Protein
■	Ca, P,	←	Vitamin D3
■	Niacin	→	tryptophan
■	Choline, meth	↔	folic acid, Vit. B12
■	Vitamin E, Se	↔	Cystine
■	Cu	↔	Zinc
■	Zinc	↔	Cadmium
■	Copper	↔	Molybdenum
■	Selenium	↔	Arsenic
■	Lysine	→	Arginine

Feed Additives and Implants

Feed additives

- Materials used in rations
- Small quantities
- Improve performance
 - Feed efficiency
 - Rate of gain
 - Health
 - Production

Criteria of a best salable feed

- ✓ **Well balanced nutrients.**
- ✓ **High manufacture quality.**
- ✓ **Excellent performance.**
- ✓ **Competitive profitability.**

Rations

1. Maintenance of vital body processes to keep animals alive
2. Growth by increasing size
 - ✓ Bones, muscles, organs, tissue
3. Fattening
 - ✓ Storing nutrients
 - ✓ Not for maintenance or growth
4. Production
 - Milk
 - Eggs
 - Wool or hair
5. Reproduction
6. Work
 - Other needs must be met first
 - Most U.S. livestock do no work (horses)

Rations

- $\frac{1}{3}$ to $\frac{1}{2}$ of the ration fed to livestock is used for body maintenance
- Maintenance must be met before nutrients are available for other functions

What we have for making ration/feed formulation

- Roughages (Green/Dry)
 - Fodder
 - Hay
 - Silage
 - Straw
- Concentrate (Grains-corn, oats, barley, wheat & By-products, Wheat bran, polish, gluten meal)
- Protein
- Energy
- Mineral & Vitamins
- Premix

Feed Formulation

- is the process of
 - quantifying the amounts of feed ingredients
 - that need to be put together,
 - to form a single uniform mixture (diet) for animal
 - that supplies all of their nutrient requirements.

Feed / Ration Formulation Requirements

Nutrient
Requirement
of Animal

Ingredients to
be used in
ration

Feed / Ration Formulation-

Nutrient Requirement of Animal

Feeding Standards

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graph TD; A[Feeding Standards] --> B[NRC Tables]; A --> C[ARC Tables]; A --> D[Many Others]; B --> E[NUTRIENT REQUIREMENTS OF DAIRY CATTLE Eighth Revised Edition];
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NRC Tables

NUTRIENT
REQUIREMENTS
OF DAIRY
CATTLE

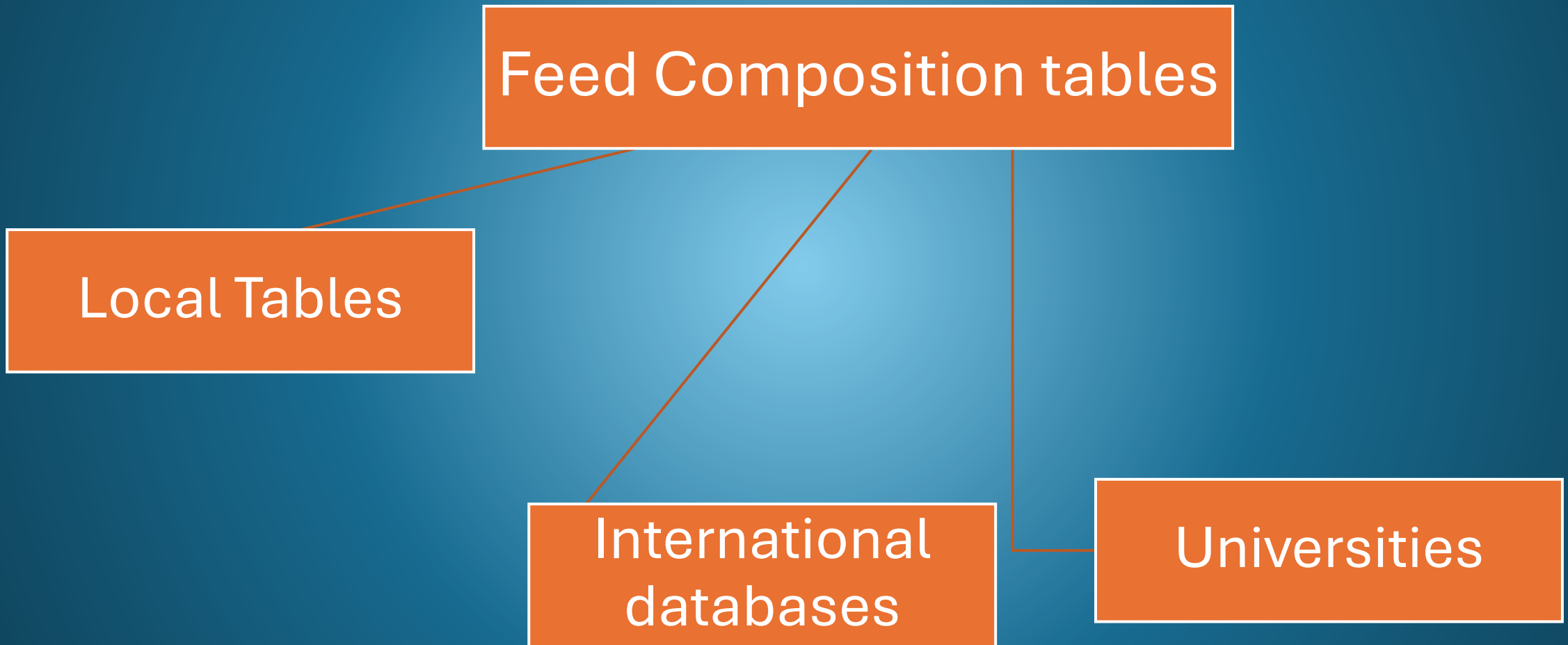
Eighth Revised Edition

ARC Tables

Many Others

Feed / Ration Formulation-

Feed Ingredients to be used



Good Ration

1. Balanced

- Has all the nutrients in the right amounts

2. Palatable

- Taste good

3. Low Cost

- Feed is about 50-75% of the cost of raising livestock

4. Not harmful to the health of animals

- Too much cotton seed can cause reproductive problems

5. Uniformly mixed

- Micronutrients- vitamins and minerals
- Feed additives

Rules for Feeding Livestock

- Beef Cattle (fattening)
 - 1.5 to 2 Kg. of air-dried roughage and 2 Kg of concentrate per 100 Kg. of body weight

Example: An 350 Kg steer will need approximately:

- 5.25 to 7 Kg. of roughage and
- 7 Kg. concentrates
 - Total= 12.25 to 14 Kg of feed

Rules for Feeding Livestock

- Cattle (maintenance)
 - mainly roughage
 - air dried roughage should be ~2% body weight (1.8 dry matter)
 - Cows nursing calves should be fed 50% more than dry cows
-

Example:

A 550 kg cow should be fed about 11 Kg ($550 \times .02 = 11$)

Rules for Feeding Livestock

- Poultry
 - The ration is 10% of body weight

FEED FORMULATION

Methods of Ration Formulation

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Methods of Ration Formulation

- Pearson Square Method
- Algebraic Equations (Simultaneous Equations)
- Trial and Error Method
- Computer Feed Formulation Software's

TRIAL AND ERROR METHOD

(Ration Formulation for Dairy Cow and Buffalo)

- Step 1

- Calculate The Nutrient Requirements of the animal for maintenance, production and pregnancy, if any.
- Sum Up all the Nutrient Requirements

- Step 2

- Decide about the Feedstuff
- Write down their chemical composition

TRIAL AND ERROR METHOD

(Ration Formulation for Dairy Cow and Buffalo)

- Step 3

- Calculate The DMI and divide it into Roughage and Concentrate Intake

- Step 4

- Made calculations for Roughage first and then check how much Nutr. Req. are met.
- Left over req. should be met from Concentrate.

TRIAL AND ERROR METHOD

(Ration Formulation for Dairy Cow and Buffalo)

Thumb Rules:

- Dry Matter Intake (DMI) requirements
 - Cow: 2.5% of the live body weight (BW)
 - Buffalo: 3.0% of the live body weight (BW)
 - Sheep 3.5-4.5% of the live body weight (BW)
 - Horse 2.0-2.5% of the live body weight (BW)
 - Beef 2.0-2.7% of the live body weight (BW)

TRIAL AND ERROR METHOD

(Ration Formulation for Dairy Cow and Buffalo)

Thumb Rules:

- **Dry Matter Intake (DMI) requirements**
 - Cow: 2.5% of the live body weight (BW)
 - Buffalo: 3.0% of the live body weight (BW)
- **Roughage Intake**
 - 2/3 of the DMI
 - **Wet/Green Roughage Intake**
 - 2/3 of the Roughage Intake
 - **Dry Roughage Intake**
 - 1/3 of the Roughage Intake
- **Concentrate Intake**
 - 1/3 of the DMI

TRIAL AND ERROR METHOD

(Ration Formulation for Dairy Cow and Buffalo)

Thumb Rules: Examples (Cow BW is 500 kg)

- Dry Matter Intake (DMI)

- Cow: 2.5% of the live BW ($2.5/100 \times 500 = 12.5$ kg)
- Buffalo: 3.0% of the live BW ($3.0/100 \times 500 = 15.0$ kg)

- Roughage Intake

- 2/3 of the DMI ($2/3 \times 15 = 10.0$ kg)
 - Wet/Green Roughage Intake
 - 2/3 of the Roughage Intake ($2/3 \times 10 = 6.66$ kg)
 - Dry Roughage Intake
 - 1/3 of the Roughage Intake ($1/3 \times 10 = 3.34$ kg)

- Concentrate Intake

- 1/3 of the DMI ($1/3 \times 15 = 5.0$ kg)

TRIAL AND ERROR METHOD

(Ration Formulation for Dairy Cow and Buffalo)

- Example

- Animal is : COW
- Body weight is : 500 kg
- Milk Production is : 15 Lit. with 3.5% Butter Fat

- Step 1.....Nutr. Req. Calculations (NRC Table)

Type of req	NE _L (M.Cal)	Crude Protein (kg)
Maintenance	8.46	0.364
Production (for 1L, 4%BF)	0.74	0.090
For 15L, 3.5%BF	(0.69*15)= 10.35	(0.084*15): 1.26
Total	18.81	1.624

4% Fat Corrected Milk: $0.4 \text{ Milk Yield (kg)} + 15 \text{ Fat (kg)}$
: $0.4 (15) + 15(0.525) = 13.875$

COMPUTER FEED FORMULATION

(by using **FAO ration tool 2016**)

FAO Ration Tool

 Food and Agriculture Organization of the United Nations

Cow data | **Ration calculation** | **Milk Income less Feed Cost (MIFC)** | **Acknowledgment**

Data inputs

Live weight (kg)	500
Pregnancy (mth)	1
Milk volume (kg)	10
Milk fat (%)	3.3
Milk protein (%)	2.8
Live weight gain/loss (kg/d)	0.75
Stage of lactation	Early lactation

Energy needs

54	MJ ME/d
0	MJ ME/d
47.3	MJ ME/d
33	MJ ME/d

Dairy Cow Ration Calculation

Calculate ration

Needs		Intake	
Energy	134.3	119	MJ/d
Crude Protein	2.40	1.81	kg/d
NDF	30	15.03	% DM
Ca	120	9.90	g/d
P	60	37.92	g/d
Max intake	15	9.50	kg DM/d
Concentrate max	50	50.01	% DM

Feed Cost (/d) 58.95

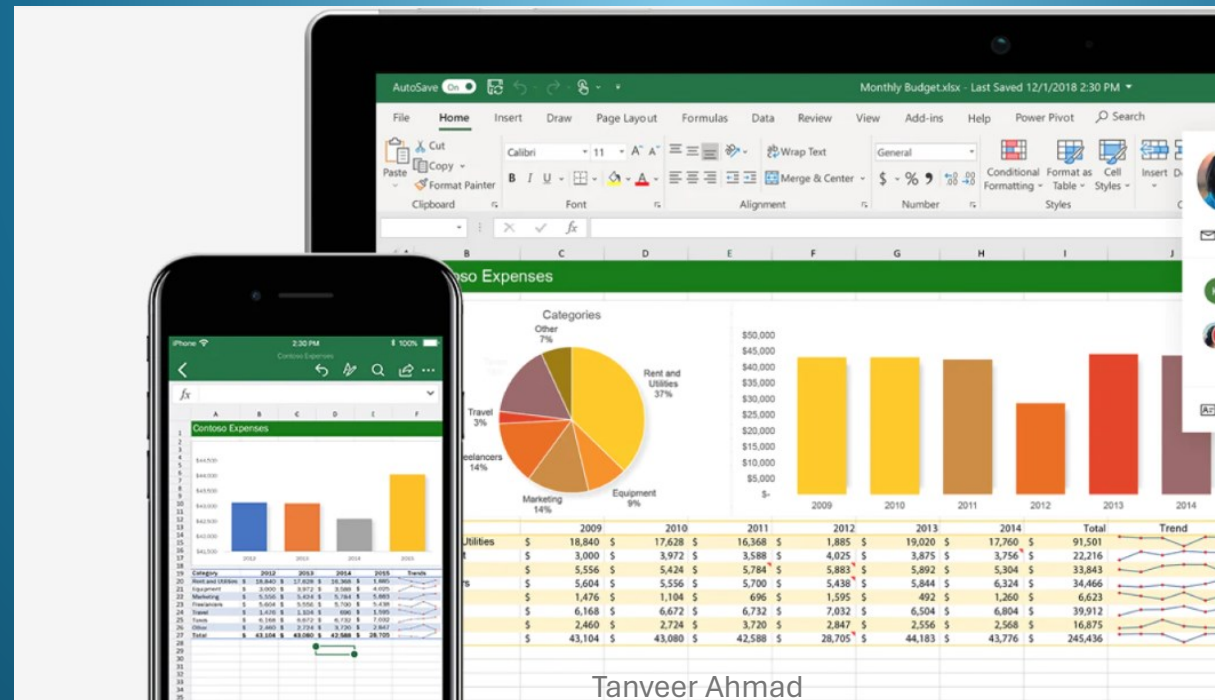
MIFC (/d) 61.05

Ration price (/kg) 3.12

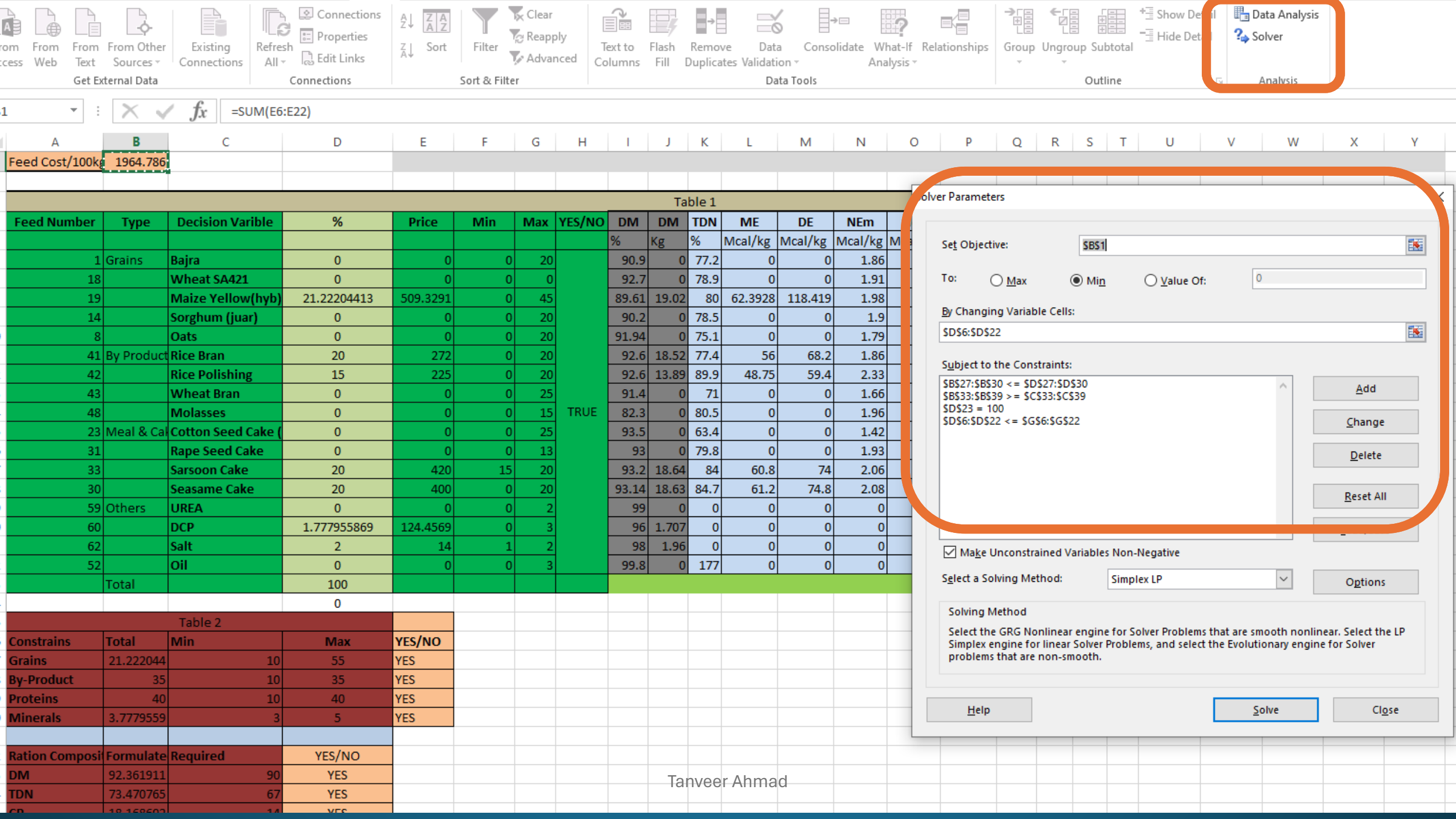
Admin **Tanveer Ahmad** **Quit**

COMPUTER FEED FORMULATION

(by using **Excel Sheet**)



Objective Cost/100Kg				EXPRESSED ON DRY MATTER BASIS EXCEPT FOR COST												
	3171			Composition Of Ingredients												
TABLE 1																
Feed #	Type	Decision Variable	%	Price Rs/=	DM %	DM Kg	TDN %	TDN Kg	CF %	CF Kg	CP %	CP Kg	MP %	MP /Kg	MP /g	ME Mcal/Kg
5	Grains	Maize Yellow (desi)	1	30	89	0.89	88.5	0.885	3.03	0.0303	11.8	0.118	8.26	0.0826		3.2
2	Grains	Barley	1	45	91.4	0.914	83.4	0.834	7.26	0.0726	10.21	0.1021	7.147	0.07147		3.01
8	Grains	Oats	20	1000	91.94	18.388	75.2	15.04	14.68	2.936	9.52	1.904	6.664	1.3328		54.4
14	Grains	Sorghum (juar)	30	900	90.2	27.06	86.9	26.07	2.47	0.741	15.75	4.725	11.025	3.3075		94.2
24	Cake & Meals	Cotton Seed Cake (dec)	1	20	92.72	0.9272	81.1	0.811	9.49	0.0949	39.59	0.3959	27.713	0.27713		2.93
37	Cake & Meals	Corn Gluten 30%	1	29	93	0.93	90.2	0.902	6.56	0.0656	30.7	0.307	21.49	0.2149		3.26
30	Cake & Meals	Seasame Cake	1	15	93.14	0.9314	83.1	0.831	6.66	0.0666	36.06	0.3606	25.242	0.25242		3.02
31	Cake & Meals	Rape Seed Cake	1	45	93	0.93	81.5	0.815	11.61	0.1161	37.1	0.371	25.97	0.2597		2.95
41	By-Products	Rice Bran	31	837	92.6	28.706	74.8	23.188	14.25	4.4175	9.99	3.0969	6.993	2.16783		83.7
45	By-Products	Molasses	10	250	82.3	8.23	84.7	8.47	0	0	3.04	0.304	2.128	0.2128		30.6
		DCP	2	140												
		SALT	1	10												
	TOTAL		100			87.9066		77.846		8.5406		11.6845		8.17915		2.8127
																281.27
TABLE 2							TABLE 4									
Constraints	Total	Min	Max	Equal			Required Input Requirements Value					Formulat ed Value	% greater or lower	Yes/No		
Grains	52		60				B.Wt (Kg)		40							
Moisture	12.0934		15				Milk Yield (Kg/day)		0.26							
By-Product	41	30					ADG (g/day)		18					Calcullation for % requirements		
Molasses	10		10				Energy Conc. In diet		1.91						CP	9.166667
							DMI (Kg)		1.08						ME	1.916667
							DMI (%BW)		2.71						TDN	52.77778
Ration Composition	Formulated	Required					TDN (Kg/d)		0.57	0.840737	32.20232539	YES			MP	6.203704
CP 20% UIP	11.6845	9.166666667	21.54849	YES			ME (Mcal/d)		2.07							
ME %	2.8127	1.916666667	31.8567	YES			CP 20% UIP (g/d)		99							
TDN %	77.846	52.77777778	32.20233	YES			MP (g/d)		67							
MP %	8.17915	6.203703704	24.15222	YES			DIP (g/d)		52							



E 6-3 Daily Nutrient Requirements of Lactating and Pregnant Cows

Energy				Total	Minerals		Vitamins	
NEL	ME	DE	TDN	Crude	Ca	P	A	D
(Mcal)	(Mcal)	(Mcal)	(kg)	Protein	(g)	(g)	(1,000 IU)	
<i>Maintenance of Mature Lactating Cows^a</i>								
7.16	12.01	13.80	3.13	318	16	11	30	12
7.82	13.12	15.08	3.42	341	18	13	34	14
8.46	14.20	16.32	3.70	364	20	14	38	15
9.09	15.25	17.53	3.97	386	22	16	42	17
9.70	16.28	18.71	4.24	406	24	17	46	18
10.30	17.29	19.86	4.51	428	26	19	49	20
10.89	18.28	21.00	4.76	449	28	20	53	21
11.47	19.25	22.12	5.02	468	30	21	57	23
12.03	20.20	23.21	5.26	486	32	23	61	24
<i>Maintenance Plus Last 2 Months of Gestation of Mature Dry Cows^b</i>								
9.30	15.26	18.23	4.15	875	26	16	30	12
10.16	16.66	19.91	4.53	928	30	18	34	14
11.00	18.04	21.55	4.90	978	33	20	38	15
11.81	19.37	23.14	5.27	1,027	36	22	42	17
12.61	20.68	24.71	5.62	1,074	39	24	46	18
13.39	21.96	26.23	5.97	1,120	43	26	49	20
14.15	23.21	27.73	6.31	1,165	46	28	53	21
14.90	24.44	29.21	6.65	1,209	49	30	57	23
15.64	25.66	30.65	6.98	1,254	53	32	61	24
<i>Milk Production—Nutrients/kg of Milk of Different Fat Percentages</i>								
0.64	1.07	1.23	0.280	78	2.73	1.68	—	—
0.69	1.15	1.33	0.301	84	2.97	1.83	—	—
0.74	1.24	1.42	0.322	90	3.21	1.98	—	—
0.78	1.32	1.51	0.343	96	3.45	2.13	—	—
0.83	1.40	1.61	0.364	101	3.69	2.28	—	—
0.88	1.48	1.70	0.385	107	3.93	2.43	—	—
<i>Live Weight Change During Lactation—Nutrients/kg of Weight Change^c</i>								
Loss	- 4.92	- 8.25	- 9.55	- 2.17	- 320	—	—	—
Gain	5.12	8.55	9.96	2.26	320	—	—	—

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The following abbreviations were used: NEL, net energy for lactation; ME, metabolizable energy; DE, digestible energy; TDN, total digestible

Ingredients Limitations for Concentrates

Name of Ingredient	The maximum safe quantity (percent)	Reasons
Cotton seed cake	20-25	Price and quality; taste; eaten in low quantity; proteins and price
Rapeseed cake	10-13	Protein level; milk does not taste good
Sunflower cake	10-13	Quality and taste
Cotton seed meal	15-20	Price, protein
Rapeseed meal	15-20	Price and the quality of the protein
Canola meal	15-20	Not much poisonous; less production
Peanut meal	20-25	Bad taste
Maize carbohydrate 20 and 30%	20-25	Increases urination
Maize carbohydrate 60%	5-10	Diarrhea
Soyabean	10-15	Price
Urea	1-2	Less quantity of calcium

Rice polishing	20	High price; not very digestible
Wheat bran	25	According to requirement
Molasses	10-15	
Wheat grains	15-20	
Maize grains	40-50	
Sorghum	15-20	
Oil	2-3	
Salt	1-2	
DCP	1-2	
Salt powder	2	

COMPUTER FEED FORMULATION



COMPUTER FEED FORMULATION

- An electric computer **can do little** than a good **MATHEMATICIAN** can do, **but** it **can do it a lot of faster and it can check all possible combinations.**
- **The computer**
 - Takes information
 - Can make thousands of calculation in a very short time
 - Determine solutions

What is Least-Cost formulation?

- Combining many feed ingredients in a certain proportion
 - To provide the target animal with a balanced nutritional feed
 - At the least possible cost.
-
- It is a mathematical solution based on linear programming.

What is Least-cost Feed Formulation?

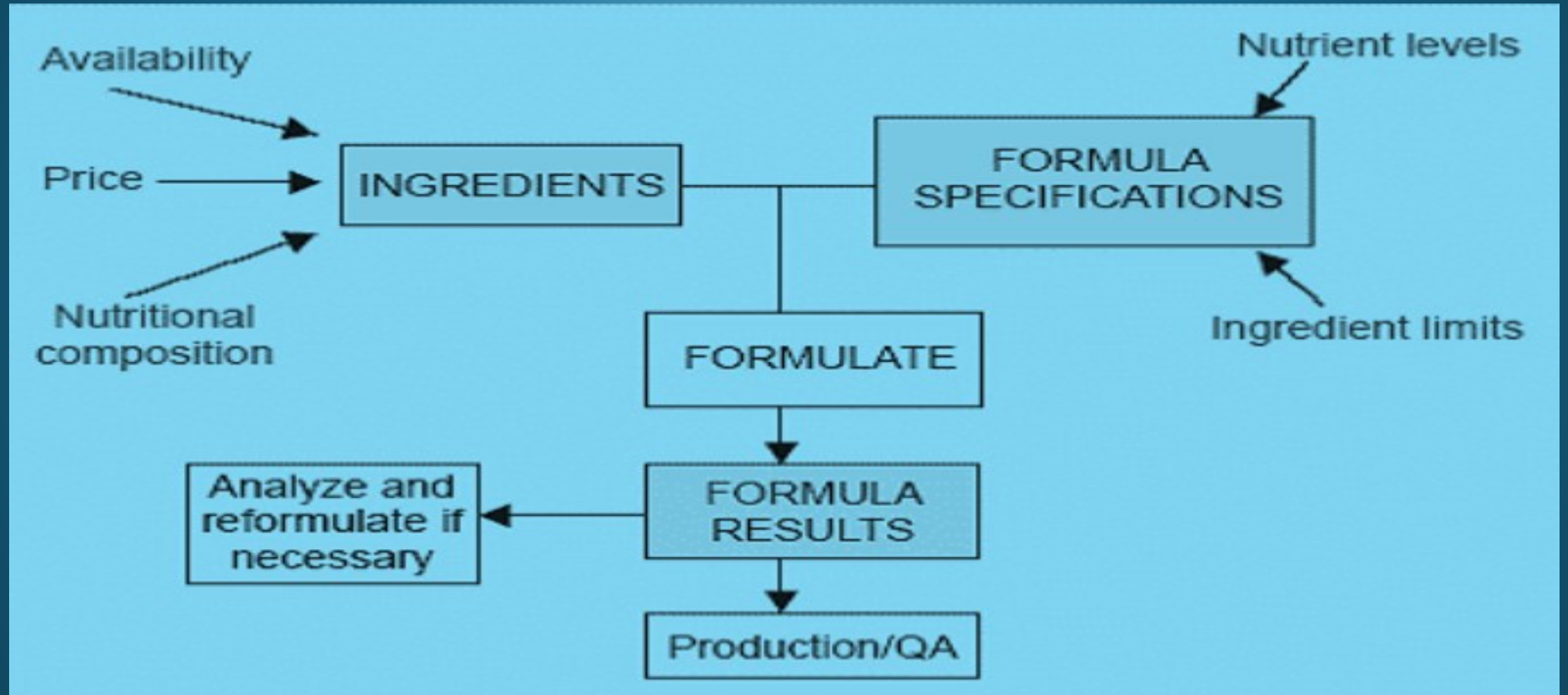
- What is required:
 - Professional knowledge of AN
 - Consider animal nutrient requirements
 - Available feedstuffs and their chemical composition
 - Animal capability to digest and assimilate nutrients
- Be Wise.....The formulation program is only as good as the nutrient and ingredient parameters entered into it.

Least-cost formulation software?

What else to expect from Software?

- Look and feel of the software
- Integration with other functionalities related to formulation and feed mill operations
- Object is to perform tasks more efficiently

Working of Basic formulation functions in a Software



Ref. An Introduction to Least-Cost Feed Formulation Software

Published on: 10/25/2006 . Author/s : Richard Rossi - Product Manager, Feedsoft Corporation

Tarveer Ahmad

STEPS IN BALANCING A RATION BY COMPUTER

1. Enter names of available feed ingredients, and the cost of each.
2. Enter nutrient values for feeds.
3. Establish ration specifications, a) Nutrient limits, & b) Ingredient limits.
4. Submit all of above information to solving portion of software package.
5. Examine the solution provided by the computer software.

Basic features

- (1) Available Ingredients
- (2) Nutrient Composition
- (3) Formula Specifications

Formulation : Formula result must be feasible both from a mathematical and a nutritional standpoint.

If infeasible results are obtained ???

THANKS