**Department of Animal Nutrition, Genetics & Breeding**
**Course Title: Poultry Nutrition**
**Course Code: ANGB 253**
**Level-2, Semester-II**
**Credit Hours: 2, Contact Hour: 2**

**Course Content (Theory)**

1. **Introductory:** Terminology related with poultry nutrition, objectives of poultry nutrition, history of poultry nutrition

2. **Utilization of nutrients:** Digestion, absorption and metabolism of nutrients (carbohydrate, protein, fat) in poultry

3. **Feedstuffs and ration formulation:** Poultry feedstuffs, conventional and unconventional feed ingredients, agro-industrial byproducts, poultry ration formulation, factors affecting the selection of feed ingredients, procurement and storage of feedstuffs, feeding standard, inclusion level

4. **Poultry feeding and feed efficiency:** Feeding systems, feeding methods, feed efficiency, factors affecting feed efficiency, improving feed efficiency

5. **Feed additives:** Definition of feed additives, classification and use of feed additives, alternative of antibiotics, probiotics and prebiotics for animals

6. **Energy for poultry:** Terms related to energy expression and measurement, energy requirement, energy deficiency, excessive energy

7. **Nutrients requirement:** Protein and fat requirement of poultry, protein for phase feeding, calorie-protein ratio, protein evaluation, protein deficiency, excessive protein, sources, requirement and deficiency symptom of vitamins and minerals

8. **Nutrient interrelationships:** Interactions among the nutrients.

9. **Latest research finding:** Information about latest research innovations in field of poultry nutrition

## Chapter-1
## Introductory

**Poultry nutrition** deals with the coordinated processes in the body which plays an important role in the maintenance of life, growth, egg production and resistance of diseases. It is concerned with providing those elements of the external environment to the internal system of the birds which are essential to maintain the homeostatic conditions in them.
The subject encompasses the study of the various nutrients, their digestion, metabolism and utilization for varied body functions. The art of poultry nutrition or poultry feeding studies various feed stuffs, availability of nutrients, their consumption and utilization for growth and egg production.

### Objectives of Poultry Nutrition

Poultry nutrition is more than just giving any available feed to your birds. Market poultry broilers and turkeys-require proper nutrition to grow and finish out. Breeding poultry require correct nutrition to reproduce. Laying flocks require correct nutrition to be productive. As humans, we need the right balance of nutrients supplied by the food pyramid (meats, vegetables, dairy products for optimum growth, maintenance, finishing, work, reproduction, and production.

The poultry producer must know the nutritional requirements of the bird's function for their production and reproduction after determining the availability and cost of appropriate feedstuffs. It is also critical that the poultry nutritionist know the limitations associated with each ingredient. Some ingredients may have anti-nutritional properties which limit their usage in poultry diets.

All foods that sustain life contain nutrients. Poultry convert the nutrients into useful forms via the walls and enter body cells to provide nourishment and energy for life processes.
Nutrients can be either dietary essential or non-dietary essential. Poultry feeds must supply the dietary essential nutrients because the body cannot produce them on its own. The body can synthesize the non- dietary essential nutrients for growth and maintenance. Poultry diets must supply daily nutrient requirements from the five classes of nutrients.

***Some terminology***

### Live weight gain

The body weight gain can be calculated by deducting initial body weight from the final body weight of the birds.

*Body weight gain (g) = Final weight (g) – Initial weight (g)*

### Feed intake

Feed intake is calculated as total feed consumption divided by number of birds in a group.

*Feed intake (g/bird)* = $\frac{\text{Feed intake a group (g)}}{\text{Total no. of birds}}$

**Feed conversion ratio**

Feed conversion ratio (FCR) was calculated as the total feed consumption divided by weight gain in each replication.

$$FCR= \frac{\text{Feed intake (kg)}}{\text{Weight gain (kg)}}$$

**Flock uniformity**

Flock uniformity is a measure of the variability of bird size in a flock. The percentage of birds having a body weight between 10% above or below the average weight is called the flock uniformity.

**Dressing yield**

Dressing yield of bird is obtained from live weight subtracting blood, feathers, head, shank and inedible viscera.

*Dressing yield=* $breast, thigh, drumstick, back, wing, giblet, abdominal\ fat\ weight\ (g)$

**Dressing percentage**

Dressing yield can be found by subtracting blood, feathers, head, shank and digestive system from live weight. Liver, heart, gizzard and neck were considered as giblet. Dressing percentage of bird was calculated by the following formula-

$$DP = \frac{Dressing\ yield\ (g)}{Live weight\ (g)} X100$$

**Benefit Cost Ratio (BCR)**

Benefit Cost Ratio (BCR) is calculated from total income divided by total cost of production.

$$BCR = \frac{Total\ income}{Total\ cost\ of\ production}$$

**Profit per bird (PPB)**

Net profit per bird can be found out by deducting the total expenditure from the total income.

*PPB = Total income/ bird – total expenditure/ bird*

**Early development of poultry nutrition**

The great French chemist *Antoine Lavoisier* (1743-1794) is considered as 'father' of the science of nutrition. The aristocrat scientist, who was killed during the French revolution, for the first time demonstrated that respiration was a process of oxidation in which food was burnt to produce necessary heat in the body to maintain the life.

Work of Lavoisier gave impetus to the use of chemistry and chemical tools in the study of the science of nutrition. By the first quarter of the last century it had become known that the 'value' of a food did not reside in a single principle but foods contained a number of constituents of which only protein, fat and carbohydrates were recognized. The remaining period of the century was spent in studying these substances and also the constituents of body ash in their role in nutrition and health of animals. Most of the developments in the science of nutrition occurred only during the current century which saw the discovery of vitamins and recognition of the role of trace minerals.

**Milestones in the development of chick nutrition science**

| **Year** | **Researchers** | **Contribution** |
|---|---|---|
| 1762 | Antoine Lavoisier | Nature of respiration, Calorimetry |
| 1834 | William Prout | Nature of food |
| 1908 | Max Rubner | Energy metabolism |
| 1897 | Eijkman | Antipolyneuritis factor in rice polish |
| 1913 | Elmer Verner McCollum | Vitamin A, Vit. B and Vit. D |
| 1922 | Evans and Bishop | Vitamin E |
| 1935 | Henrik Dam | Vitamin K |
| 1936 | W.C. Rose | Essential Amino Acide |
| 1936 | Warburg and Christian | Riboflavin and niacin |
| 1920-1925 | Various workers | Relationship between calcium. phosphorus and vitamin D. Confinement rearing of poultry possible |
| 1925 | Various workers | Essential trace minerals. |
| 1949 | Stokstad | Growth promoting value of antibiotics |
| 1948 | Ricks and co-workers | Vitamin $B_{12}$ isolated |
| 1956 | Various workers | Caloric: protein ratio |
| 1958 | Nesheim and Scott | Selenium in chick nutrition |
| 1960-70 | Various workers | High energy diets |

**Chapter-2**
**Utilization of nutrients**

**Digestion, Absorption**

**Digestion** = the process of breaking nutrients (proteins, carbohydrates, and fats) down into smaller compounds which can be absorbed through the gut wall.

Digestive enzymes play an important role in digestion. Enzymes are also called biocatalysts, necessary for the chemical reaction (breakdown). Digestive enzymes are produced by glands situated along the digestive tract (organs and walls of the gut).

The digestive tract

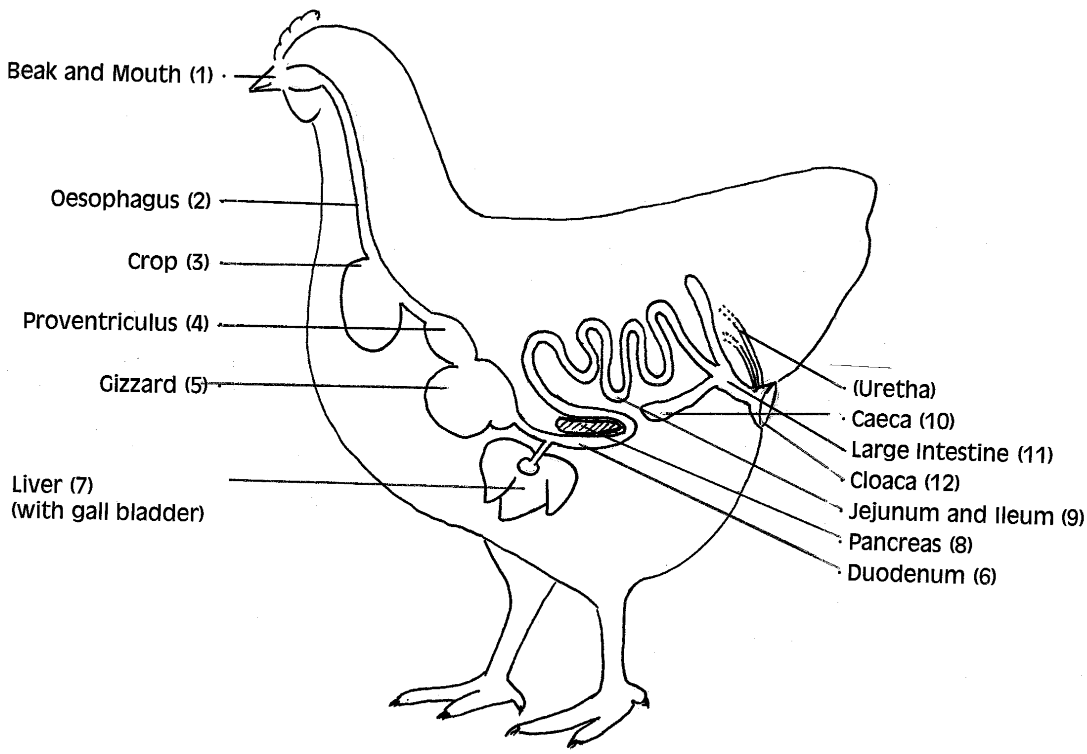



**Figure: The digestive tract of the chicken**

**Beak and Mouth:** The beak is used to pick up the feed and by mouth and tongue the feed is swallowed. A little saliva is added here.

**Oesophagus:** The oesophagus, or gullet, is dilatable and transports the feed from the beak to the crop, and from there to the stomach. No enzymes are produced in the oesophagus.

**Crop:** The crop is an expanded part of the oesophagus; it stores and moistens the food. The crop wall produces mucus to wet the food. No enzymes.

**Proventriculus:** The proventriculus (glandular stomach) secretes gastric juice containing the enzyme ‘pepsin´, which has to be activated by HCL (Hydrochloric acid). The stomach wall also produces HCL.

Pepsin is the enzyme that starts breaking down proteins.

**Gizzard:** The gizzard is unique to birds. The gizzard wall is strong and muscular and its lining is tough, leathery and keratinised. No enzymes are produced here. The gizzard contains grit (stones, pebbles) which replace teeth for grinding the feed. Pepsin continues to work here.

**Duodenum:** The first part of the small intestines. The products of two organs (liver and pancreas) are deposited in the duodenum.

**Liver:** The liver produces, bile, which is, stored in the "gallbladder" and flows through the bile duct into the duodenum. The bile acids emulsify the fat-fraction in the feed: i.e. fat droplets (in the gut contents) are broken down into smaller droplets. In this way the inside of a fat droplet can be reached easier by fat digesting enzyme (lipase). The functions of bile can be listed as follows:

1. Emulsification of fats.
2. Activating peristaltic movement of the intestines.
3. Neutralising the content of the intestines (together with pancreas).
4. Giving specific colour to the faeces.

**Pancreas:** The pancreas produces pancreatic juice, which contains:

- Sodium bicarbonate to neutralise the acid gut contents
- Digestive enzymes:
  - ***amylase*** and a little bit of maltase for the digestion of carbohydrates
  - ***trypsin*** for a further breaking down of proteins
  - ***lipase*** to digest fats

**Jejunum + ileum:** The jejunum and ileum (small intestines) produce intestinal juice containing the following digestive enzymes:

- ***erepsin*** to digest proteins and break them down into their final products;
- ***lipase*** to digest fats;
- ***maltase* and *saccharase*** to digest carbohydrates and break them down into their final products.

The small intestine is the main site of absorption. It contains the villi (microscopic finger-like projections) which greatly increase the surface available for absorption of nutrients.

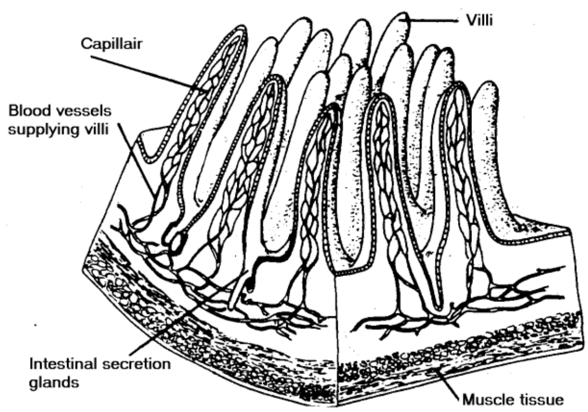



Figure: The villi of the small intestine

- Amino acids are the products of protein digestion;
- Glucose is the product of carbohydrate digestion;
- Glycerol and fatty acids are the products of fat digestion.

**Caeca:** Birds have two caeca, where bacteria and other micr-organisms use crude fibre as the most important medium to live on. They produce the enzyme cellulase in order to digest cellulose.
At the same time, the bacteria produce Vitamin K and B12. Water is re-absorbed in the caeca.

**Colon:** The colon, or large intestine, and rectum are very short. Faeces can be stored here temporarily and a little absorption of water takes place.

**Cloaca:** The cloaca is the cavity at the end of the digestive tract where the digestive tract meets with the urinary and genital systems.

**Chemical digestion in short**

**Proteins**

Proteins are long chains of amino acids.
*Proteins* are broken down into *peptones* (smaller chains) by *pepsin (+ HCL*),
*Peptones* are broken down into *polypeptides* by trypsin,
*Polypeptides* are broken down into single *amino acids* by *erepsin*.
Some examples of amino acids:
Lysine; Methionine; Cystine; Tryptophan; Threonine, … etc.

**Fats or lipids**

Fats are short molecules, badly soluble in water.
After emulsification by bile, fats are broken down into glycerol and 3 fatty acids by the enzyme lipase. The fatty acids present in the fat may be variable.
Some examples of fatty acids:
Oleic acid; Linoleic acid; Palmitic acid; Stearic acid.

**Carbohydrates**

Carbohydrates (or sugars) are long chains of "saccharide’s".
Polysaccharides are broken down into disaccharide’s by *amylase*. Disaccharide’s are broken down into mono-saccharide’s by several enzymes. Examples are given in the table below.

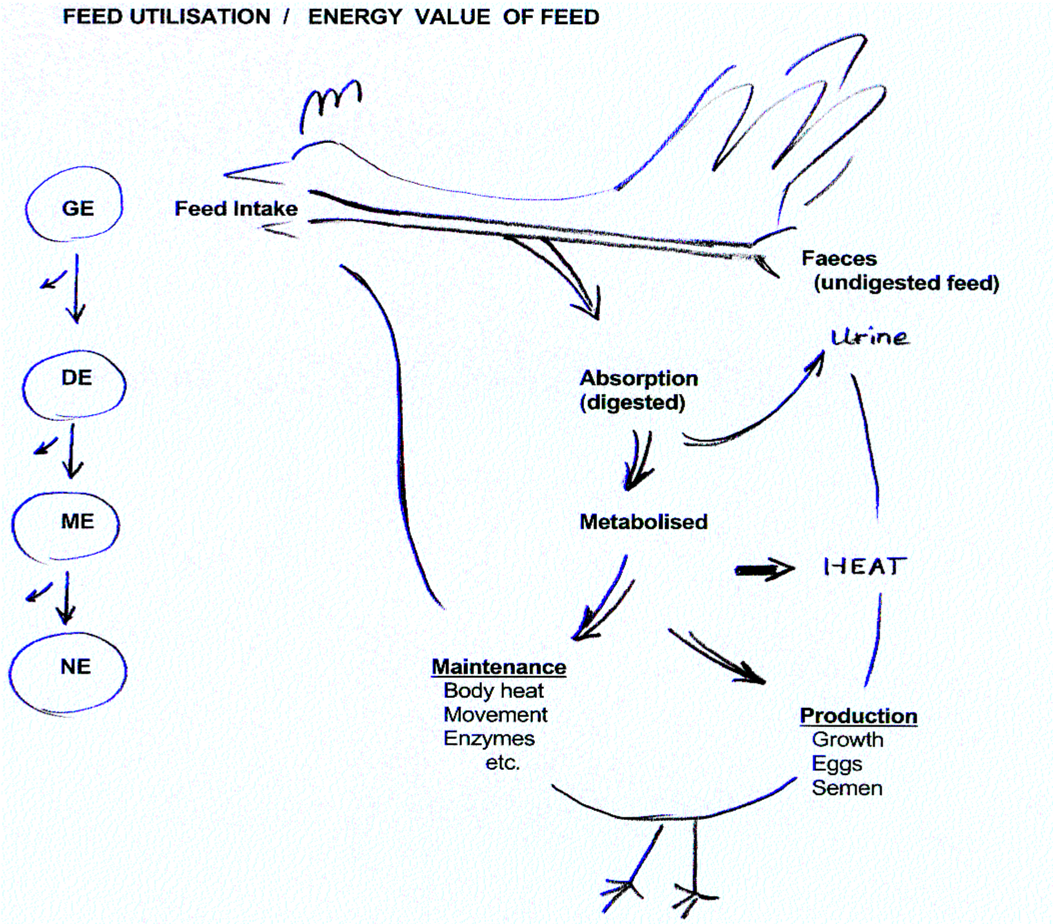
| **Disaccharide** | **Enzyme** | **Mono-saccharide’s** |
|---|---|---|
| Maltose | Maltase | 2 glucose molecules |
| Saccharose | Saccharase | fructose and glucose |
| Lactose | Lactase | galactose and glucose |

Some remarks about different carbohydrates:

- Starch is the main carbohydrate in poultry feeds, abundantly present in grains and tubers. Cooking (baking) is breaking the starch-structure and is improving digestion (making easier approach for the enzymes).
- The fowl lacks the enzyme lactase so birds cannot make use of lactose (milk sugar) which is present in milk products.
- *Dextrose* is a kind of glucose.
- *Cellulose* is the main component of crude fibre. Only micro-organisms have the enzyme "cellulase" to digest cellulose into maltose.

**Utilisation of Energy**

**Fig: Schematic presentation of the energy utilisation of birds**




Estimating ME through feed analysis:

$$ME\ (kcal/kg) = 4.31 \times grams\ dcp + 9.28 \times grams\ dee + 4.14 \times grams\ dNFE$$

or

$$ME\ (kcal/kg) = 3.82 \times grams\ cp + 7.85 \times grams\ ee + 4.1 \times grams\ starch + 3.6 \times grams\ sugars$$

The formulas utilised to estimate the energy value of feeds, are based on the components of the organic matter of the feed, those that are contributing to the potential energy in the feed.

A major problem remains how to estimate reliable figures for the digestibility of the different components.

**Metabolism (CHO, Protein, Lipid)**

The hydrolysis products of digestion are absorbed through the alimentary tract into the blood stream and distributed to the cells of the body where they undergo chemical changes. The utilization of nutrients and excretion of the end products in the body are the processes of the metabolism.

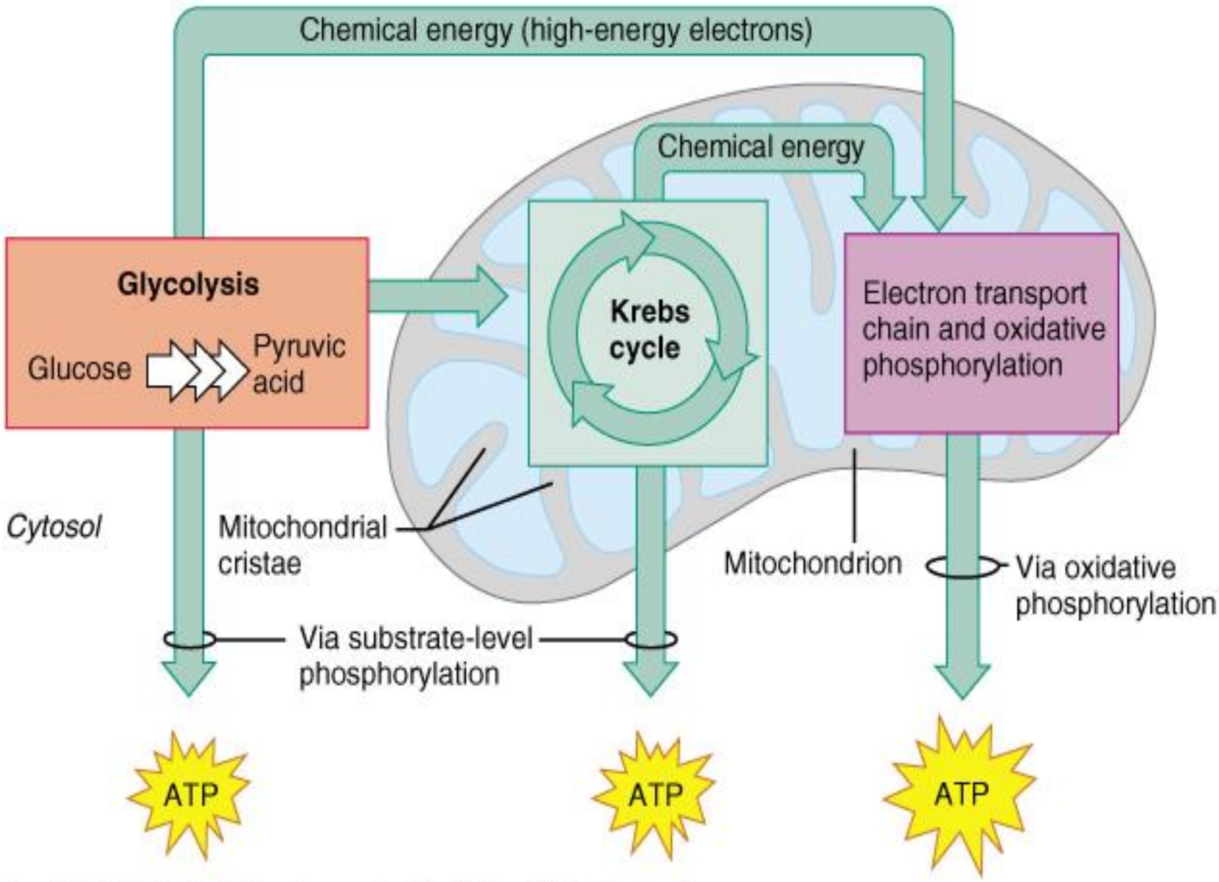
**Types of Metabolic Reactions**

- Anabolic reactions - energy requiring synthesis reactions

- Catabolic reactions - energy releasing reactions that generate ATP

**Glucose Metabolism**

- Glycolysis
- Acetyl Coenzyme A
- Krebs Cycle
- Electron Transport Chain





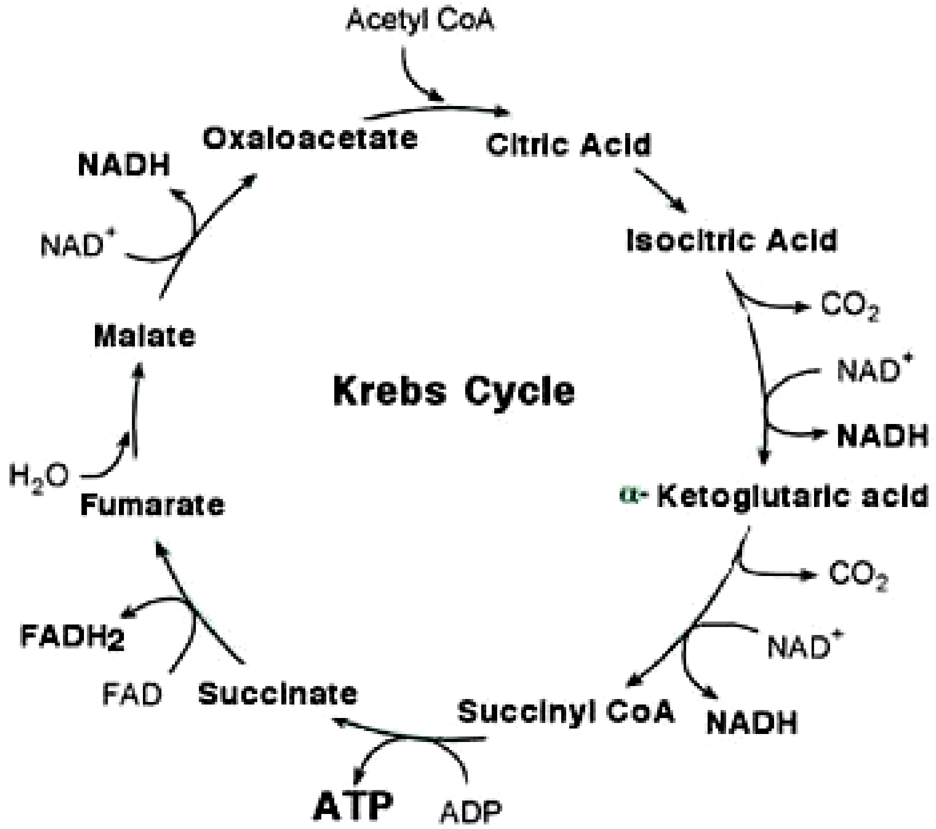

**Glycolysis**

- Glucose molecules are broken down into two molecules of pyruvic acid in the cytoplasm of the cell

**Acetyl CoA Formation**

- Pyruvic acid is decarboxylated by the removal of $CO_2$ into a two carbon acetyl group
- Occurs in the mitochondria of the cell

**Kreb's Cycle - TCA Cycle**




**Electron Transport**

- Involves electron carrier molecules that will release energy in a controlled way
- This energy is used to generate ATP
- Occurs inner mitochondrial membrane

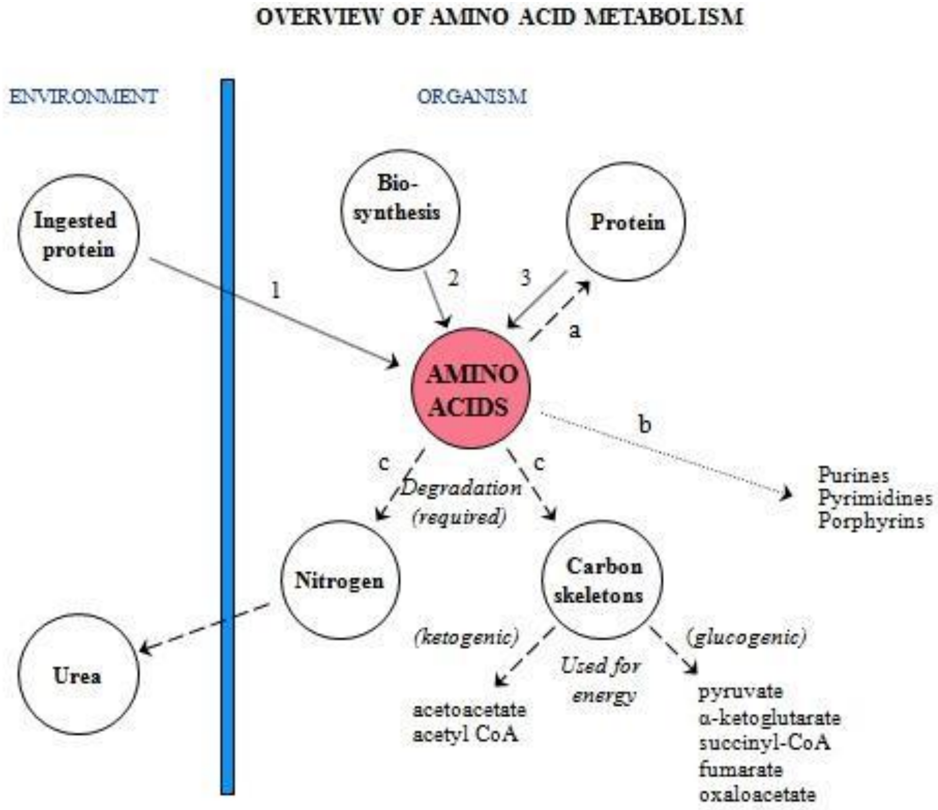
**ATP Production**

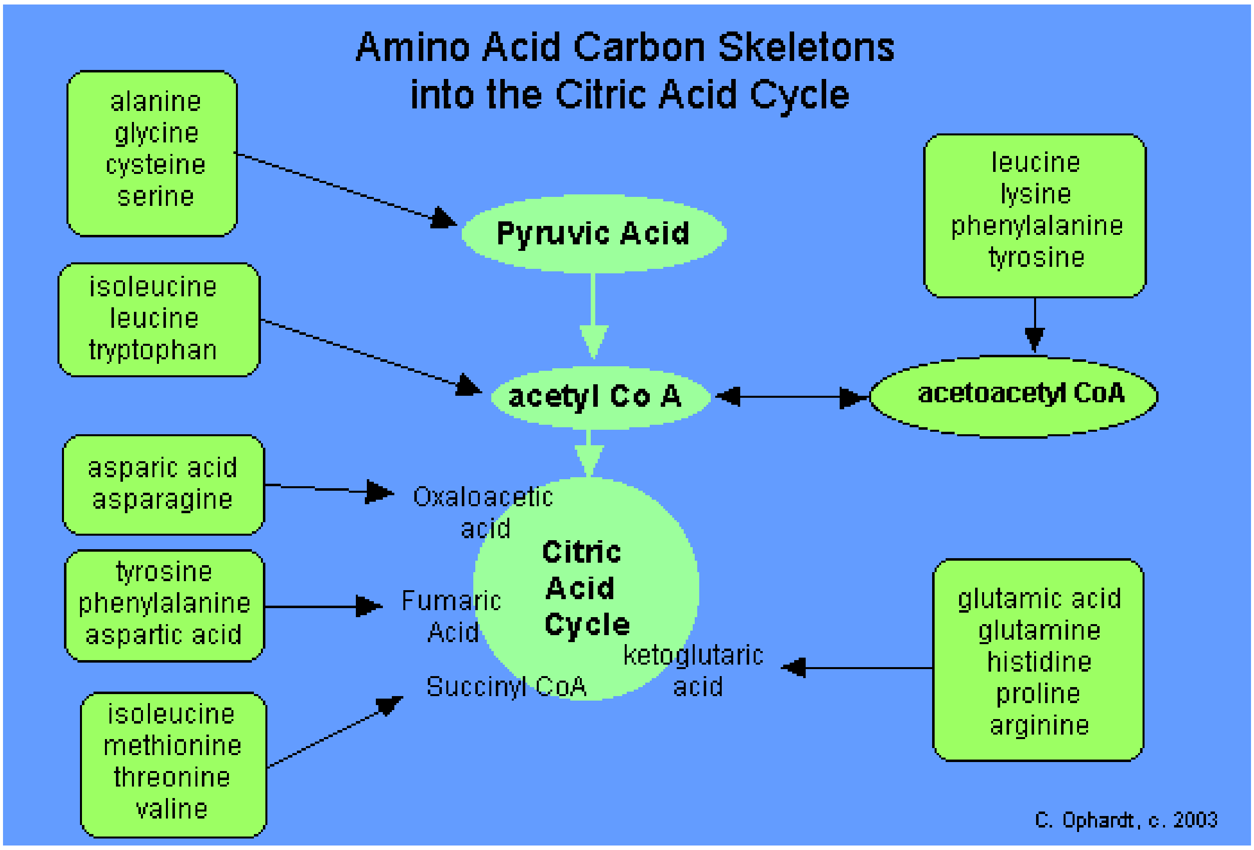
1 mole of glucose to 2 moles of pyruvate → 8 ATP (Glycolysis)
2 moles pyruvate to 2 moles of Acetyl CoA → 6 ATP
2 moles of pyruvate to CO2 and water → 24 ATP (TCA Cycle)

**Glucose Anabolism**

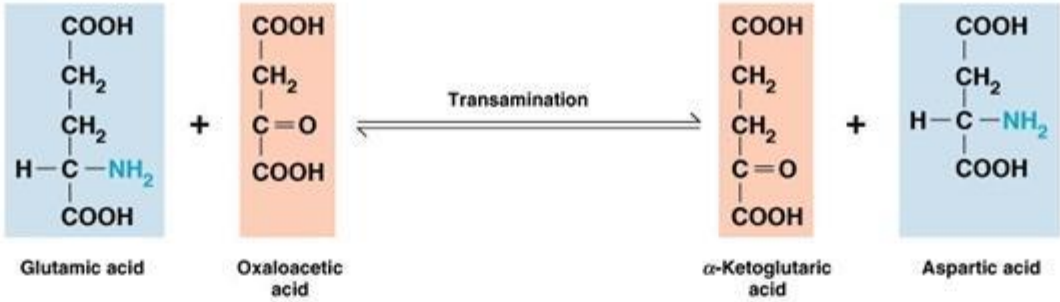
- Glycogenesis - conversion of glucose to glycogen; stimulated by insulin
- Glycogenolysis - hydrolysis of glycogen to form glucose; stimulated by glucagon
- Gluconeogenesis - synthesis of glucose from non-carbohydrates such as fats and amino acids

**Protein Metabolism**



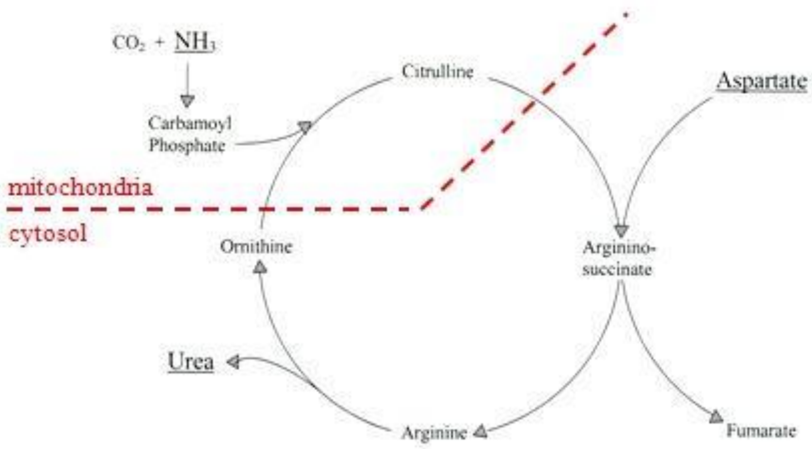
# TRANSAMINATION




**(b) Process of transamination**

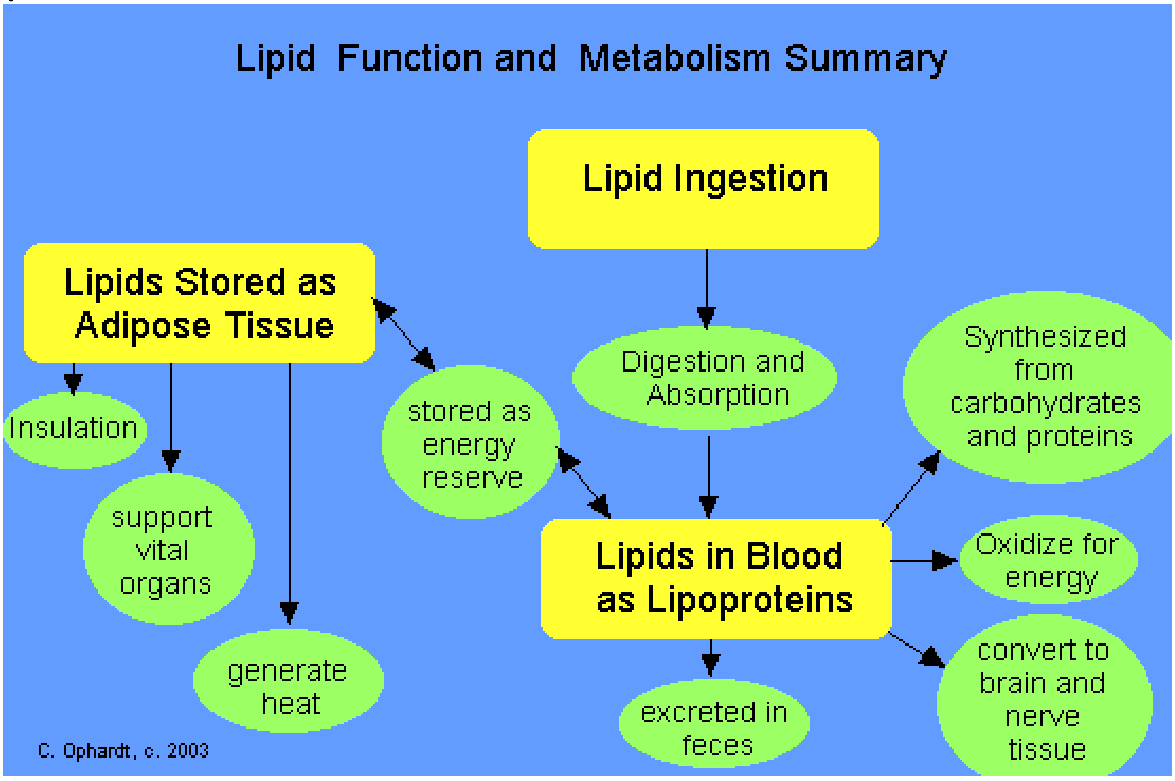


# UREA CYCLE

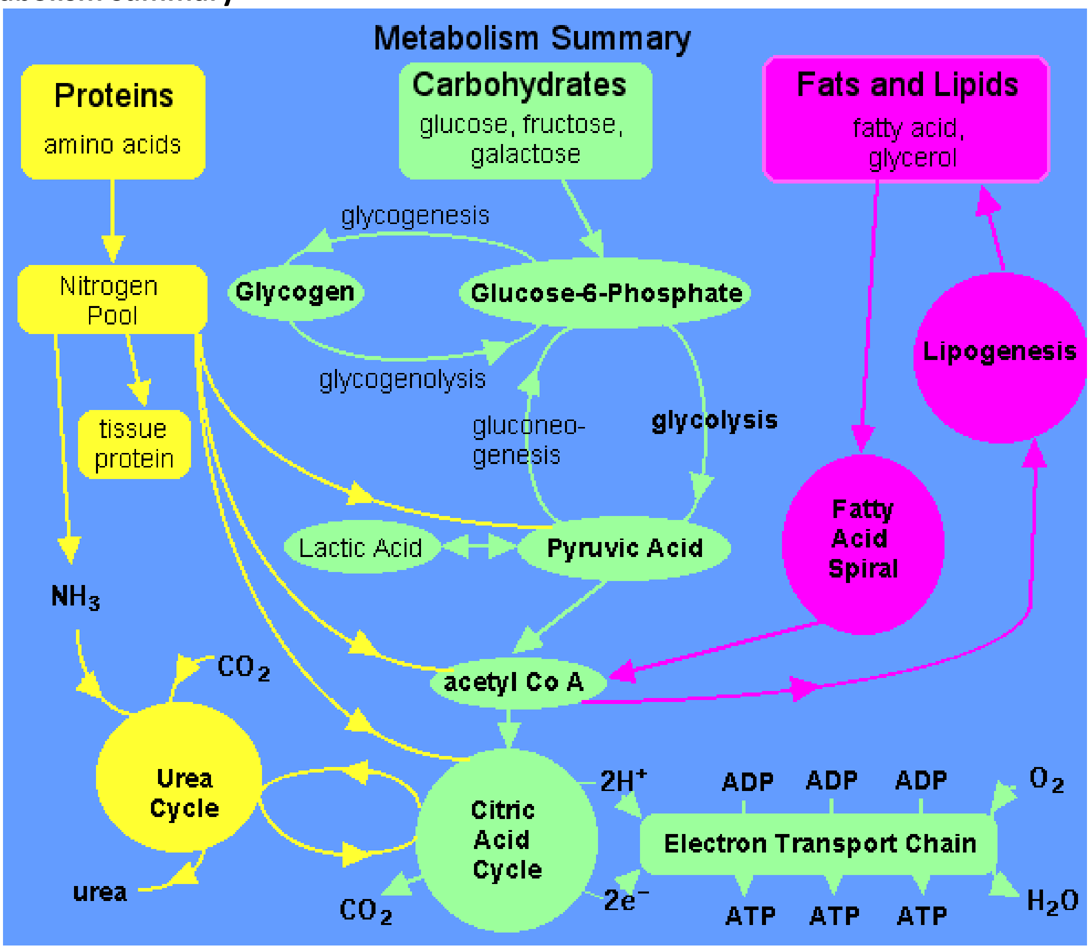



Function: detoxification of ammonia
(prevents hyperammonemia)

**Lipid Metabolism**




**Metabolism summary**



## Interrelations among Fats, Proteins and Carbohydrates

The metabolism of fatty acids and that of carbohydrates and proteins are intimately related. The constituents are in a constant state of flux. Even the structural proteins, carbohydrates and storage lipids are constantly broken down and rebuilt.

The status of a particular animal is the net result between the rates of synthesis and of breakdown of its body constituents. Glycerol is the only component of lipids that is involved in the synthesis of carbohydrates. On the other hand, lipids can be formed from carbohydrate in many ways. Indeed, the metabolism of lipids, carbohydrates and proteins is metabolically dynamic.

Some of the facts about metabolism of carbohydrates, fats and proteins set forth in the earlier chapters are summarized in Table 2.

**TABLE 2** Metabolism

| Nutrient | Anabolism | Catabolism |
|---|---|---|
| Carbohydrates | Temporary excess changed into glycogen by liver cells in presence of insulin; stored in liver and skeletal muscles until needed and then changed back to glucose | Oxidized, in the presence of insulin, to yield energy and wastes ($CO_2$ and $H_2O$) |
| Fats | Built into adipose tissue; stored in fat depots of body | Fatty acids are beta-oxidized to acetyl CoA; glycerol is converted into acetyl CoA through glycolysis |
| Proteins | Synthesized into tissue proteins, blood proteins, enzymes, hormones, etc. | Deaminated by liver, forming ammonia (which is converted to urea) and keto acids (which are either oxidized or changed to glucose or fat) |

# Chapter-3
## Feedstuffs and ration formulation

### Principles of poultry feeding

The production of eggs and market poultry is a process of transforming comparatively cheap feeds into high-priced products for human consumption. The fowl's body is the agent which effects this transformation. Under the highly specialized conditions of commercial egg production, the poultryman cannot expect the greatest efficiency from his birds without a working knowledge of the principles of animal nutrition. Poultry feeding should be based on the food requirements of the birds, the nutritive value of the different feeds and a knowledge of how to use these with particular objects in view.

### Assignment-

Conventional and unconventional feedstuffs- limitation, use and prospect in poultry industry

### Factor affecting the selection of feed ingredients

- Price of feed ingredient
- Nutritional level
- Toxicity level of feed
- Availability of feed ingredient
- Moisture content of feed
- Inclusion level
- Physical condition (sticky, solid, powder, liquid, semi-solid etc.)
- Chemical nature
- Foreign particles
- Smell
- Residue effect
- Etc.

### Use of agro-industrial byproducts in poultry ration

Ref.- Poultry by G. C. Banerjee. Page 128-129.

### Essential steps in ration formulation

- Classes of animal (species, age, weight, production stage)
- Requirement of animals (feeding standard)
- Selection of feed ingredients
- Composition of feeds (proximate analysis)
- Priority for balancing
    - ✓ Energy
    - ✓ Protein
    - ✓ Minerals (Ca & P), Etc.

**Feeding Standard (European standard)**
(also called the nutrient requirements)

| | ME/kg | | | Maximum | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Feed** | **MJ** | **Kcal** | **cp** | **c.fat** | **c.fibre** | **lys** | **meth** | **M+C** | **Ca** | **P** | **Pav** |
| Chick | 11.7 | 2800 | 20.0 | 6.0 | 5.0 | 1.00 | 0.45 | 0.80 | 1.0 | 0.7 | 0.50 |
| Grower | 11.7 | 2800 | 16.0 | 6.0 | 6.0 | 0.80 | 0.32 | 0.70 | 1.0 | 0.6 | 0.35 |
| Layer: | | | | | | | | | | | |
| complete | 11.5 | 2750 | 16.5 | 8.0 | 8.0 | 0.70 | 0.28 | 0.60 | 3.7 | 0.8 | 0.50 |
| High Energy | 11.9 | 2850 | 17.0 | 8.0 | 7.0 | 0.75 | 0.30 | 0.65 | 3.7 | 0.8 | 0.50 |
| Low calcium | 11.3 | 2700 | 16.0 | 8.0 | 8.0 | 0.70 | 0.28 | 0.60 | 2.5 | 0.8 | 0.50 |
| Broiler: | | | | | | | | | | | |
| starter | 13.0 | 3000 | 22.0 | 9.0 | 5.0 | 1.20 | 0.50 | 0.90 | 1.0 | 0.8 | 0.50 |
| finisher 1 | 13.4 | 3200 | 20.0 | 10 | 5.0 | 1.00 | 0.45 | 0.80 | 1.0 | 0.7 | 0.50 |
| finisher 2 | 13.4 | 3100 | 19.0 | 10 | 5.0 | 0.95 | 0.44 | 0.76 | 0.9 | 0.7 | 0.50 |
| Parentstock: | | | | | | | | | | | |
| Broiler.p.stoc | 11.3 | 2700 | 16.0 | 8.0 | 9.0 | 0.70 | 0.30 | 0.60 | 3.2 | 0.7 | 0.45 |
| k | 11.5 | 2750 | 16.5 | 8.0 | 8.0 | 0.70 | 0.28 | 0.60 | 3.6 | 0.8 | 0.50 |
| Layer.p.stock | 11.5 | 2750 | 16.0 | 8.0 | 8.0 | 0.70 | 0.30 | 0.60 | 1.5 | 0.65 | 0.40 |
| Pre-breeder | 11.5 | 2750 | 11.0 | 8.0 | 8.0 | 0.48 | 0.22 | 0.40 | 0.90 | 0.65 | 0.40 |
| Cocks> 22 wks | | | | | | | | | | | |

**Note**: Energy is expressed per kg of feed; other nutrients as % of feed.

**Different between broiler and layer nutrition**

- Different in feeding standard
- Pellet for broiler
- Mash for layer
- High Ca in laying bird
- Restriction feeding in layer
- Free feeding for broiler
- Pick order occurred in layer

## Feeding Standard (Animal Feed Rules, 2013 of Bangladesh)

তফসিল- ৪ (ঙ)

(বিধি-৭ দ্রষ্টব্য)

বিভিন্ন বয়সের বাণিজ্যিক লেয়ার মুরগির পুষ্টি তালিকা

(ক) বাড়ন্ত মুরগি

| পুষ্টির বিবরণ | একক | স্টার্টার (০-৫ সপ্তাহ) | গ্রোয়ার (৫-১০ সপ্তাহ) | পুলেট/ডেভলপার (১০-১৬ সপ্তাহ) |
|---|---|---|---|---|
| মেটাবোলাইজেবল এনার্জি | কিলো ক্যালরি/কেজি | ২৯৫০-৩০১০ | ২৮০০-২৯৫০ | ২৭৫০-২৮৫০ |
| ক্রুড প্রোটিন | % | ২০.৫-২১.৫ | ১৭.৫-২০.০ | ১৬.৫-১৬.৮ |
| মিথিওনিন | % | ০.৪৩-০.৫২ | ০.৩৬-০.৪৭ | ০.৩৪-০.৩৫ |
| মিথিওনিন ও সিষ্টিন | % | ০.৭৭-০.৮৬ | ০.৬৫-০.৮০ | ০.৫৮-০.৬৩ |
| লাইসিন | % | ১.০৭-১.১৬ | ০.৮৮-১.০৩ | ০.৭৬-.০৭৮ |
| ট্রিপটোফেন | % | ০.২১-০.২২ | ০.১৯-০.২০ | ০.১৬-০.১৭ |
| থ্রিওনিন | % | ০.৭৫-০.৭৮ | ০.৬৭-০.৬৯ | ০.৫৩-০.৬০ |
| আইসোলিওসিন | % | ০.৯০-০.৯৫ | ০.৮২-০.৮৫ | ০.৭২-০.৭৫ |
| আরজিনিন | % | ১.০-১.১৫ | ০.৯৪-১.০ | ০.৮৮-০.৯০ |
| লিনোলেনিক এডিস | % | ১.২-১.৩ | ১.০-১.১০ | ১.০-১.১০ |
| অতিরিক্ত তেল | % | ১.০-১.২৫ | ০.৫০-০.৬০ | ০.৫০-০.৬০ |
| মেজর মিনারেলস | | | | |
| ক্যালসিয়াম | % এর কম নয় | ১.০৫ | ০.৯০ | ০.৯৫ |
| ফসফরাস (এভাইল্যাবল) | % এর কম নয় | ০.৪৮ | ০.৪৪ | ০.৩৮ |
| ক্লোরিন | % এর কম নয় | ০.১৫-০.১৭ | ০.১৫-০.১৭ | ০.১৫-০.১৭ |
| সোডিয়াম | % এর কম নয় | ০.১৫-০.১৮ | ০.১৫-০.১৮ | ০.১৫-০.১৮ |
| এডেড ট্রেস মিনারেল/কেজি | | | | |
| ম্যাঙ্গানিজ | পিপিএম | ৫০-৬০ | ৫০-৬০ | ৫০-৬০ |
| জিংক | পিপিএম | ৪০-৬০ | ৪০-৬০ | ৪০-৬০ |
| আয়রন | পিপিএম | ৩৫-৬০ | ৩৫-৬০ | ৩৫-৬০ |
| কপার | পিপিএম | ৫-১০ | ৫-১০ | ৫-১০ |
| আয়োডিন | পিপিএম | ০.৩৫-১.০ | ০.৩৫-১.০ | ০.৩৫-১.০ |
| সেলিনিয়াম | পিপিএম | ০.২-৩০ | ০.২-৩০ | ০.২-৩০ |
| এডেড ভিটামিন/কেজি | | | | |
| ভিটামিন এ | আই ইউ | ১০০০০-১৩০০০ | ১০০০০-১৩০০০ | ১০০০০ |
| ভিটামিন ডি ৩ | আই ইউ | ৩০০ | ৩০০ | ২০০০-৩০০০ |
| ভিটামিন  ই | আই ইউ | ২০-২৫ | ২০-২৫ | ২০-২৫ |
| ভিটামিন কে ৩ | মিলি গ্রাম | ২.০-২.২ | ২.০-২.২ | ২.০-২.২ |
| ভিটামিন বি ২ | মিলি গ্রাম | ৫.০-৫.৫ | ৫.০-৫.৫ | ৫.০-৫.৫ |
| ভিটামিন বি ১২ | মিলি গ্রাম | ০.০১-০.০২ | ০.০১-০.০২ | ০.০১-০.০২ |
| থায়াসিন | মিলি গ্রাম | ৩৫-৬০ | ৩৫-৬০ | ৩৫-৬০ |
| ভিটামিন বি ১ | মিলি গ্রাম | ২.০-২.১ | ২.০-২.১ | ২.০-২.১ |
| ভিটামিন বি ৬ | মিলি গ্রাম | ৪.৫-৫.০ | ৪.৫-৫.০ | ৪.৫-৫.০ |
| প্যানটোথেনিক এসিড | মিলি গ্রাম | ১২-১৫ | ১২-১৫ | ১২-১২ |
| ফলিক এসিড | মিলি গ্রাম | ০.৫ | ০.৫ | ০.৫০-০.৭৫ |
| বায়োটিন | মিলি গ্রাম | ০.১-০.২০ | ০.১-০.২০ | ০.১-০.২০ |
| ক্লোরিন ক্লোরাইড | মিলি গ্রাম | ৬০০-১৩০০ | ৬০০-১৩০০ | ৫০০-১৩০০ |

## Feeding Standard (Animal Feed Rules, 2013 of Bangladesh)

(খ) প্রি-লেয়ার

| **উপাদান** | **একক** | **প্রিলেয়ার ১৬-প্রথম ডিম পাড়া পর্যন্ত** | **লেয়ার-১ প্রথম ডিম পাড়া থেকে ৩০ সপ্তাহ পর্যন্ত** | **লেয়ার-২ ৩১-৪২ সপ্তাহ পর্যন্ত** | **লেয়ার-৩ ৪৩ সপ্তাহ থেকে ৮০% ডিম পাড়া পর্যন্ত** | **লেয়ার-৪ ৮০% ডিম পাড়ার নিচে** |
|---|---|---|---|---|---|---|
| মেটাবোলাইজেবল এনার্জি | কিলো ক্যালরি/কেজি | ২৭৫০-২৯১০ | ২৮৮০-২৯৬০ | ২৮৬০-২৯২৫ | ২৮২০-২৯১০ | ২৮২০-২৯১০ |
| ক্রুড প্রোটিন | % | ১৭.৫ | ১৮.৭ | ১৮.০ | ১৮.৫ | ১৬.০ |
| মিথিওনিন | % | ০.৩৬-০.৩৮ | ০.৪৩ | ০.৪১-.৩৮ | ০.৩৯-.৩৭ | ০.৩৫ |
| মিথিওনিন ও সিষ্টিন | % | ০.৬২-০.৬৮ | ০.৭১ | ০.৬৭-০.৭০ | ০.৬৩-০.৬৬ | ০.৬১ |
| লাইসিন | % | ০.৮০-৮৭ | ০.৮৮ | ০.৮৫ | ০.৮১ | ০.৭৮ |
| ট্রিপটোফেন | % | ০.১৮-১৯ | ০.২১-২২ | ০.১৯-.২০ | ০.১৮-.১৯ | ০.১৭ |
| থ্রিওনিন | % | ০.৫৬-৬১ | ০.৬৭-৬৯ | ০.৬৪-.৬৭ | ০.৬-.৬২ | ১.৫৯ |
| লিনোলেনিক এসিড | % | ১.১০ | ১.৩০ | ১.২৫ | ১.২০ | ১.১০ |
| অতিরিক্ত তেল | % | ০.৫-১.০ | ১.০-৩.০ | ০.৫-১.০ | ০.৫-১.০ | ০.৫-১.০ |
| মেজর মিনারেল | | | | | | |
| ক্যালসিয়াম | %এর কম নয় | ২.০ | ৩.৯৫ | ৪.০ | ৪.১৫ | ৪.২০ |
| ফসফরাস (এভাইল্যাবল) | %এর কম নয় | ০.৪৭ | ০.৪৬ | ০.৪৪ | ০.৪২ | ০.৩৮ |
| ক্লোরিন | %এর কম নয় | ০.১৫-০.১৬ | ০.১৬ | ০.১৫ | ০.১৫ | ০.১৫ |
| সোডিয়াম | %এর কম নয় | ০.১৫-০.১৮ | ০.১৭-০.১৯ | ০.১৬-০.১৮ | ০.১৫-০.১৮ | ০.১৫ |
| এডেড ট্রেস মিনারেল/কেজি | | | | | | |
| ম্যাঙ্গানিজ | পিপিএম | ৬০-৬৫ | ৬০-৬৫ | ৬০-৬৫ | ৬০-৬৫ | ৬০-৬৫ |
| জিংক | পিপিএম | ৫০-৬০ | ৫০-৬০ | ৫০-৬০ | ৫০-৬০ | ৫০-৬০ |
| আয়রন | পিপিএম | ৩৫-৬০ | ৩৫-৬০ | ৩৫-৬০ | ৩৫-৬০ | ৩৫-৬০ |
| কপার | পিপিএম | ৫.০-৬.০ | ৫.০-৬.০ | ৫.০-৬.০ | ৫.০-৬.০ | ৫.০-৬.০ |
| আয়োডিন | পিপিএম | ০.৫-১.০ | ০.৫-১.০ | ০.৫-১.০ | ০.৫-১.০ | ০.৫-১.০ |
| সেলিনিয়াম | পিপিএম | ০.২-০.৩০ | ০.২-০.৩০ | ০.২-০.৩০ | ০.২-০.৩০ | ০.২-০.৩০ |
| এডেড ভিটামিন/কেজি | | | | | | |
| ভিটামিন এ | আই ইউ | ১০০০০ | ১০০০০ | ১০০০০ | ১০০০০ | ১০০০০ |
| ভিটামিন ডি ৩ | আই ইউ | ২০০০-৩০০০ | ২০০০-৩০০০ | ২০০০-৩০০০ | ২০০০-৩০০০ | ২০০০ |
| ভিটামিন ই | আই ইউ | ২০-২৫ | ২০-২৫ | ২০-২৫ | ২০-২৫ | ২০-২৫ |
| ভিটামিন কে ৩ | মিলি গ্রাম | ২.০ | ২.০ | ২.০ | ২.০ | ২.০ |
| ভিটামিন বি ২ | মিলি গ্রাম | ৫.০ | ৫.০ | ৫.০ | ৫.০ | ৫.০ |
| ভিটামিন বি ১২ | মিলি গ্রাম | ০.০০৮-০১ | ০.০০৮-০১ | ০.০০৮-০১ | ০.০০৮-০১ | ০.০০৮ |
| নায়াসিন | মিলি গ্রাম | ২৫-৩০ | ২৫-৩০ | ২৫-৩০ | ২৫-৩০ | ২৫-৩০ |
| ভিটামিন বি ১ | মিলি গ্রাম | ২.০ | ২.০ | ২.০ | ২.০ | ২.০ |
| ভিটামিন বি ৬ | মিলি গ্রাম | ৩.০-৫.০ | ৩.০-৫.০ | ৩.০-৫.০ | ৩.০-৫.০ | ৩.০-৫.০ |
| প্যানটোথেনিক এসিড | মিলি গ্রাম | ১০-১১ | ১০-১১ | ১০-১১ | ১০-১১ | ১০-১১ |
| ফলিক এসিড | মিলি গ্রাম | ০.৫০-০.৭৫ | ০.৫০-০.৭৫ | ০.৫০-০.৭৫ | ০.৫০-০.৭৫ | ০.৫০ |
| বায়োটিন | মিলি গ্রাম | ০.১০-০.১৫ | ০.১০-০.১৫ | ০.১০-০.১৫ | ০.১০-০.১৫ | ০.১০ |
| ক্লোরিন ক্লোরাইড | মিলি গ্রাম | ৫০০-৫৫০ | ৫০০-৫৫০ | ৫০০-৫৫০ | ৫০০-৫৫০ | ৫০০-৫৫০ |

বিশেষ দ্রষ্টব্য: পোল্ট্রি ব্রিডার্স এসোসিয়েশন অব বাংলাদেশ কর্তৃক বিভিন্ন বয়সের বাণিজ্যিক লেয়ার মুরগির পুষ্টি তালিকা যুক্তিসংগতভাবে কম বেশী হতে পারে।

## Feeding Standard (Animal Feed Rules, 2013 of Bangladesh)

বিভিন্ন বয়সের বাণিজ্যিক ব্রয়লার মুরগির পুষ্টি তালিকা

| উপাদান | একক | স্টার্টার<br>০-২১ দিন পর্যন্ত | গ্রোয়ার<br>২২-৩৭ দিন পর্যন্ত | ফিনিশার<br>৩৮ দিন |
|---|---|---|---|---|
| মেটাবোলাইজেবল এনার্জি | কিলো ক্যালরি/কেজি ডিএম | ৩০০০-৩১০০ | ৩০৫০-৩২০০ | ৩১০০-৩২০০ |
| ক্রুড প্রোটিন | % | ২১-২৩ | ১৯-২১ | ১৮-২০ |
| ক্রুড ফ্যাট | % | ৫.০-৭.০ | ৫.০-৭.০ | ৫.০-৭.০ |
| লিনোলেনিক এসিড | % | ০.৯৫-১.০ | ০.৯৫-১.০ | ০.৯৫-১.০ |
| এন্টি অক্সিডেন্ট | মিলি গ্রাম/কেজি | ১২০-১৫০ | ১২০-১৫০ | ১২০-১৫০ |
| অ্যামাইনো এসিড | | | | |
| মিথিওনিন | % | ০.৪৭-০.৫ | ০.৪৪-০.৪৯ | ০.৩৮-০.৪৭ |
| মিথিওনিন ও সিস্টিন | % | ০.৯০-০.৯৩ | ০.৮২-০.৮৯ | ০.৭৫-০.৮৬ |
| লাইসিন | % | ১.০৬-১.২৫ | ০.৯৮-১.১৫ | ০.৯০-১.০৫ |
| ট্রিপটোফেন | % | ০.০২-০.২৪ | ০.১৮-০.২১ | ০.১-০.১৮ |
| থ্রিওনিন | % | ০.৭০-০.৮০ | ০.৬৭-০.৭৬ | ০.৬৩-০.৭০ |
| আরজিনিন | % | ১.২৮-১.৪০ | ১.২০-১.২৫ | ০.৯৬-১.০৫ |
| মেজর মিনারেল কনটেন্ট | | | | |
| ক্যালসিয়াম | % এর কম নয় | ০.৯০ | ০.৯০ | ০.৮০ |
| ফসফরাস (এভাইল্যাবল) | % এর কম নয় | ০.৪৩ | ০.৩৯ | ০.৩৫ |
| ক্লোরিন | % এর কম নয় | ০.১৮-০.৩০ | ০.১৮-০.৩০ | ০.১৮-০.৩০ |
| সোডিয়াম | % এর কম নয় | ০.১৬-০.২২ | ০.১৬-০.২২ | ০.১৬-০.২২ |
| এডেড ট্রেস মিনারেল/কেজি | | | | |
| ম্যাঙ্গানিজ | পিপিএম | ৬৬-১০০ | ৬০-১০০ | ৬০-১০০ |
| জিংক | পিপিএম | ৫০-৮০ | ৫০-৮০ | ৫০-৮০ |
| আয়রন | পিপিএম | ৬৬-১০০ | ৬৬-১০০ | ৬৬-১০০ |
| কপার | পিপিএম | ৮-১০ | ৮-১০ | ৮-১০ |
| আয়োডিন | পিপিএম | ০.৪৫-১.০ | ০.৪৫-১.০ | ০.৪৫-১.০ |
| সেলিনিয়াম | পিপিএম | ০.২০-.৩০ | ০.২০-.৩০ | ০.২০-.৩০ |
| এডেড ভিটামিন/কেজি | | | | |
| ভিটামিন এ | আই ইউ | ৯,০০-১২,৫০০ | ৯,০০-১২,৫০০ | ৯,০০-১০০০০ |
| ভিটামিন ডি ৩ | আই ইউ | ২০০০-৩৩০০ | ২০০০-৩৩০০ | ২০০০-৩০০০ |
| ভিটামিন ই | আই ইউ | ৩০-৩৫ | ৩০-৩৫ | ৩০-৩৫ |
| ভিটামিন কে ৩ | মিলি গ্রাম | ২০-২২ | ২০-২২ | ২০-২২ |
| ভিটামিন বি ২ | মিলি গ্রাম | ৫.৫-৮.০ | ৫.৫-৮.০ | ৫.৫-৮.০ |
| ভিটামিন বি ১২ | মিলি গ্রাম | ০.০১-০.০২২ | ০.০১-০.০২২ | ০.০১-০.০১৫ |
| নায়াসিন | মিলি গ্রাম | ৪০-৬৬ | ৪০-৬৬ | ৪০-৬৬ |
| ভিটামিন বি ১ | মিলি গ্রাম | ২.০-৪.৫ | ২.০-৪.৫ | ১.৬৫-৪.০ |
| ভিটামিন বি ৬ | মিলি গ্রাম | ৩.০-৪.৪ | ৩.০-৪.৪ | ৩.০ |
| প্যানটোথেনিক এসিড | মিলি গ্রাম | ১০-১২ | ১০-১২ | ৯.০-১২ |
| ফলিক এসিড | মিলি গ্রাম | ১.০ | ০.৯-১.০ | ০.৭৫-১.০ |
| বায়োটিন | মিলি গ্রাম | ০.১০-০.২০ | ০.১০-০.২০ | ০.১০-০.১৫ |
| কোলিন ক্লোরাইড | মিলি গ্রাম | ৫৫০-৭৫০ | ৫৫০-৭৫০ | ৪৪০-৬৭৫ |

বিশেষ দ্রষ্টব্য: পোল্ট্রি ব্রিডার্স এসোসিয়েশন অব বাংলাদেশ কর্তৃক বিভিন্ন বয়সের বাণিজ্যিক ব্রয়লার মুরগির পুষ্টি তালিকা যুক্তিসংগতভাবে কম বা বেশী হতে পারে।

**Maximum inclusion rates poultry feed (Inclusion Level)** Safe maximum recommended percentages of ingredients in poultry rations

| **Ingredients** | **Animal (category)** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **starter 0-6 wks** | **grower > 6 wks** | **rearing > 14 wks** | **layers** | **broiler** | **Broiler parent stock** | **remarks** |
| Alfalfa meal | 5 | 5 | 5 | 5 | 5 | 5 | High fibre, only use 2.5% for layer |
| Barley | 20 | 30 | 45 | 50 | 10 | 50 | Low fibre, low energy, not for broiler |
| Barley: by-products | 10 | 10 | 15 | 15 | 10 | 15 | |
| Beans; toasted | 5 | 5 | 5 | 5 | 5 | 5 | ANF lactin present |
| Blood meal | 2 | 2 | 2 | 2 | 2 | 2 | Taste not good |
| Coconut cake / meal | 5 | 5 | 5 | 5 | 5 | 5 | depending on aflatoxin |
| Fats / oils | 5 | 5 | 5 | 5 | 8 | 5 | Laxative, technical problems with mixing |
| Feather meal | 2 | 2 | 2 | 2 | 2 | 2 | Digestion problem |
| Fish meal | 10 | 10 | 10 | 5 | 5 | 5 | Smell |
| Groundnut cake / meal | 5 | 5 | 7.5 | 10 | 5 | 10 | depending on aflatoxin between 5 – 30% |
| Maize | 60 | 60 | 60 | 60 | 60 | 60 | White meat broilers 10% max. |
| Maize Bran | 20 | 30 | 30 | 30 | 15 | 30 | Fibre, Germ and high oil |
| Maize gluten meal | 10 | 10 | 10 | 10 | 10 | 10 | As a colorant |
| Meat & bone meal | 6 | 6 | 6 | 7 | 6 | 7 | Ca, P ratio not balance; high Ca |
| Millet | 20 | 20 | 20 | 20 | 20 | 20 | High fibre |
| Molasses | 3 | 3 | 3 | 3 | 3 | 3 | Sugar is laxative, High potassium |
| Oats | 20 | 20 | 20 | 20 | 10 | 20 | High fibre, low energy |
| Peas | 5 | 5 | 10 | 10 | 5 | 5 | ANF tanin |
| Sesame cake / meal | 15 | 15 | 20 | 20 | 15 | 20 | High methionine |
| Bone meal | 7 | 7 | 7 | 7 | 7 | 7 | Ca, P ratio, 7% needed |
| Cassava | 20 | 30 | 30 | 30 | 30 | 30 | Dusty, In mash feeds 10% less than mentioned |
| Rapeseed meal | 5 | 5 | 5 | 5 | 10 | 5 | ANF |
| Soybean full fat | 20 | 20 | 20 | 20 | 20 | 20 | Well tested, Not more due to oil |
| Soya oil | 5 | 5 | 5 | 5 | 5 | 5 | High oil |
| Rice bran | 10 | 10 | 10 | 10 | 10 | 10 | depending on CF level: < 9 cf 30%, 9 – 15 cf 20% and > 15 cf 10% |
| Sesame cake / meal | 15 | 15 | 20 | 20 | 15 | 20 | High methionine |
| Sorghum | 30 | 30 | 50 | 50 | 30 | 50 | ANF tannin, not more than 10% if don't know tannin level |
| Soybean meal | 35 | 35 | 35 | 35 | 35 | 35 | Well taste, as much as you like |
| Sunflower cake / meal | 5 | 5 | 5 | 5 | 5 | 5 | non dehulled, high fibre 40% CF |
| Sunflower cake | 10 | 10 | 10 | 10 | 10 | 10 | partly dehulled, 30% CF |
| Sunflower cake | 15 | 15 | 15 | 15 | 15 | 15 | dehulled, 20% CF |
| Sweet potatoes | 10 | 10 | 15 | 15 | 15 | 15 | Sugar laxative |
| Pure lysine | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | |
| Synthetic methionine | 0.20 | 0.20 | 0.20 | 0.30 | 0.30 | 0.30 | |
| Wheat | 30 | 40 | 50 | 50 | 30 | 50 | It is coagulate, High viscisity |

**Chapter-4**
**Poultry feeding and feed efficiency**

**Methods of Poultry Feeding:**
Improperly fed well-balanced ration will not give the most satisfactory results unless a satisfactory method is followed. Some of the methods are as follows:

**1. Whole grain feeding**: In this system feed ingredients are supplied to the birds in the separate containers.

**2. Grain and mash method**: In this system some ingredients are supplied as grain or gain mixture along with balanced mash.

**3. All mash:** This is a scientific and popular method. Ingredients mixture mash is fed either in dry or wet. Dry mash is used in layer chicken and wet mash is used in duck.

**4. Pellet feedings**: Now-a-days it is a very popular method. There is no option for bird during feed intake. Pellet is prepared from dry mash under high pressure. In this system wastage of feed can be avoided. Pellet is used in broiler chicken.

There are mainly two types of poultry feeding system

1. Pan Feeding System (Manual and Automatic)

**Tube and Auger**

**Feed Hopper**

**Drive Unit**

**Poultry Manual Feeder and Drinker**

2. Chain Feeding System

**Feeding Hopper**

**Drive Unit**

**90 DEGREE CORNER**

**Feed Chain**

**Feeding Trough**

**CHAIN FEEDING SYSTEM ON STANDS**

**AUTOLIMIT FEED SCALE**

**GOOD REASONS FOR PAN FEEDING**

- $360^{o}$ mechanism in the pan– ideally suited for day-old chicks.
- Circular arrangement of hens around the pan feeds 60% more birds per running meter than a linear trough.
- Height and width of the feeding space can be adjusted to the hen's growth.

- Elevated feed channel and rotateable pan gives freedom of movement for the birds and easy for cleaning.
- Minimum cost than chain feeder.

**GOOD REASONS FOR CHAIN FEEDING**

- Automated chain feeding system.
- Robust and simple.
- Restricted broiler breeder feeding by increasing the conveying speed to 36m/min.
- Proven system that has been improved and adapted to today's modern requirements for poultry management.

**Feed efficiency**

Feed efficiency is considered as an important parameter assessing the potential of bird strain or feeding programs. However many factors (e.g. bird age, sex, health and environmental temperature) affecting feed intake and growth rate. Although the single largest factor affecting feed efficiency is the energy level of the feed. Research shows that as the nutrient level of diets is reduced, birds eat more to compensate. Birds almost doubled their normal feed intake on very low nutrient based diets.

Therefore nowadays feed efficiency can be quite a variable number, and perhaps losing is significance as being able to compare birds' performance under a range of field conditions. High energy prices often result in lower energy values usage in one or all of the diets of feeding program.

Striving for a low feed efficiency may not be always the most economical situation, because economics may dictate the optimum use of low rather than high diet energy levels. Much more useful measures will be feed cost/kg weight gain for economic insights or energy intake per unit of weight gain for feed usage.

## Chapter-5: Feed additives

### Introduction

Making compound feed is generally referring to choosing from different raw materials in such quantities, that a balanced feed for the most important nutrients is obtained.

Besides, there is a wide variety in additional ingredients in order to enhance the nutritive value of the feed, or to improve the health and productivity of the animals.

They are indicated as “additives” and are generally only required in very small amounts.
Therefore they may be included in a premix, to mix properly with the other feed ingredients.
Compared to the other ingredients the premixes commercially available, are very expensive.
In order to keep the costs of feed within limits each additive should be considered carefully, before deciding to include it in the ration formula.

### Nutritive additives

Additives which are necessary from a nutritional viewpoint are called nutritive additives. If there is a shortage of these, it will result in deficiency diseases. In complete feeds these are generally considered as indispensable.
Examples of nutritive additives are:

- Vitamins
- Minerals
- Amino acids.

### Non-nutritive additives

Additives, which are not necessary from a nutritional viewpoint are called non-nutritive additives. If they are left out of the feed, no deficiency diseases occur. Non-nutritive additives have an effect on the feed and on the production of the animal. Examples of non-nutritive additives are:

| | |
|---|---|
| Antibiotics | Pelleting agents (binders) |
| Coccidiostats | Anti-oxidants |
| Growth stimulants | Emulsifiers/stabilisers |
| Organic acids | Flavours |
| Pigments | Mould inhibitors. |

In certain occasions a waiting period before the animal is slaughtered, is obligatory, during which no drugs should be given, or included in the feed.
This is called: withdrawal period.

The use of additives is subject to regulations and instructions, which should be followed carefully. Always there should be concern for:

1. Toxicity, if dosage is too high
2. Residue in the product, with dangerous effect for the consumer (carcinogenous)
3. Development of resistant strains of micro-organisms
4. Pollution of the environment.

In 1950-1960's antibiotics and sulfa drugs were produced on large scale.
Nowadays almost all the feeds contain additives, mainly for conservation of the feed and improving Feed Conversion Rates.
The growth promoting additives stimulate performance indirectly: They reduce the growth of pathogenic micro-organisms in the digestive tract. By doing that these additives may cause a better health of the animal and allow a better nutrient utilisation and an improved development. The performance is generally better, compared to when no growth promoting additives were used.

Growth promoting additives have the biggest effect on:

- young growing animals
- low hygienic conditions
- sub-healthy animals

The response is mostly greater in sub-quality diets, but .... they do not improve the feed itself, they do not compensate when the feed is not well-balanced!

Growth promoting additives should not be included in rations for:

- breeding stock: no proper selection, less effect in adult animals
- last days before slaughter: withdrawal period
- laying birds: residues may pass on to the eggs.

**Antibiotics**
Antibiotics are isolated from live-micro-organisms, they kill (bactericide) of reduce growth (bacteriostatic) of other micro-organisms.
"Broad = (Wide) spectrum" activity means, that they act against different kind of micro-organisms.

Antibiotics are used in two ways:

| **Preventively = Prophylactic** | **Curatively = Therapeutic** |
|---|---|
| low dosage<br>permanently in the feed<br>increase performance<br><br>sometimes short withdrawal period. | high dosage<br>short period<br>treatment through feed, water, or injection<br><br>always withdrawal period when applied through the feed, called: medicated feed. |

- Antibiotics should not be used in feeds for breeding stock Reasons:
    - adult animals less effective
    - less differentiation for selection
    - less antibodies produced by the body against diseases
    - accumulation in the body, when used for a long lifetime.

Antibiotics are mostly found in feeds for young stock in order to overcome the risks of the youth period; they are found in feeds for fattening animals in order to obtain optimal results.

Examples of antibiotics used

| Preventively | Curatively |
|---|---|
| Zn-bacitracin *<br>Tylosin *<br>Flavomycin<br>Spiramycin *<br>Virginiamycin *<br>Avoparcin *<br>Avilamycin<br>Monensin-Na (for rumen stimulation) | Oxytetra cycline<br>Chlortetra cycline<br>Penicillin<br>Streptomycin |

* In 1998 a heated debate started, about the danger of "cross-resistance" of different bacteria's against even the most potent antibiotics, used in hospitals. As a result of this discussion the inclusion of these antibiotics in animal feed is forbidden in the E.U., and the intention is to ban all preventive antibiotics from 2006.

Other anti-microbial agents

Synthetic substances, which kill or inhibit growth of micro-organisms.

In Europe these products are not permitted to be included in the feed preventively.

Examples: Arsenicals
Sulfa products
Nitro furans.

**Coccidiostats**

Drugs to protect the animals against coccidiosis:

- poultry (broiler, rearing;  layers not possible because of residues)
- rabbits
- calves
- lambs

Even if coccidiosis is not detected, it might be present at a low level and retard growth which results in:

- low production
- high feed conversion rate.

Examples are (active substances):

- Amprolium (+ ethopabate)
- D O T (Dinitro Ortho Toluamide) *
- Monensin-Na (poultry)
- Ethopabate

Nicarbazin
Narasin
Meticlorpindol/methylbenzoquate
Lasalocide-Na
Aprinocide *
Salinomycine-Na.

* Not permitted in the EU anymore after October 1999.

**Growth stimulants**

These drugs, which improve growth (better health) are used mainly in feeds for young fatteners. Mostly it is not allowed to add antibiotics to a ration when there are growth stimulants added.

Examples:

- Nitrovin* (mainly in poultry feeds)
- Carbadox*
- Olaquindox* (mainly in pig feeds)
- Cu (copper sulfate) in pig rations.

*The first 3 are now banned from the list of permitted additives in the EU, while the use of copper has been strongly limited: in animal feeds maximum Cu content is 35 ppm, while only for fatteners younger than 16 weeks, a maximum of 175 ppm Cu may be included in the feed.

**Hormones**

Estrogens stimulate the rate of gain and feed conversion, especially in ruminants.

- DES (Di Ethyl Stilboestrol), synthetic estrogen widely used subcutaneously implanted or injected.
- Thyroprotein (Iodinanted casein), orally with thyroid hormone activity.
- Growth hormone: Somatotrop Hormone: PST (Porcine) and BST (Bovine).
  Especially (steroid) sex hormones are feared for possible residues in the animal products, and in Europe the use of hormones is not allowed.

**Pigments:** colouring matters

The yellow pigments are of importance in poultry rations

**yellow pigments:**

| **Carotenoids** | **xanthophylls** |
| --- | --- |
| with vitamin A activity | no vitamin A activity |
| eg. $\alpha$-carotene | eg. zeaxanthin |
| $\beta$-carotene | capsanthin |
| $\gamma$ -carotene | canta xanthin |
| Cryptoxanthene | luteïn |

Xantophylls and excess carotenes are deposited in bodyfat and yolk.

The main natural sources of yellow colouring matters are:

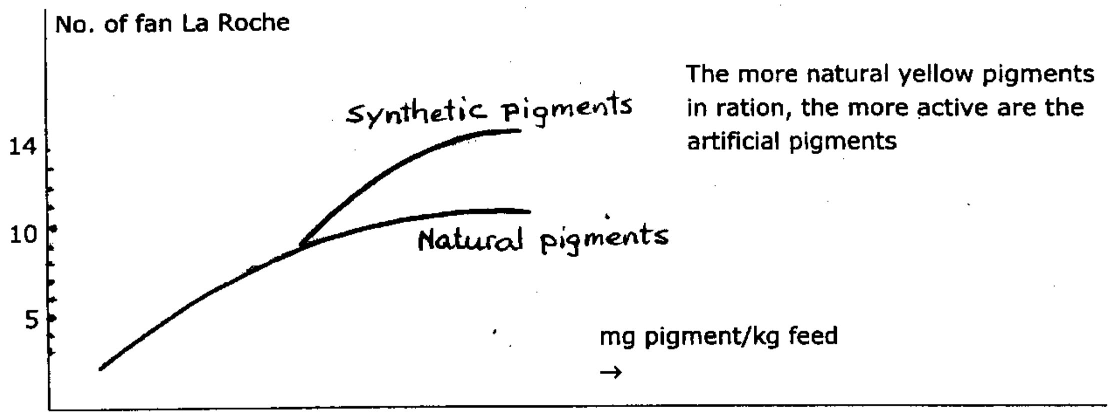
yellow corn and its byproducts, especially maize gluten
dried lucerne meal.

**Layers**

The consumer usually prefers a dark yellow to orange coloured yolk.
The colour can be measured with a colour fan (a.o. developed by Hoffmann - Laroche).

A ration, including 50% yellow maize and 2% dried lucernemeal will result in a colour rating of
+ 10 in the scale of LaRoche.

If for example a colour no. 14 is required, then extra artificial pigments are needed.
The effect of additional pigments can be indicated by a graph:




Infections in the wall of the intestines decrease the absorption of pigments and show a yolk which will be more pale.
Antibiotics and other anti-microbial substances reduce infections in the gut and improve absorption of the yellow pigments also.

**Broilers**
Sometimes white meat is preferred by the consumer, in other cases the consumer prefers yellow meat.
Sources for yellow pigments in the meat, see above.
White meat is produced by raw materials which do not contain yellow colouring matters such as:

- white maize
- tapioca
- wheat
- sorghum
- millet
- animal fat

So it depends on which ingredients are used as sources for energy (lucerne meal is not practised in broiler rations).

**Antioxidants**
Oxidation will occur in time, but is accelerated by ultra-violet light, and high temperatures.

Sensitive for oxidation are: vitamins A and E
unsaturated fatty acids
colouring matters, especially carotene's

Examples of anti-oxidants are: a-tocopherol (vitamin E)
ethoxyquin
BHT (Butyl Hydroxy Toluene)
BHA (Butyl Hydroxy Anisol)

**Emulsifiers or stabilisers**

- Substances to bring fats in emulsion.

The emulsifier has got a fat soluble part and a water-soluble part. Frequently used in artificial milk powder.
Examples:

- Lecithin
- CMC (Carboxy-Methyl-Cellulose)

**Organic acids**
Organic acids are often utilized in:

- Milk replacers, to prevent prepared milk from spoilage or deterioration.
- Feeds for young mammals (piglets, calves) in order to create and acid environment in stomach and duodenum, that harmful bacteria do not develop.

The application of organic acids has also been extended to poultry feeds.
Examples:

- lactic acid (natural)
- citric acid
- acetic acid
- formic acid
- sorbic acid
- propionic acid

**Mould inhibitors**
Mould inhibitors are added to a feed to preserve the product. Moulds develop very fast under more humid conditions; also when the humidity of the feed prepared is too high (> 13%)
Example:

- propionates (Ca-, NH4-)
- Gentian Violet

**Binders or peletting agents**
Binders are added to the ration in order to produce a hard and compact pellet. They hold the ingredients together, besides that they may not be toxic and may not interfere with the other nutrients. Also molasses and oil can be used for that purpose, but only in low percentages.
Important also in feeding fish, when the pellet may not fall apart (dissolve) in the water.
Examples:

- seed gums
- ligno sulfonate
- cellulose derivates, such as CMC = Carboxy Methyl Cellulose
- kaolinite
- bentonite

**Flavours**
Flavours give an attractive smell or taste to the feed, which is important for young mammals (piglets, calves). When their first feed is tasty, they tend to eat early solid food and as much as they like.

Examples:

- Vanilla
- Dextrose
- "pig nectar"

**Probiotics**
To give a stimulant to the presence of good bacteria in the balance of micro-organisms in the gut (in the large intestines mainly), cultures of lacto-bacillus, acidophilus or saccharomyces spp are included in dry form (but alive) in pig feeds for young animals.
This bacteria are supposed to have a first chance within the gut and therefore improve the colonisation-resistance against pathogenic bacteria. This means that the pathogenic bacteria, for example Coli's, get less opportunity to establish and damage the intestines.
Additional compounds , like oligo-saccharides, were discovered to be used as specific nutrients for the probiotics, to enhance them in their fight against pathogenic bacteria. These compounds are indicated as “Pre-biotics “.

**Immuno-globulines**
Also to enhance the resistance of young animals against pathogenic bacteria the inclusion of immuno-globulines is possible. This is quite expensive, but effective. For that reason the use of “dried serum solubles” has been used for feeds for piglets.
Enzymes
To support the digestion, additional enzymes may be added to feed, when:

- the own enzymes are not fully developed yet; e.g. very young piglets;
- the animal does not produce these enzymes at all; e.g. cellulase;
- to reduce the excretion by increasing the digestibility; e.g. phytase to release phytin-P;
- to break down NSP (Non Starch Polysaccharides), preventing the content of the intestines to be to viscous for the digestive enzymes to function well.

Other commercial enzymes are:

- Ilzyme (pentosanase = xylanase)<br>amylase, cellulase<br>protease, glucanase
- Lyxasan ß-xylanase
- Avizyme xylanase, protease<br>ß-glucanase, pectinase

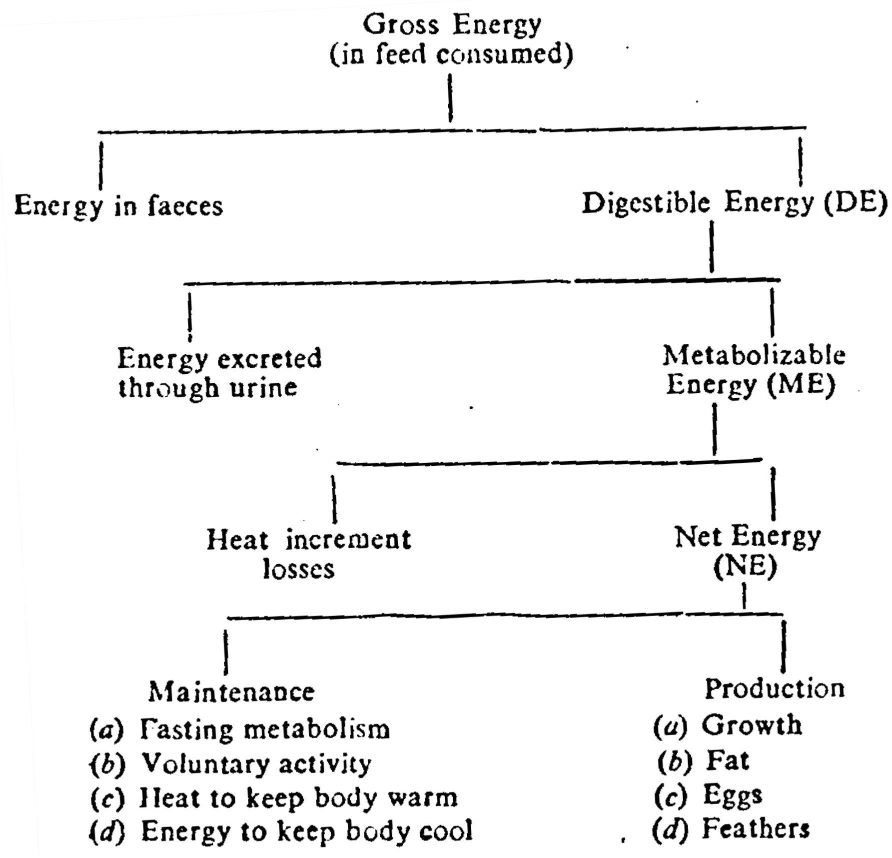
Other health stimulants
Since 1997 a strong consumers demand developed to ban all preventive antibiotics and growthstimulants from animal feed. Since then a lot of research is going on to find alternative products, to maintain the high feed efficiency.
Nutritional acids received a lot of extra attention and also the positive influence of indigestible carbohydrates (oligo-saccharides) on a healthy intestinal flora seems very promising.

Furtheron also the use of natural herbs or extracts, to improve resistance of the animals, or enhance efficiency of metabolisme, or even reduce the ammonia evaporation from the manure are getting more attention nowadays.

**Chapter-6**
**Energy for poultry**

## Measures of feed energy

Measures of energy value of feeds are shown in the following chart:




## Energy requirement of chickens

*Basal metabolism*

Basal metabolic rate determinations have indicated that BMR of the adult hens in terms of net energy may be calculated according to the formula: NEm = 83XBW $(Kg)^{0.75}$. Thus for a hen weighting 1.75 kg, the NEm = 83X1.52 = 126 Kcal/hen/day. Since NEm is approximately 82% of the Mem (the metabolizable energy values are about 18% higher than the net energy values) then 126/0.82 = 154 Kcal represents the MEm.

*Activity*

The energy required for activity depends upon the degree of activity of the bird. Under normal conditions this amounts to about 50% of the energy needed for the basal metabolism. It is only 37% of the BMR in the caged layers. In the example given in the preceding paragraph, adding 50% of the BMR value for the normal activity, the total ME requirement of a non-laying hen comes to 154+77 = 231 Kcal/hen/day. The energy content of a large egg is 86 Kcal. Thus the total ME requirement of a white leghorn hen in 100% production is 231+86 = 317 Kcal/day at $21^0$ C.

**Factors affecting metabolic rate of birds**

*Ration*

Fed high protein and low energy rations, growing birds utilize food energy with less efficiency, as a higher proportion is lost in the form of heat.

**Feed consumption of Broilers as affected by the dietary energy levels**

| *Metabolizable energy content of ration (megacalorie/kg)* | *Feed consumption (kg upto 6th week (of age)* |
|---|---|
| 2.8 | 2.4 |
| 2.9 | 2.3 |
| 3.0 | 2.2 |
| 3.1 | 2.1 |
| 3.2 | 2.0 |
| 3.3 | 2.0 |

*Environmental temperature*

At temperature lower than the physiological critical temperature birds increase their metabolic rate for maintaining the deep body temperatures.

*Nutritional status*

In well-nourished poultry, the metabolic rate is higher than in undernourished or starving birds.

*Season*

Seasonal changes in the metabolic rate have been reported and seen to result from the alterations in the thyroid secretion. Some workers have reported up to 50% increase in the thyroid secretion during the autumn.

*Breed*

Significant differences in metabolic rates of various breeds have been reported, but in most cases, these differences may only reflect the differences in the body size of these breeds and may not be real. However, two distinct populations in a group of Plymouth Rock and white leghorn crossed hybrids, one having an average metabolic rate of 67 $Kcal/Kg^{0.75}$ per day and the other 86 $Kcal/Kg^{0.75}$ per day have been reported by Tasaki and Sakurai (1969).

*Sex and reproductive ability*

Makes probably have a higher metabolic rate than females, although during the growing period, it is difficult to separate the factors of metabolic size, age and endocrinological status. A laying chicken has a higher metabolic rate than a non-laying bird and during the egg production phase, the basal metabolic rate of chickens attains highest levels.

*Activity*

The effect of activity of birds on their heat production and metabolic rate are well known. The metabolic rate is increased by about 40-50% immediately on standing.

**Symptoms of energy deficiency**

When energy requirements for maintenance are not met through dietary sources, body energy stores are consumed up in the following order:

1. The small amount of glycogen normally stored in the liver and muscle tissues are used up
2. Body stores of fat are depleted
3. Ultimately the protein tissues are also exhausted to maintain the glucose level of blood and to permit other vital body processes.

**Symptoms of excess of energy**

A slight dietary excess of energy produces no deleterious effect except that the fat deposition on carcass is increased and growth rate declines. The growth rate reduced because due to the excess dietary energy levels, the birds are able to meet their energy requirements by the ingestion of only a small amount of feed which restricts their protein and other nutrients consumption to a level below that required for normal growth or egg production. With the energy level of the ration being in excess feed intake many decrease to a level that severe deficiency symptoms of amino acids, minerals and vitamins may appear and growth may cease. The chickens become obese and show signs of protein and vitamin malnutrition.

## Chapter 7
## Nutrients requirement

### Protein nutrition

Proteins are complex, organic compounds composed of many amino acids linked together through peptide bonds. Chicken cannot synthesize many of the amino acids present in their body proteins. These amino acids need to be provided as such by dietary proteins. As proteins vary in their amino acid composition, different feeds and diets having similar protein levels may differ widely in nourishing the body. Thus, protein differ in their quality.

**Protein requirement of growing chickens**

The protein requirement of a growing chickens is composed of the amount needed for maintenance plus that in the growth tissue formed with an allowance for the losses in the digestion and metabolism. The protein requirement of growing white leghorn chicken can be estimated from the following formula:

$$\text{Protein requirement (grams/day)} = \frac{(0.0016 \times W) + (0.18 \times W) + 0.07 \times W\ 0.82}{0.55}$$

Where,

0.0016, as the gram protein needed for maintenance per gram body weight,

W, as the gain in body weight in gram/day,

0.18, as the tissue gain contains 18% protein,

0.07, as the feather weight constitutes 7% of body weight,

0.82, as the protein content of feathers is 82%,

0.55, as the efficiency of utilization of dietary protein is 55%.

Broiler chickens are more efficient in the utilization of dietary proteins for growth (64%) than white leghorn chickens (55%). Hence, the above formula can be used for calculating the daily protein requirement of broilers, simply by replacing 0.55 with 0.64.

**Protein requirement of laying chickens**

During the first phase of laying (20-42 weeks) of chickens, about 12 gm protein will be required in the diet for the formation of an egg. Maintenance requirement of protein of an average pullet of white leghorn or similar types is about 3 gm/day. Increase in the body weight per day is about 10 gm on an average and therefore will require about 2 gm protein. Thus a total of 17 gm protein needs to be provided in the diet of laying chicken during the first phase of egg production.

The second phase of egg laying lasts from 43-62 weeks. During this period, the eggs laid are heavier than during the first phase and therefore protein requirement for egg production slightly increases. However, chickens do not normally increase their body weight during this phase and therefore no protein allowance is needed for growth. Thus the requirement of 17 gm protein per day per laying bird remains constant throughout the first and second phase of egg production.

Chickens are not individually fed and therefore their protein requirement needs to be expressed as percent of diet. It is reported that practical layer diets may contain 18% protein during the first phase of egg production, 16% during the second phase and 15% after crossing 62 weeks in age.

**Calorie-Protein Ratio**

It is said that birds eat for energy. Once their energy requirement has been met, they will not consume any more feed even if the requirement for other nutrients like proteins, vitamins or minerals have not been met. This makes necessary that diets must contain protein in relation to their energy content so that symptoms of protein deficiency do not occur. Thus a constant relationship between the dietary metabolizable energy and protein level needs to be maintained in the diet of various classes of chickens. The calorie : protein ratio (C : P ratio) is defined as bellows:

$$\text{C: P ratio} = \frac{\text{Metabolizable energy in Kcal/Kg diet}}{\text{\% protein in the diet}}$$

The recommended C : P ratio for the diet of various classes of chickens are as follows:

| | |
|---|---|
| Starter chicken (0-8 weeks) | 135:1 |
| Grower chicken (8-20 weeks) | 140:1 |
| Layer chicken (20 weeks onward) | 170-180:1 |
| Starter broiler chicken (0-6 weeks) | 135:1 |
| Finisher broiler chicken (6 weeks onward) | 155:1 |

**Protein for phase feeding**

Phase feeding refers essentially to reductions in the protein and amino acid level of the diet as the bird progresses through a laying cycle. The concept of phase feeding is based on the fact that as birds get older, their feed intake increases, while egg mass output decreases. For this reason, it should be economical to reduce the nutrient concentration of the diet. The two reasons for reducing the level of dietary protein and amino acids during the latter stages of egg production are first, to reduce feed costs and second, to reduce egg size. The advantages of the first point are readily apparent if protein costs are high, but the advantages of the second point are not so easily defined and will vary depending upon the egg pricing.

The appropriate reduction in protein level will depend on the season of the year (effect of temperature on feed consumption, age and production of the bird, and energy level of the diet). It is recommended that protein intake be reduced from 19 to 18 g/day after the birds have dropped to 90% production, and to 15-16 g/day after they have dropped to 80% production. With an average feed intake of 95 g/day, this would be equivalent to diets containing 20, 19 and 16% protein. The amino acid to be considered in this exercise is methionine, since this is the amino acid that has the greatest effect on egg size. A one-time reduction in diet methionine of 20% has been reported to reduce egg size by 3% with concomitant loss in egg production of 8%.

**Methods for evaluating protein quality (for non-ruminants)**

**1. Protein efficiency ratio (PER):** It is a measure of weight gain of a growing animal divided by protein intake.

$$\text{PER} = \frac{\text{Weight gain (gm)}}{\text{Protein intake (gm)}}$$

**2. Biological value (BV):** Biological value (BV) is defined as that proportion of the digested (and absorbed) that is not excreted in the urine i.e. percent of the absorbed nitrogen retained by the body for maintenance and/for growth.

$$BV= \frac{\text{N intake} - (\text{faecal N} + \text{urinary) N)}}{\text{N intake} - \text{faecal N}} \times 100$$

$$BV = \frac{\text{Retained nitrogen}}{\text{Absorbed nitrogen}} \times 100$$

**3. Net Protein utilization (NPU):** Net Protein utilization (NPU) a measure of protein quality based on the percentage of ingested nitrogen that is retained by the body.

$$NPU= \frac{\text{Retained nitrogen}}{\text{Intake of nitrogen}} \times 100$$

**Symptoms of protein deficiency**

Marginal deficiency of protein in the diet of chicken stimulates their appetite and feed consumption is increased. In layer chickens marginal protein deficiency may not cause reduction in egg production but causes the reduction in egg production but causes the reduction in the egg size. Severe deficiency of protein in the diet of growing chicken causes slow growth, poor feathering, lack of appetite, feather picking and cannibalism. In layer chickens feed consumption decreases and egg production declines markedly. In deep litter houses not many feathers may be seen on the floor as birds develop the tendency to consume them.

**Symptoms of excess protein**

Excessively high protein content in the diets (over 30%) result in a higher concentration of uric acid in the blood, deposition of calcium ureate crystal in and on the soft internal tissues and degeneration of kidney.

## Lipid Nutrition

### Fatty Acid

Fatty acid is a carboxylic acid with a long aliphatic chain. Fatty acids are important source of energy because when metabolized, they yield large quantities of ATP.

### Type

1. Saturated: Without double bond.
2. Unsaturated: Have carbon-carbon double bond one or more.

### Free Fatty acids

When fatty acids are not attached to other molecules, are known as free fatty acid.

### Essential Fatty Acids

Essential Fatty Acids are fatty acids that humans and other animals must ingest because the body requires them for good health but cannot synthesize them. The term essential fatty acid refers to fatty acids required for biological processes but one fatty acids are essential for chicken named Linoleic acid.

### Beta-oxidation

Beta-oxidation is the catabolic process by which fatty acid molecules are broken down in the mitochondria to generate acetyl-CoA, which enters the citric acid cycle, and NADH and FADH2, which are co-enzymes used in the electron transport chain. It is named as such because the beta carbon of the fatty acid undergoes oxidation to a carbonyl group. Various mechanisms have evolved to handle the large variety of fatty acids.

### Classification of Lipids

1. Simple lipids: These are esters of fatty acids with various alcohols.
   a) Fats: These are the esters of the fatty acids with glycerol.
   b) Waxes: These are the esters of the fatty acids with an alcohol other than glycerol.
2. Compound lipids: These are the fatty acids esters containing groups in addition to alcohol and fatty acid. Most important members of this class are the phospholipids (lecithin, cephalin and sphingomyelin), glycolipids (cerebrosides) and aminolipids.
3. Derived lipids: Substance derived from the above groups by hydrolysis like fatty acids of various series and sterols.

### Energy content of lipids

Gross energy content of the pure fats and oils is about 9.4 kilocalories per gram which is approximately 2.25 times greater than that of starch (4.15 kilocalories per gram.)

The metabolizable energy value of fats and oils is determined mainly by the absorbability of their constituent fatty acids from the intestine. Fats are not excreated in urine. Therefore their meta-bolizable energy values are directly related to their digestability. The metabolizable energy content of a fat is calculated by multiplying its percent digestability by its gross energy value as determined in a bomb colorimeter. The latter value is approximately the same for all fats (9.4 Kcal/gram).

**The digestibility of fats is influenced by the following factors**

1. Average molecular weight of the constituent fatty acids.
2. The extent of unsaturation of the constituent fatty acids.
3. The presence or absence of ester linkages, i.e., whether the fat is in the form of triglyceride or as a free fatty acid.
4. Position of the saturated and unsaturated fatty acids on the glycerol moiety.
5. Age of the chicken.
6. Activity of intestinal bacteria.
7. Composition of the diet in which the fats are incorporated; and
8. Amount and types of fats in the diet.

**Apparent digestibility of some lipids in the diet of chickens**

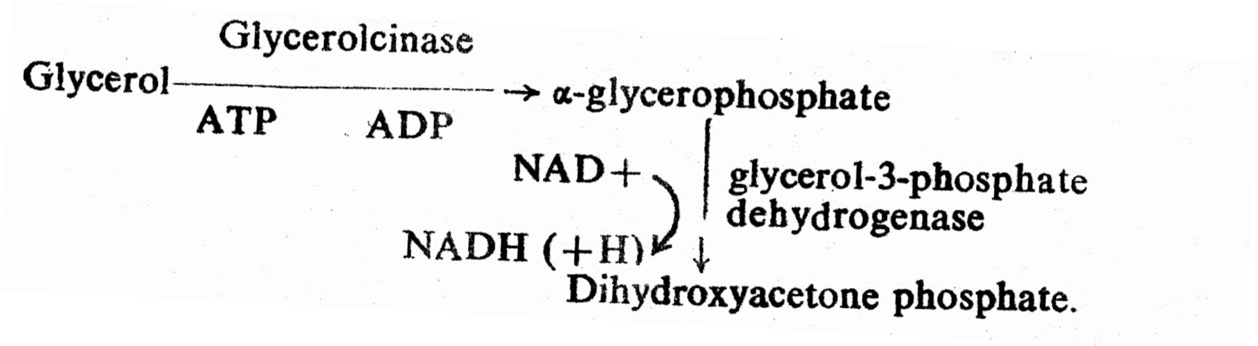
| Percent digestibility | | |
|---|---|---|
| | **Under 8 weeds of age** | **Over 8 weeks of age** |
| Oils | | |
| Soyabean oil | 96 | 96 |
| Maize oil | 94 | 95 |
| Fish oil | 88 | - |
| Fats | | |
| Tallow | 70 | 76 |
| Lard | 92 | 93 |

**Fats and Efficiency of Energy Utilization**

The supplementation of diets with small amount of fat in-creases the efficiency of utilization of the ingested energy for growth. Chickens fed diets containing 5-10 percent fat deposit 10-15 percent more energy in their body as compared with similar diets low in fat. It holds good even when metabolizable energy intake from the two diets are equal. This phenomenon has also been observed in rats, and is called as the 'specific dynamic effect' of fats. The enhanced efficiency of energy utilization has been attributed to the lowering of the heat increment losses with the inclusion of the fat in the diets. The improvement in the dietary use of tallow, lard, maize and soyabean oils but not the hydrogenated coconut oil.

**Glycerol as Energy Source**

Lipases help mobilize the body fat stores by catalyzing the production of glycerol and fatty acids. Glycerol is glycogenic. It is catabolized via the glycolytic pathway as shown in the following reaction:



Dihydroxyacetone phosphate enters the glycolytic pathway. By the reverse of the aldolase reaction, which produces fructose-1, 6-diphosphate, glucose may be formed. Efficiency of glycerol as an energy source may be assessed as follows:

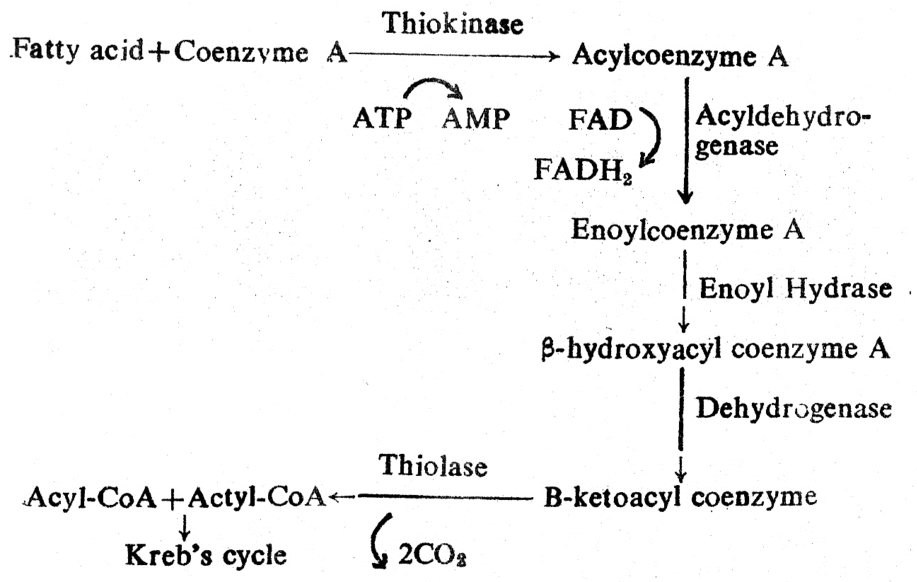
| Description | Moles ATP | |
|---|---|---|
| | + | - |
| 2 moles glycerol to 2 moles of dihydroxyacetone phosphate | 6 | 2 |
| 2 moles of dihydroxyacetone phosphate to 1 mole glucose | | |
| 1 mole glucose to carbondioxide and water | 38 | |
| Total | 44 | 2 |

Net yield of ATP per mole of glycerol = 21

**Fatty Acids as Energy Source**

Major portion of the energy content of fats is contributed by the fatty a cids. The oxidative degradation of fatty acids takes place via the beta-oxidation pathway. By the removal of two carbon atoms at a time, it results in a gradual reduction of the carbon chain length of the fatty acids. In the first step of beta-oxidation, the fatty acids react with coenzyme A in the presence of ATP and thiokinase to result in the production of an acyl coenzyme A.

This undergoes a series of reactions to give an acyl coenzyme A with two less carbon atoms than the original. Essentially, the pathway consists of the following steps:



# Chapter 8
# Nutrient interrelationships

Nutritional therapeutics has largely been directed toward the recognition and correction of nutritional deficiencies. However, it is now becoming more evident that a loss of homeostatic equilibrium between nutrients can also have an adverse impact upon health.
It seems reasonable to assume that all the nutrients might be interrelated in the function and therefore the levels of the nutrients requirement in the chicken diets should be interdependent. However, only some of the interrelationships are known and still less has been firmly established. The exact site in the body where these nutrients may interact with each other ranges from the intestinal tract at the time of absorption to that of enzymatic action during the cellular metabolism. The interrelationships which are well known and alter the nutrient requirements of chickens under practical conditions may be listed as follows:

1. The energy-protein interrelationship.
2. The interrelationship between Ca, P and vitamin $D_3$.
3. Nicotinic acid, tryptophan and pyridoxine.
4. Choline, methionine, folic acid and vitamin $B_{12}$.
5. Vitamin E, Se and cysteine.
6. Cu and Zn, Zn and Cd, Mo and Tungstan, Se and As.
7. Interrelationships between arginine and lysine, between leucine, isoleucine and valine.

Of these, the relationship between dietary energy and protein levels has already been discussed earlier.

**Vit. $D_3$, Ca and P balance**

It is advisable that the starter and grower diets should not contain more than 1percent Ca due to enlargement and degeneration of kidneys. The ratio of dietary Ca and P should ideally be 2:1. The Ca content of the diets needs to be increased only during the last 2-3 weeks prior to egg laying.
It is well established that vit. $D_3$ requirements of chickens are increased in the diets which contain Ca and P in improper ratios. In reverse, importance of vit. $D_3$ decreases in the diets which contain Ca and P in the proper ratio.

**P, Mg and Ca**

Mg levels needed in the diets increase with an increase in their Ca contents. Apparently, P interferes with Mg absorption and this effect of P seems uninfluenced by the effect of Ca. Excess of Mg in the diets increases the dietary Ca requirement especially if the dietary P levels are also higher.
Ca and Mg appear to compete not only at the level of absorption but also for binding sites on certain serum proteins.

**Nicotinic acid- Tryptophan- Pyridoxine**

The amino acid tryptophan would be converted in the body into nicotinic acid. Milk or proteins, especially of animal origin contained higher levels of tryptophan and thus these proteins had the ability to prevent or cure pellagra, resulting from the deficiency of nicotinic acid.

Another member of vitamin B complex, pyridoxine is required in the metabolic reactions involved in the conversion of tryptophan into nicotinic acid and therefore, dietary requirements of all the three nutrients are interrelated.

**Choline, Methionine, Folic acid and Vit. $B_{12}$**

The requirement for choline needed in the diets decreases with adequate supply of vit. $B_{12}$ and folic acid as these are required in the body synthesis of methyl groups. Thus these vitamins may spare choline partly and reduce its requirement. Methionine and compound betaine also may provide the needed labile methyl groups and to some extent, can similarly spare choline. Conversely, the dietary requirement for vit. $B_{12}$ depends to a certain extent on the choline and methionine contents of the diet.

**Vitamin E, A, Cystine and Selenium**

Se and cystine are interrelated with vit. E for the prevention of a number of diseases. For example, muscular dystrophy is produced in chickens fed diets low in vit. E, Se and cystine. The addition of vit. E in a diet also protects and spares the dietary vit. A.

However, in the case of nutritional encephalomalacia, Se has no preventive role. The symptoms are caused due to the deficiency of vit. E alone.

**Interrelationships between trace minerals**

Various trace minerals are interrelated in their metabolism. Cu and Mo counteract each other. Arsenicals reduce the toxicity of excess Se. chelating agents like EDTA and also sugars and amino acids have an important influence on the absorption of minerals especially Zn. Cu is essential for the utilization of iron in the synthesis of heme for the formation of hemoglobin.

Mo influences Cu absorption and sulphur has an important bearing Cu-Mo interrelationship. An inverse relationship between Cu and Zn has been observed in chickens also. Trace minerals seem to interact not only amongst themselves, but also influence the utilization of vitamins, certain amino acids and other nutrients.

**Interrelationships between amino acids**

The pioneering work of Dean and Scott (1968) showed that a diet adequate in proteins and all other nutrients could also harm the chickens due to an excess of some amino acids. An explanation has been provided about the antagonistic effect of lysine towards arginine. Thus, the dietary level of lysine has an important bearing on the requirement of arginine in chicken diets.

There is also present relationship between the requirement of leucine and valine and threonine and tryptophan in the diet of the chickens.

It has been suggested that amino acid in excess of the amount required by the animal would drain the pool of the most limiting amino acid and thus adversely affect its utilization. Amino acid imbalance also results in a depression in food intake which reduces the rate of weight gain.

## Chapter 9

## Latest research finding

### Development of Poultry industry

Poultry industry has advanced remarkably over the past 50 years. In particular, poultry meat production has undoubtedly been the most successful industry. Now-a-days broiler industries have become a rapidly developing enterprise among all other sectors of poultry production and a large number of farms are being established in whole the country. This profitable business is responsible for employment of rural masses particularly small and marginal farmers.

According to recent statistics, total poultry population in our country is 347.04 million from where about 289.28 million chicken and 57.75 million duck in number (DLS, 2019). During 1970-80, the poultry population growth rate was 0.7% which increased to 4% per year during 1990-2005. Since 1995, a significant annual average growth rate of commercial poultry has been achieved 15-20% until 2007 and slow downed after due to avian influenza outbreak. According to Department of Livestock Service (DLS), there are 8820 registered poultry farms in Bangladesh up to 3 August 2018.

In our country, the per capita requirements of meat and eggs are 120 g/day and 104 eggs/ year, respectively however the average per capita availability of meat and eggs are 124.99 g/day and 103.89 eggs/ year (DLS, 2019). The demand of egg & meat consumption per head is almost able to fulfill the requirement. Poultry can play a pivotal role to retain in meat production level and to achieve the expected egg production.

Production standards of broilers and layers have continually improved over this period, with male broilers currently reaching a live weight of 2.5 kg at 33～35 d of age and white egg layers capable of producing 330 eggs in 52 weeks of lay. The need to achieve and sustain the improvements in genetic potential was the driving force behind the advances in poultry nutrition and, there had been continuous refinement in the nutrition and feeding practices of commercial poultry.

In this study, the key advances in poultry nutrition will focus on three main categories: (i) to develop an understanding of nutrient metabolism and nutrient requirements, (ii) to determine the supply and availability of nutrients in feed ingredients, and (iii) to formulate least-cost diets that bring nutrient requirements and nutrient supply together in an effective manner.

The overall aim is precision feeding to lower costs and maximize economic efficiency. In the past, there had been a tendency to over-formulate diets when doubts exist on the availability of critical nutrients (especially amino acids and phosphorus) or if the nutrient requirement was uncertain. This practice is no longer acceptable because this is not only wasteful, but also excess nutrients are excreted in the manure and are ultimately a source of pollution.

**MAJOR ADVANCES IN POULTRY NUTRITION**

A major challenge in defining the nutrient needs is the fact that they are influenced by a number of factors and are subject to constant changes. Nutrient requirements are influenced by two main factors, namely bird-related factors (genetics, sex and, type and stage of production) and external factors (thermal environment, stress, husbandry conditions). Requirements of major nutrients for various classes of poultry are now available and these developments are made possible largely because of increasing uniformity of genotypes, housing and husbandry practices in the poultry industry.

Of all the dietary components, the most expensive and critical are essential amino acids and energy. Defining the requirements for the ten essential amino acids poses considerable degree of difficulty, but has been made easier by the acceptance of ideal protein concept. Like other nutrients, the requirements for amino acids are influenced by various factors, including genetics, sex, physiological status, environment and health status. However, the actual changes in amino acid requirements can be expressed in relation to a balanced protein or 'ideal protein'. The ideal protein concept uses lysine as the reference amino acid and the requirements for other essential amino acids are then set as a percentage (or ratio) of the lysine requirement.

The principal role of feed ingredients is to provide the nutrients that can be digested and utilized for productive functions by the bird. Over the years, enormous volume of data has been generated and compiled on the nutrient composition of raw materials. The variability that is inherent to each raw material is also recognized and such variability places pressure on precise feed formulations. Data on variation (or matrixes) are available for the main feed ingredients and applied in feed formulation packages to achieve better precision. A related development is the availability of rapid tests, such as the near infrared reflectance (NIR) analysis, to predict gross nutrient composition and to access the variability in ingredient supplies on an on-going basis.

However, not all of the nutrients in ingredients are available for production purposes and a portion of nutrients are excreted undigested or not utilized. With advances in feed evaluation techniques, data have been accumulating on the availability of nutrients, especially of amino acids and phosphorus, for poultry. Formulating diets based on digestible amino acids makes it possible to increase the range and inclusion levels of alternative ingredients in poultry diets. In effect, this approach improves the precision of formulation, may lower feed cost and ensures more predictable bird performance.

Progress in biotechnology during the past two decades has offered new opportunities to enhance the productivity and efficiency of animals through improved nutrition. Biotechnologies cover a vast field of applications in animal nutrition.

The growth in acceptance of feed additives in poultry production over the last two decades has been an extraordinary development. However, the recent mandatory or voluntary removal of antibiotics from poultry diets, spurred by reports of potential antibiotic resistance in humans, is creating a major challenge. A number of alternatives are being tested and researched which are broadly accepted by the commercial industry. Now, there is increasing focus on alternatives to sustain good gut flora and gut health, and potential alternatives include enzymes, probiotics, prebiotics, essential oils, botanicals and organic acids.

Currently, majority of the feed used in the production of broilers is fed in pelleted or crumbled form. Offering feed to poultry in pellet or crumbled form has improved the economics of production by improving feed efficiency and growth performance. These improvements are attributed to decreased feed wastage, higher nutrient density, reduced selective feeding, decreased time and energy spent for eating, destruction of pathogenic organisms and, thermal modification of starch and protein.

Phase-feeding, a form of precise-feeding, is another development during the past two decades. This is a feeding system in which dietary amino acid levels are reduced steadily over time in an attempt to reduce costs associated with excess dietary protein or amino acids. Commercial phase feeding programmes may include several phases to step down amino acids and other nutrients for broilers and layers.