

Department of Animal Nutrition, Genetics & Breeding

Course Title: Poultry Nutrition

Course Code: ANGB 355

Level-3, Semester-II

Credit Hours: 2, Contact Hour: 2

Course Content (Theory)

- 1. Introductory:** Definition of poultry nutrition, objectives of poultry nutrition, History of Poultry Nutrition.
- 2. Digestion, absorption and metabolism of nutrients:** Digestion, absorption and metabolism of nutrients (carbohydrate, protein, fat) in poultry.
- 3. Feedstuffs and ration formulation:** Principle of poultry feeding; Poultry feedstuffs; conventional and unconventional feedstuffs, prospect and limitations of using unconventional feed stuffs; Factors affecting the selection of feed ingredients; use of agro-industrial byproduct in ration, procurement and storage of feedstuffs; Information needed during ration formulation, essential steps in ration formulation; Feeding standard, inclusion level, Differences between broiler and layer nutrition.
- 4. Feeding system/ method and feed efficiency:** Different feeding system, difference and advantages and disadvantages of feeding systems; feed efficiency, feed efficiency ratio, factors affecting feed efficiency, techniques of improving feed efficiency.
- 5. Feed additives:** Definition of feed additives, classification of feed additives, selection of feed additives.
- 6. Energy for poultry:** Terms related to energy expression and measurement, applicability of different systems, calculation of energy requirements for avian species.
- 7. Protein nutrition:** Amino acids, essentiality, measurement of availability; Methods for evaluating protein quality, estimation of protein requirements.
- 8. Lipid Nutrition:** Essential fatty acids, oxidation, cholesterol or fat as an energy source; Lipid Metabolism.
- 9. Nutrient interrelationships:** Interactions among the nutrients.

Chapter-1 Introduction

Poultry nutrition deals with the coordinated processes in the body which play 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 (proteins, carbohydrates, fats and oils, vitamins, minerals, and water) for optimum growth, maintenance, finishing, work, reproduction, and production.

The poultry producer must know the nutritional requirements of the bird's function; either egg production. 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.

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	E.V. McCollum	Vitamins A and 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 Digestion, Absorption and Metabolism

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

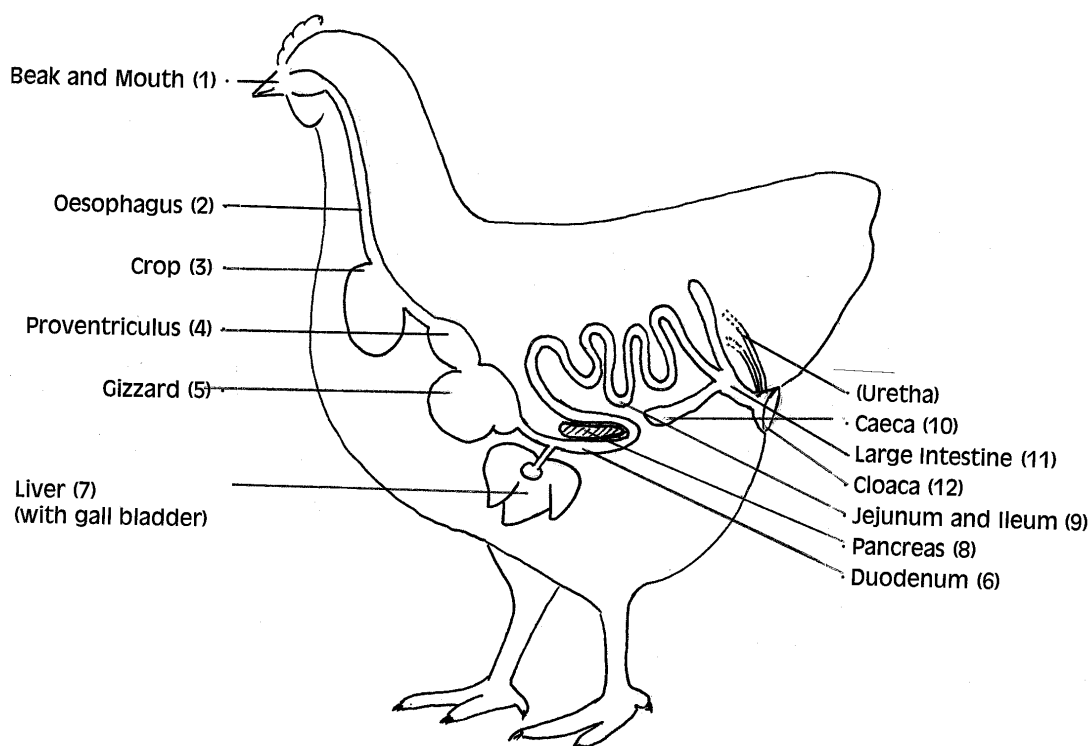


Figure: The digestive tract of the chicken

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.

Figure: Intestinal villi

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.

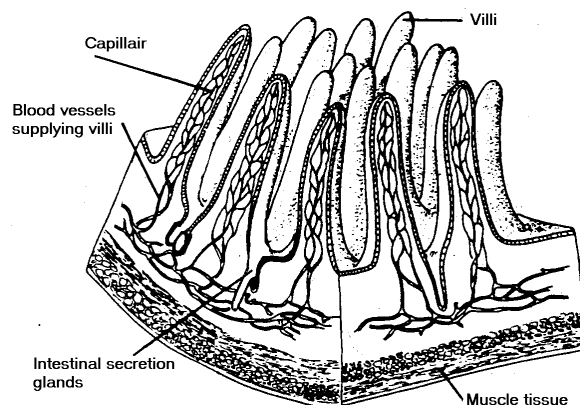


Figure: The villi of the small intestine

- 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.

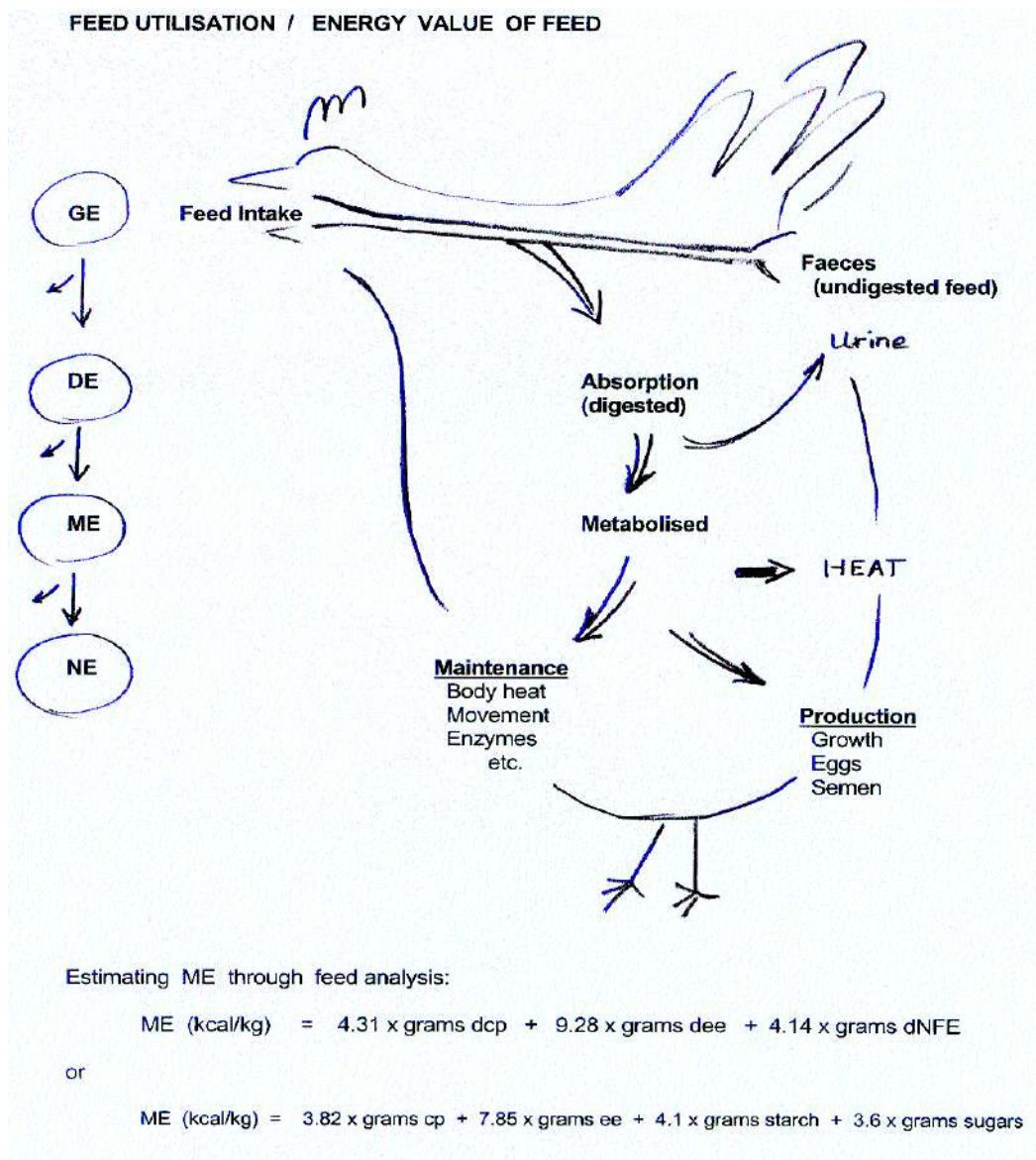
Disaccharide	Enzyme	Mono-saccharide's
Maltose	Maltase	2 glucose molecules
Saccharose	Saccharase	fructose and glucose
Lactose	Lactase	galactose and glucose

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



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.

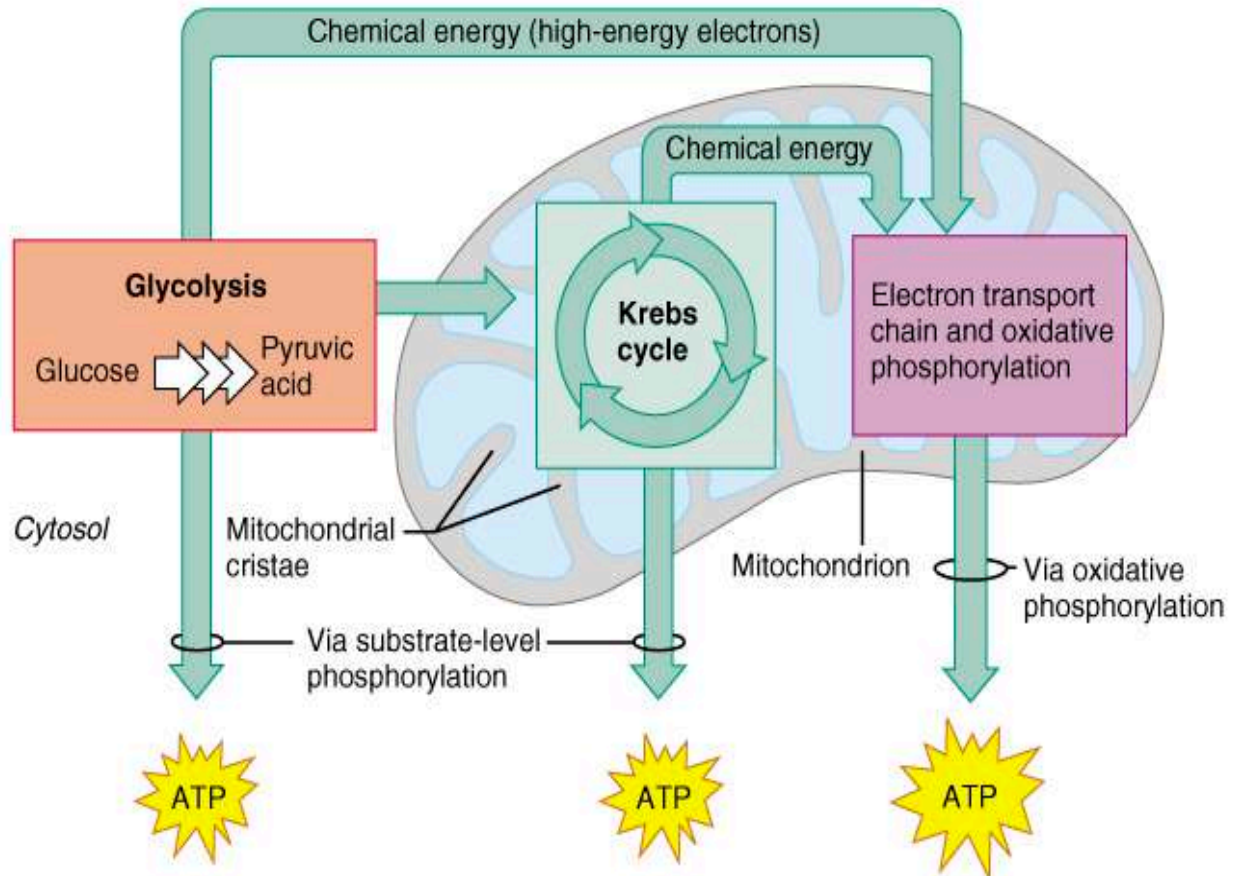
Types of Metabolic Reactions

- 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



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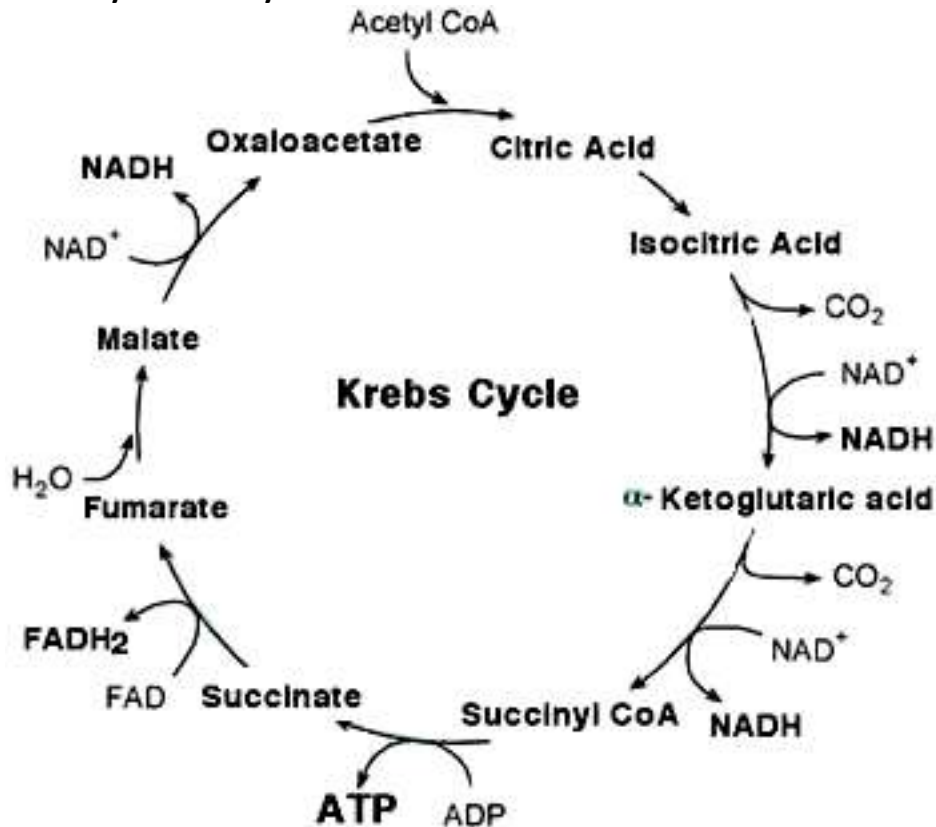
Glycolysis

- 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 CO₂ 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

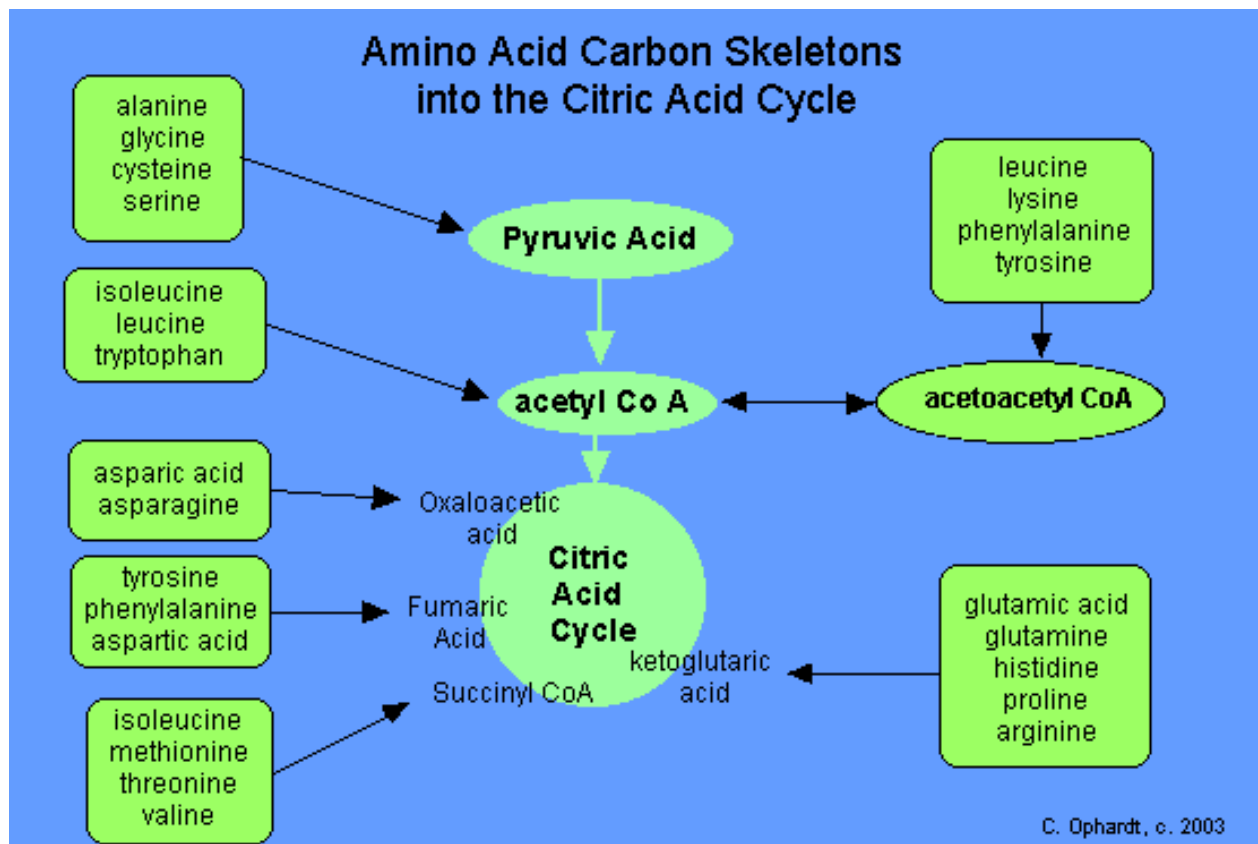
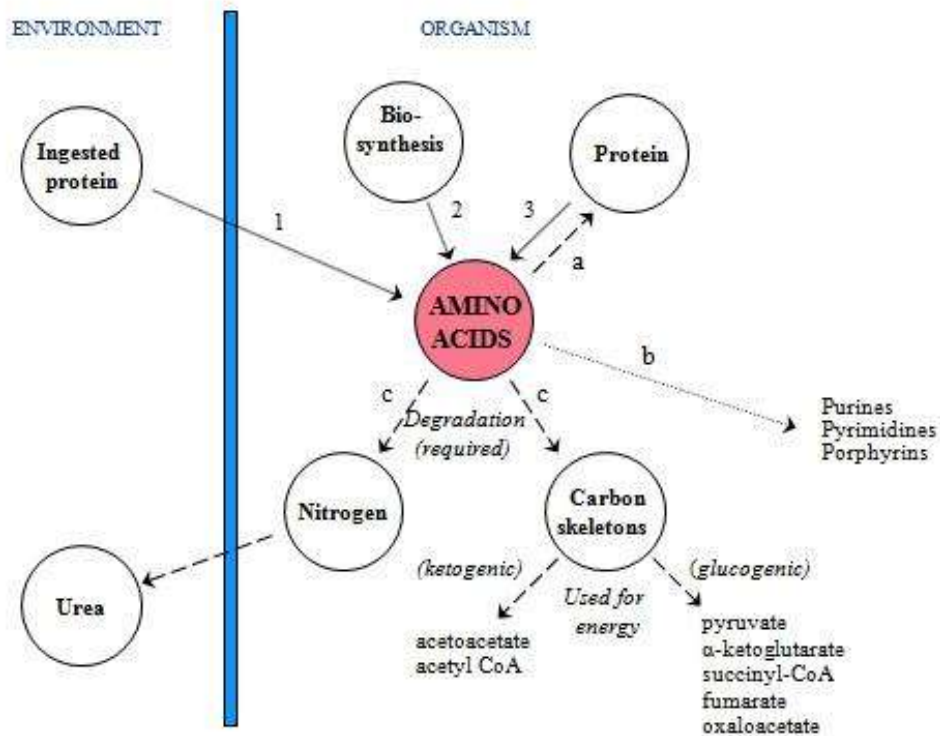
2 moles of pyruvate to CO₂ and water → 24 ATP (TCA Cycle)

Glucose Anabolism

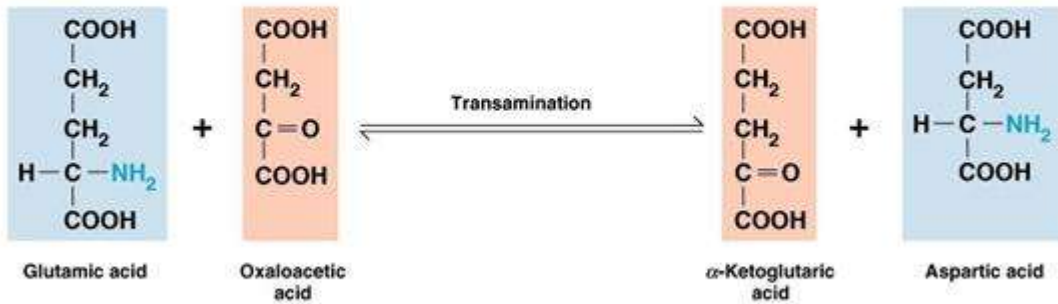
- Glycogenesis - conversion of glucose to glycogen; stimulated by insulin
- Glycogenolysis - hydrolysis of glycogen to form glucose; stimulated by glucagon
- Gluconeogenesis - synthesis of glucose from non-carbohydrates such as fats and amino acids

Protein Metabolism

OVERVIEW OF AMINO ACID METABOLISM



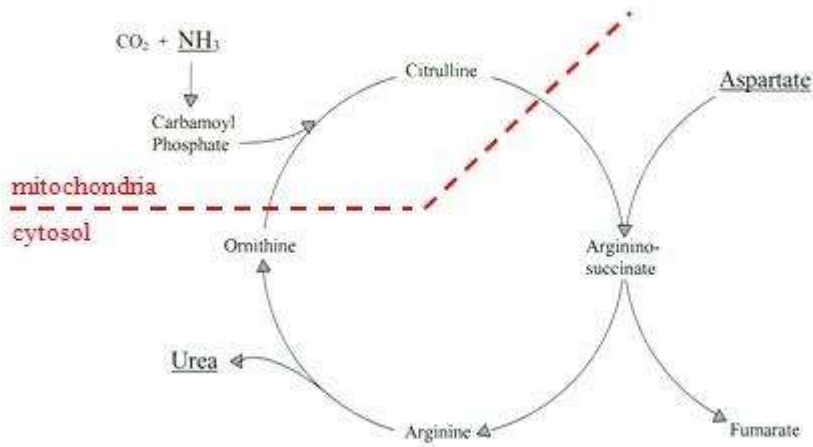
TRANSAMINATION



(b) Process of transamination

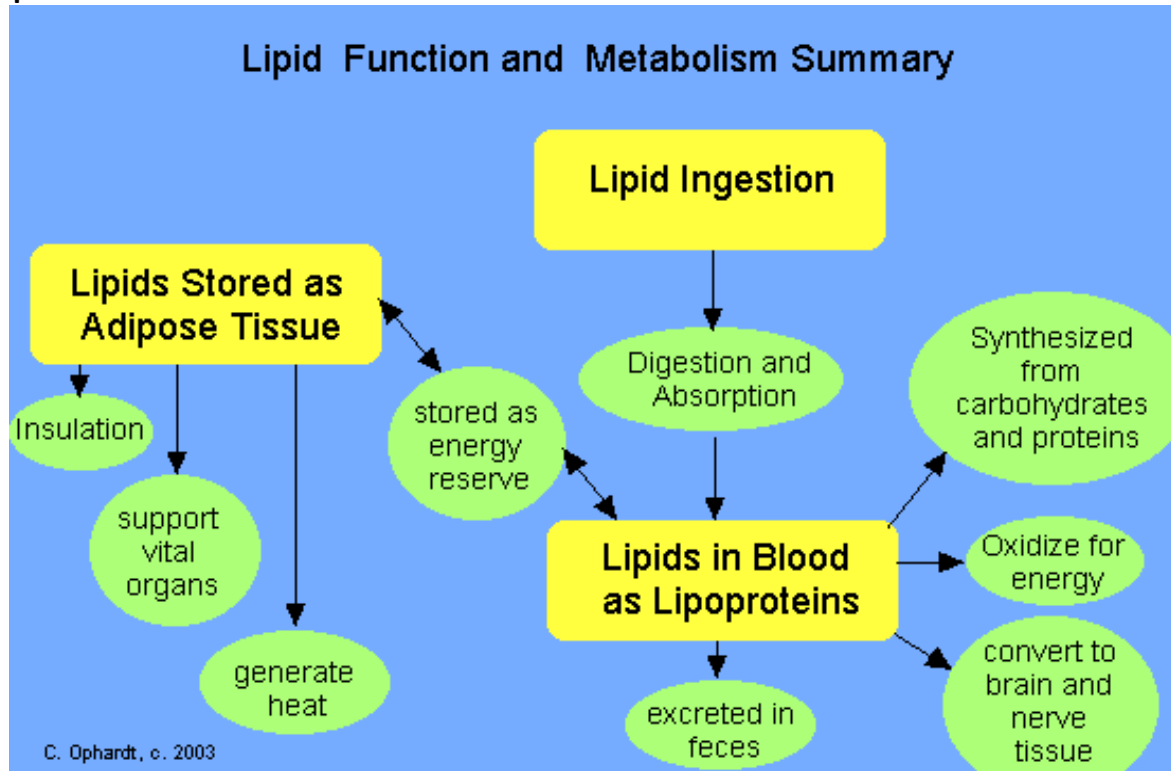
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UREA CYCLE

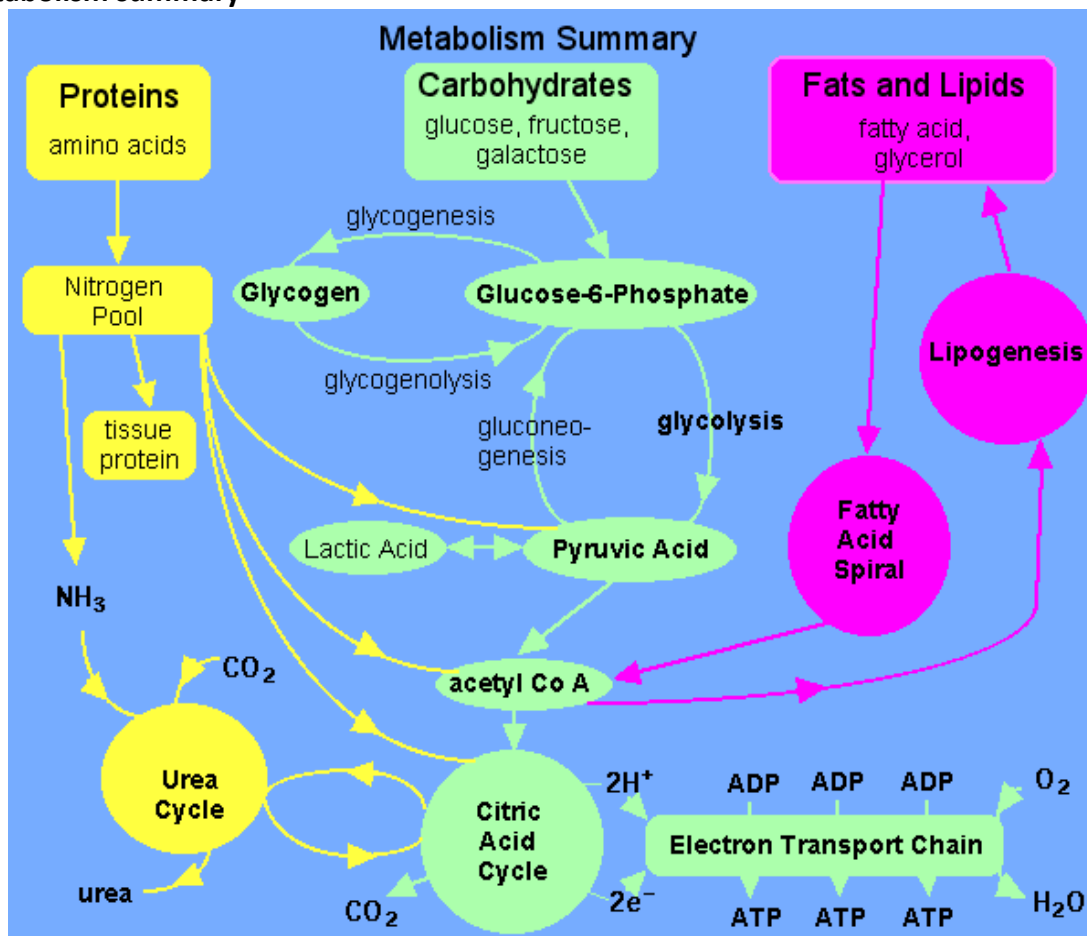


Function: detoxification of ammonia
(prevents hyperammonemia)

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 ₂ O)
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)

Feed	ME/kg		Maximum								
	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) বাড়মান 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
কুড প্রোটিন	%	২০.৫-২১.৫	১৭.৫-২০.০	১৬.৫-১৬.৮
মিথিওনি	%	০.৪৩-০.৫২	০.৩৬-০.৪৭	০.৩৪-০.৩৫
মিথিওনি ও সিস্টিন	%	০.৭৭-০.৮৬	০.৬৫-০.৮০	০.৫৮-০.৬৩
লাইসিন	%	১.০৭-১.১৬	০.৮৮-১.০৩	০.৭৬-০.৭৮
ট্রিপটোফেন	%	০.২১-০.২২	০.১৯-০.২০	০.১৬-০.১৭
থ্রিওনি	%	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
ক্রোরিন	% 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				
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সেলিনিয়াম	পিপিএম	০.২-৩০	০.২-৩০	০.২-৩০
এডেড ভিটামিন/কেজি				
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ভিটামিন ডি ৩	আই ইউ	৩০০	৩০০	২০০০-৩০০০
ভিটামিন ই	আই ইউ	২০-২৫	২০-২৫	২০-২৫
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প্যানটোটেনিক 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
ক্রোরিন ক্লোরাইড	মিলি গ্রাম	৬০০-১৩০০	৬০০-১৩০০	৫০০-১৩০০

Feeding Standard (Animal Feed Rules, 2013 of Bangladesh)

(খ) প্রি-লেয়ার

উপাদান	একক	প্রি-লেয়ার 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
মিথিওনি	%	০.৩৬-০.৩৮	০.৪৩	০.৪১-০.৩৮	০.৩৯-০.৩৭	০.৩৫
মিথিওনি ও সিষ্টিন	%	০.৬২-০.৬৮	০.৭১	০.৬৭-০.৭০	০.৬৩-০.৬৬	০.৬১
লাইসিন	%	০.৮০-০.৮৭	০.৮৮	০.৮৫	০.৮১	০.৭৮
ট্রিপটোফেন	%	০.১৮-০.১৯	০.২১-০.২২	০.১৯-০.২০	০.১৮-০.১৯	০.১৭
থ্রিওনি	%	০.৫৬-০.৬১	০.৬৭-০.৬৯	০.৬৪-০.৬৭	০.৬-০.৬২	১.৫৯
লিনোলিনিক 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 (এডাইল্যাবল)	% এর কম নয়	০.৪৭	০.৪৬	০.৪৪	০.৪২	০.৩৮
ক্রোরিন	% 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						
ম্যাগ্নানিজ	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	০.০০৮-০.০১	০.০০৮-০.০১	০.০০৮-০.০১	০.০০৮-০.০১	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
ক্রোরিন ক্রোরাইড	মিলি গ্রাম	৫০০-৫৫০	৫০০-৫৫০	৫০০-৫৫০	৫০০-৫৫০	৫০০-৫৫০

বিশেষ দৃষ্টব্য: 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 ব্রহ্মার মুরগির পুষ্টি তালিকা

উপাদান	একক	স্টার্টার ০-২১ দিন পর্যন্ত	গ্রোয়ার ২২-৩৭ দিন পর্যন্ত	ফিনিশার ৩৮ দিন
মেটাভেলাইডেবল এনার্জি	কিলো ক্যালরি/কেজি ডিএম	৩০০০-৩১০০	৩০৫০-৩২০০	৩১০০-৩২০০
কৃত প্রোটিন	%	২১-২৩	১৯-২১	১৮-২০
কৃত ফাট	%	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
এপি অক্সিজেন্ট	মিলি গ্রাম/কেজি	১২০-১৫০	১২০-১৫০	১২০-১৫০
এনাইনো এসিড				
নিথ্রিওনিন	%	০.৪৭-০.৫	০.৪৪-০.৪৯	০.৩৮-০.৪৭
নিথ্রিওনিন ও মিট্রিন	%	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 (একইল্যাবল)	% এর কম নয়	০.৪৩	০.৩৯	০.৩৫
ক্রোরিন	% 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				
ম্যাগনিজ	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	০.২০-০.৩০	০.২০-০.৩০	০.২০-০.৩০
এডেড ভিটামিন/কেজি				
ভিটামিন এ	আই ইউ	৯,০০-১২,৫০০	৯,০০-১২,৫০০	৯,০০-১০,০০০
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
প্যানটোটেনিক 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
ক্রোরিন ক্লোরাইড	মিলি গ্রাম	৫৫০-৭৫০	৫৫০-৭৫০	৪৪০-৬৭৫

বিশেষ দ্রষ্টব্য: পোল্ট্রি ব্রিডার্স এসোসিয়েশন অব বাংলাদেশ কর্তৃক বিভিন্ন বয়সের বাণিজ্যিক ব্রহ্মার 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)						remarks
	starter 0-6 wks	grower > 6 wks	rearing > 14 wks	layers	broiler	Broiler parent stock	
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 tannin
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 viscosity

Chapter-4 Feeding method/ system 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 system:** 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° 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 effecting 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 utilization 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) or 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 permanently in the feed increase performance sometimes short withdrawal period.	high dosage short period treatment through feed, water, or injection 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 *	Oxytetra cycline
Tylosin *	Chlortetra cycline
Flavomycin	Penicillin
Spiramycin *	Streptomycin
Virginiamycin *	
Avoparcin *	
Avilamycin	
Monensin-Na (for rumen stimulation)	

* 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) Nicarbazin
- D O T (Dinitro Ortho Toluamide) * Narasin
- Monensin-Na (poultry) Meticlorpindol/methylbenzoquate
- Ethopabate 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*
- Olaquinox* (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

with vitamin A activity

eg. α -carotene

β -carotene

γ -carotene

cryptoxanthene

xanthophylls

no vitamin A activity

eg. zeaxanthin

capsanthin

canta xanthin

lutein

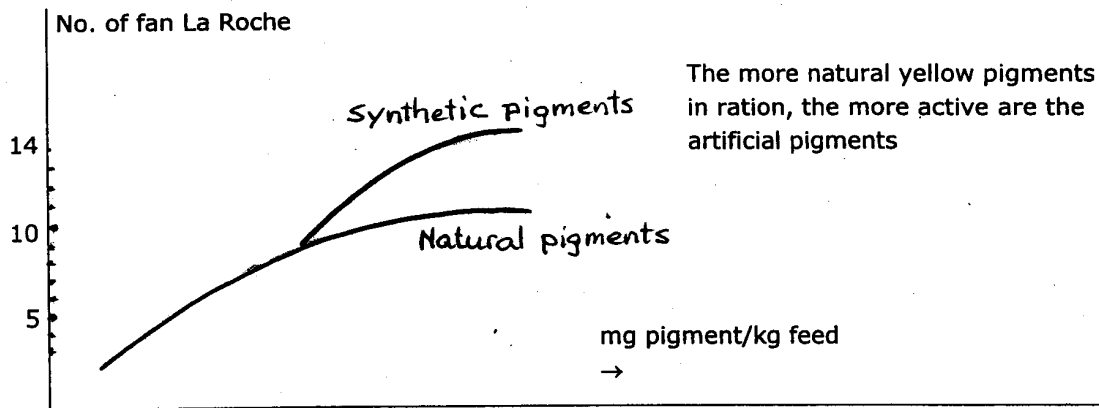
Xanthophylls and excess carotenes are deposited in bodyfat and yolk.

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 an 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 derivatives, 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 too viscous for the digestive enzymes to function well.

Other commercial enzymes are:

- Ilzyme (pentosanase = xylanase)
amylase, cellulase
protease, glucanase
- Lyxasan β -xylanase
- Avizyme xylanase, protease
 β -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.

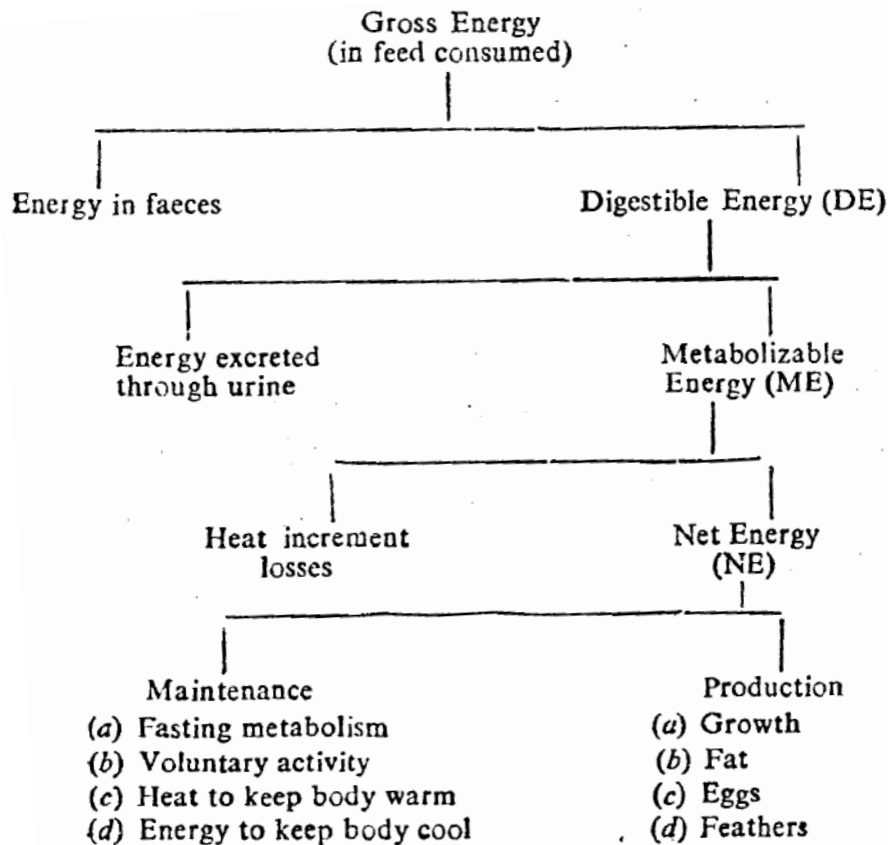
Nutritional acids received a lot of extra attention and also the positive influence of indigestible carbohydrates (oligo-saccharides) on a healthy intestinal flora seems very promising.

Furtheron also the use of natural herbs or extracts, to improve resistance of the animals, or enhance efficiency of metabolism, 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: $NEm = 83 \times BW \text{ (Kg)}^{0.75}$. Thus for a hen weighting 1.75 kg, the $NEm = 83 \times 1.52 = 126 \text{ Kcal/hen/day}$. Since NEm is approximately 82% of the ME_m (the metabolizable energy values are about 18% higher than the net energy values) then $126/0.82 = 154 \text{ Kcal}$ represents the ME_m .

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 $154 + 77 = 231 \text{ Kcal/hen/day}$. The energy content of a large egg is 86 Kcal. Thus the total ME requirement of a white leghorn hen in 100% production is $231 + 86 = 317 \text{ Kcal/day}$ at 21°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

<i>Metabolizable energy content of ration (megacalorie/kg)</i>	<i>Feed consumption (kg upto 6th week (of age)</i>
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

Males 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 may 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 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:

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

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/or growth.

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

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

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.

Chaptr-8

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 excreted 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 calorimeter. The latter value is approxi-mately 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

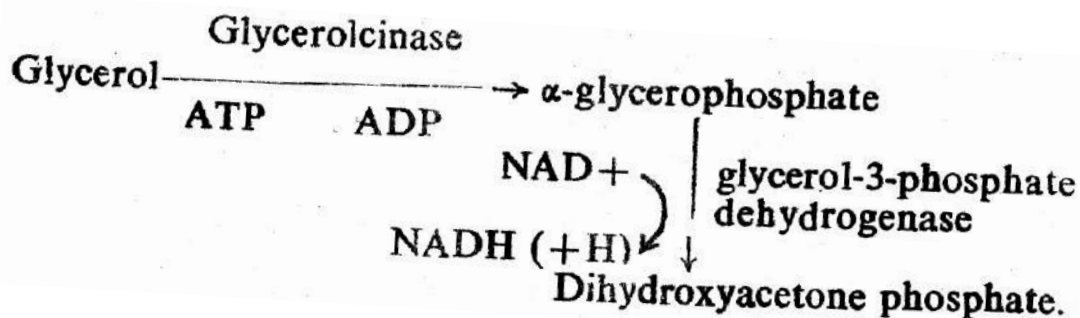
Percent digestibility		
	Under 8 weeks of age	Over 8 weeks of age
Oils		
Soyabean oil	96	96
Maize oil	94	95
Fish oil	88	-
Fats		
Tallow	70	76
Lard	92	93

Fats and Efficiency of Energy Utilization

The supplementation of diets with small amount of fat increases 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:

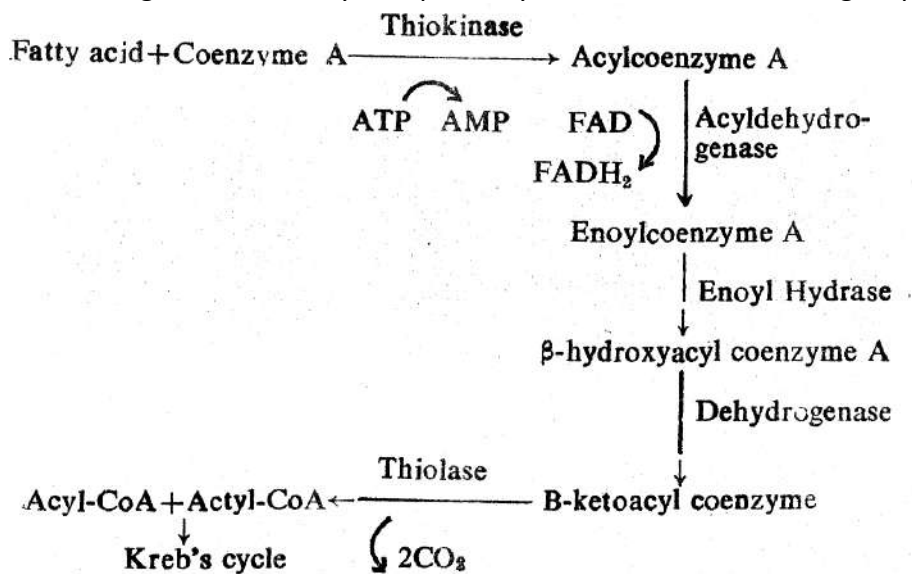
Description	Moles ATP	
	+	-
2 moles glycerol to 2 moles of dihydroxyacetone phosphate	6	2
2 moles of dihydroxyacetone phosphate to 1 mole glucose		
1 mole glucose to carbondioxide and water	38	
Total	44	2

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 acids. 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 9

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 D₃.
3. Nicotinic acid, tryptophan and pyridoxine.
4. Choline, methionine, folic acid and vitamin B₁₂.
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. D₃, 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. D₃ requirements of chickens are increased in the diets which contain Ca and P in improper ratios. In reverse, importance of vit. D₃ 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. B₁₂

The requirement for choline needed in the diets decreases with adequate supply of vit. B₁₂ 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. B₁₂ 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.