
UNIT 1 DIETARY REQUIREMENTS

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1.0 OBJECTIVES

After studying this unit, you will be able to:

- discuss about nutrient requirements of broiler and layer chicken;
- explain the inclusion level of ingredients in poultry feeds;
- describe the concept of feed formulation; and
- determine the feed intake and efficiency of broiler and layer chicken.

1.1 INTRODUCTION

In order to achieve a cost-effective diet for poultry, there is a continuing need to have knowledge on the ways to reduce feeding cost and wastage of nutrients, ensure efficient utilization of nutrients through feed processing, use of additives and maintaining the quality of raw materials and compounded feed. The recommendations of Bureau of Indian Standards (BIS) acts as guidelines for feed manufacturers. You will have to learn some basic concepts of various nutrient requirements and the methods to formulate feed for poultry.

1.2 NUTRIENT REQUIREMENTS

Poultry diets are composed primarily of a mixture of several feedstuffs such as cereal grains, vegetable proteins, animal by-products, fats, vitamin and mineral premixes.

Each of these as nutrient requirements in different poultry species and age groups (though variable) is considered in the following sections. Those birds reared for the production of eggs for human consumption (Leghorn-type) have a small body size and are prolific layers, whereas, those used as broilers or broiler breeders (meat-type) have rapid growth rate and a large body size and are less efficient egg producers.

1.2.1 Broiler Chicken

The requirements of various nutrients for broiler chicken as per Bureau of Indian Standards (BIS) are given below:

(i) Energy

The reasonable energy levels of 2800 and 2900 kcal ME/kg were suggested by BIS (1992) for broiler starter (0-6 weeks) and finisher (7-9 weeks), respectively.

(ii) Protein

As per BIS (1992), the protein requirement is 23% and 20% for starter and finisher, respectively. The concentrations of amino acids are important in broiler nutrition to avoid the chances of deficiency and toxicity.

(iii) Minerals

The requirement of calcium (Ca) suggested by BIS (1992) is at the rate of 1.2 % for both starters as well as finishers. BIS (1992) have suggested the available phosphorus requirements at 0.5% during starter and finisher phases. The BIS (1992) has recommended to keep sodium chloride (common salt) @ 0.6 % during both the phases.

(iv) Vitamins

Vitamin A, riboflavin (B₂) and Vitamin D₃ are the most important vitamins in practical broiler diets. The BIS (1992) has suggested common levels of 6000 International Unit (IU) of Vitamin A, 600 International Chick Unit (ICU) of Vitamin D₃ and 6 mg of Vitamin B₂ (riboflavin) during both the phases of broilers.

(v) Feed additives

Certain feed additives or growth promoters *viz.*, antibiotics, antioxidants, coccidiostats, enzymes, pro-biotics, etc. can be added in diets depending upon their need.

1.2.2 Layer Chicken

The requirements of various nutrients for layer chicken as per Bureau of Indian Standards (BIS) are given below:

(i) Energy

As per BIS (1992), for starter, grower and layer phases, the recommended energy requirements are 2600, 2500 and 2600 kcal ME/kg, respectively.

(ii) Protein

BIS (1992) have recommended a protein requirement of 20%, 16% and 18% for starter, grower and layer phases, respectively.

(iii) Minerals

You should have a clear idea of why and how much calcium (Ca) is required in the

diets of different age groups of egg type chicken. Among minerals, the role of Ca for egg type birds is very much important as the egg shell is made up of purely calcium carbonate. This is the reason why the level of Ca in the diets of egg producing layers is in the higher side as compared to those of starter and grower diets. As per BIS (1992), the Ca level in the diet of egg type starter and grower is 1%. The Ca concentration is increased gradually to about 2% of diet a week before onset of egg production i.e. during 16th to 20th weeks of age. Once the egg laying is started, the birds adjust Ca requirements from dietary intake and also by drawing from the body reserve. Therefore, you have to increase the level of Ca in the diet of laying chicken at 3 to 3.5 %. Half of the calcium in diet should be supplied through coarsely ground powder of limestone and remaining half as shell grit so that the needy hens may select and consume Ca as per need and palatability of feed is maintained.

(iv) Vitamins

The vitamin requirement for starter, grower and layer phases as per BIS (1992) is presented in Table 1.1.

Table 1.1: Vitamin Requirements for Different Phases of Egg Type Chicken

Vitamin	BIS (1992)		
	Starter	Grower	Layer
A (IU/kg)	6000	6000	8000
B ₂ (mg/kg)	5.0	5.0	8.0
D ₃ (ICU/kg)	600	600	1200

Check Your Progress 1

Note: a) Use the space given below for your answers.

b) Check your answers with those given at the end of the unit.

1) Explain the mineral requirements of layer chicken under different phases.

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2) Give the protein requirements as per BIS (1992) for:

- i) Finisher (Broiler)
- ii) Starter (Broiler)
- iii) Grower (Egg type)
- iv) Layer (Egg type)
- v) Starter (Egg type)

1.3 INCLUSION LEVEL OF INGREDIENTS

Certain feedstuffs naturally contain one or more anti-nutritional factors that limit their utilization. Similarly, certain feed ingredients are either deficient in one or more nutrients or not acceptable to the birds that make their utilization difficult. The inclusion levels of different feed ingredients are given in Table 1.2 for your comprehensive understanding.

Table 1.2: Suggested Inclusion Levels of Raw Feed Ingredients in Poultry Ration

Ingredients	Broiler Diet (%)	Layer Diet (%)	Remarks
Bajra (Pearl millet)	20-30	30-40	Polyphenolic substances, generally not ground
Barley	10-15	10-20	High fibre, beta-glucan present, fibre injures mucosa
Blood meal	2-5	2-4	Presence of microbes, if not sterilized
Canola/Mustard/Rapeseed meal	3-5	5-8	Erucic acid, goitrogens, tannins
Cassava/Tapioca meal	5-10	10-20	Cyanogen producing hydrocyanic acid (HCN), prussic acid
Castor meal autoclaved	1-2	2-3	High fibre, toxic ricin, ricinin
Coconut/Copra meal	3-5	5-8	High fibre
Coconut oil	2-5	-	-
Cottonseed meal	5-10	2-5	Gossypol (safe if less than 0.04%)
Fat or oil	3-5	1-2	Cost limits inclusion
Feather meal	3-5	2-4	Less digestible, low in lysine and methionine
Fish meal	8-10	5-8	Salt, silica, urea and smell
Groundnut cake	20-30	15-20	Aflatoxin problem
Guar meal	4-6	5-8	Gum, mucilages, trypsin inhibitor
Jowar/Sorghum	20-30	30-40	Low in oil, 2% tannin, coarsely ground
Linseed meal	3-5	3-5	Linamarin, linatin, mucilage
Maize	50-70	40-50	-
Maize gluten meal	10-15	10-20	Low arginine and lysine but rich in methionine
Meat meal	5-10	2-5	Must be sterilized, may be restricted up to 5%
Molasses	2-3	3-5	High potassium, problem of diarrhoea
Neem kernel meal	2-5	5-8	Toxic nimbidine, nimbinin
Niger/Ramtil cake	5-10	8-10	High in fibre
Oats	5-10	10-15	Beta-glucan, high fibre, fibre injures mucosa
Rice	10-20	20-30	Less protein and poor protein quality
Rice bran	10-20	20-30	High Fibre
Rice polish	15-20	20-25	High oil, rancidity problem
Safflower meal	5-10	8-10	High in fibre
Salseed meal	3-5	5-7	High tannin
Sesame/Til cake	10-15	5-10	-
Silkworm pupae meal	2-5	5-8	Low in threonine
Soybean meal	20-30	15-20	Deficient in methionine
Sunflower meal	5-10	10-15	High fibre, presence of chlorogenic acid
Wheat	20-30	30-40	Arabinoxylans, new wheat should be avoided, coarsely ground
Wheat bran	5-10	10-20	High fibre and cost, very low ME value

Check Your Progress 2

Note: a) Use the space given below for your answers.
b) Check your answers with those given at the end of the unit.

- 1) Write True or False
 - i) Castor meal contains toxin (ricin).
 - ii) Salseed meal contains higher tannin.
 - iii) Rice bran has low fibre.
 - iv) Wheat bran can be included @ 30 % in broiler ration
 - v) Wheat can replace 100% maize in layer diet.
- 2) Give the inclusion level of ingredient for broiler diet
 - i) Guar meal
 - ii) Rapeseed meal
 - iii) Soybean meal
 - iv) Sunflower meal
 - v) Wheat bran

1.4 FEED FORMULATION

Feed and feeding represent about 65-75% of the cost of poultry production. A feed efficient economic diet is always a balanced one in all nutrients at a low cost. The feed formulation is mathematical calculations to prepare a balanced ration.

1.4.1 Balanced Ration and its Basic Components

A balanced ration supplies all the nutrients in proper quantity and proportion that support optimum growth, egg production and health maintenance.

The components can be divided into: (a) Compulsory constituents – Nutrients
(b) Feed additives - Optional and added for specific purpose. Please refer the previous Block for detailed discussion on each of these components.

1.4.2 Points to be Considered for Formulation of Diet

The important points to be considered during feed formulation are as follows:

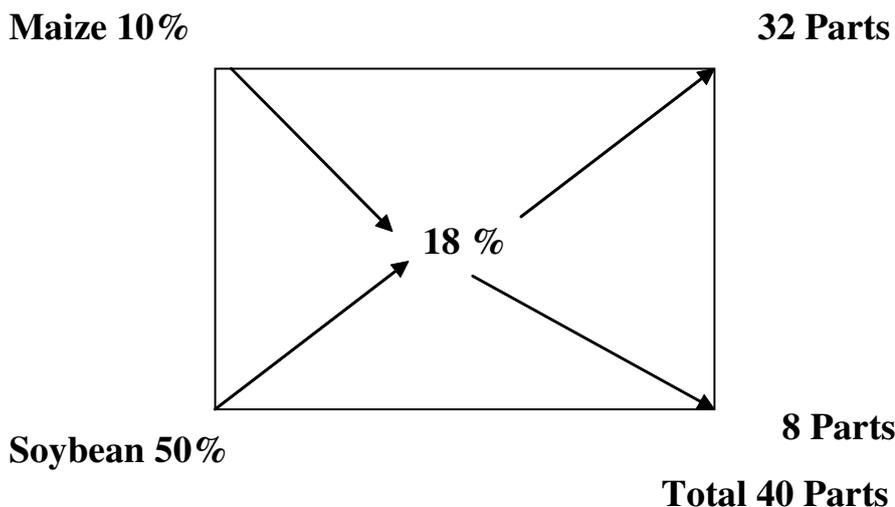
- (i) **Nutrient content of feedstuffs:** Composition of feed ingredients is variable due to climatic conditions, varieties of crop, processing types and method of storage. Therefore, it is always better to have analysis of feed ingredients for different nutrients. Comprehensive knowledge on different feed ingredients that are used, their nutritional merits and demerits including nutrient supply, palatability, anti-nutritional factors and bulkiness and cost of feed ingredients is essential.
- (ii) **Nutrient Requirements:** Several feeding standards are available which have been developed from the results of feeding trials conducted in India and abroad. The recommendations made by BIS (1992) for nutrient requirements for poultry may be referred.
- (iii) **Availability, Cost and Quality of Feedstuffs:** A nutritionally sound diet can be achieved only from quality feed ingredients. The grains should be fresh,

good quality, intact and free from contamination. The ingredients must be palatable, good quality and free from anti-nutritional factors like moulds and toxins. Importance should be given to low cost and locally available feed ingredients.

1.4.3 Methods of Feed Formulation

It is possible to design simple diet by hand or using computer software. Important nutrients such as energy, protein, calcium, phosphorus etc. are taken into consideration. The task of feed formulation involves the process of solving a series of mathematical simultaneous equations.

(i) **Pearson square method**



Also known as square method and is direct, easy, quick and simple technique that helps in achieving desired nutrients by mixing two ingredients based on the balancing of protein content of the ration. It does not give attention to minerals, vitamins and other nutrients. Suppose, a feed mixture containing 18% Crude Protein (CP) is to be prepared by mixing soybean meal (CP 50%) and maize grain (CP 10%), the desired content of the nutrient (in this case CP) is written in the middle of the square. Then, the values are deducted diagonally ($50 - 18 = 32$ or $10 - 18 = -8$, but written as 8) and written on the right side irrespective of the positive or negative value. The values on the right side at the face of ingredient are the quantities of that ingredient.

In this case, the values are 8 and 32 for soybean meal and maize, respectively. It means that out of 40 parts, 8 parts will be soybean meal and the remaining 32 parts will be maize. Thereafter, the values are calculated in 100 parts.

For 100 parts, the amount of soybean meal and maize required are calculated as under:

$$\text{Soybean meal required} = (8/40) \times 100 = 20 \text{ parts}$$

$$\text{Maize required} = (32/40) \times 100 = 80 \text{ parts}$$

The Pearson square method is useful for increasing or decreasing the nutrient density of a feed mixture. The Pearson square method is useful even today to calculate the amount of concentrate and cereal/cereal mixture required to prepare a mixed feed from readymade concentrates with variable protein.

(ii) **Software for Feed Formulation**

Computers are being utilized for feed formulation more efficiently. The methods that

are used in computer, in true sense, are the application of one or more above methods. **Make Feed Poultry** (a) It is Windows based easy, efficient, effective, simple software developed by Central Avian Research Institute (CARI), Izatnagar, Bareilly (UP) for efficient balanced formulation of feed on Computer for a wide variety of poultry (b) It gives two options for formulation of feed without considering the cost factor and with the cost.

Check Your Progress 3

Note: a) Use the space given below for your answers.

b) Check your answers with those given at the end of the unit.

1) Mention the important points to be considered during feed formulation.

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2) Name the two methods of feed formulation.

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Activity 1

Prepare a feed mixture containing 23 % Crude Protein (CP) by mixing groundnut cake (CP 40%) and jowar or sorghum grain (CP 10%).

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1.5 FEED INTAKE AND EFFICIENCY

Feed is the largest input in poultry production accounting for 65-75% of total cost of production. The feed intake (FI) or feed consumption (FC) and its utilization efficiency are very important factors in the economic production of eggs and meat. The feed intake is governed by many factors such as age, breed, sex, dietary energy-protein concentration, form of feed, type of ingredients used in mixed feed, environmental temperature, humidity, stress, diseases, vaccination, trimming of beak etc. These factors which affect the feed intake and efficiency of broilers and layers as discussed below:

1.5.1 Broiler Chicken

The feed intake and feed utilization of broiler chicken are detailed below:

(a) **Feed intake:** Several stocks of meat type chicken (broilers) have been developed to grow at a very rapid rate of about 1.8 to 2.0 kg at 6 weeks of age after consuming about 3.2 to 3.6 kg of feed. The feed intake is quite variable due to many factors and the age of the bird is primarily an important factor. Normal feed intake and weekly body weight gain of broilers at different ages is given in Table 1.3 and 1.4.

Table 1.3: Body Weight, Feed Intake and Feed Conversion Ratio of Broilers

Age (weeks)	Body Weight (g/bird)	Daily Feed Intake (g/bird)	Cumulative Feed Intake (g/bird)	Feed Conversion Ratio (g feed/g body weight gain)
1	130	25	175	1.34
2	320	40	455	1.42
3	600	70	945	1.57
4	975	110	1715	1.76
5	1400	145	2730	1.95
6	1850	160	3850	2.08

Table 1.4: Feeding Schedule for Broiler Parent Stock in Relation to Egg Production

Egg Production (%)	Broiler Parent (g feed/bird/day)
1-5	130-135
5-10	135-140
10-20	140-150
20-30	150-155
30-40	155-160
40-50	160-165
50-60	165-170
60-70	170-175
70-80	175-180
Above 80	180-185

(b) Feed Utilization: The feed utilization is an important parameter of economic importance. This refers to various terms such as feed conversion efficiency (FCE) or feed conversion ratio (FCR) and feed efficiency (FE) or feed efficiency ratio (FER). In simple way, FCR is defined as the amount of feed consumed for one kg gain in live weight of chicks or broilers. A reduction in about 0.1 unit in FCR for gain will provide opportunity to raise about 5% more broilers within the quantity of feed being used. It is calculated as follows:

$$FCR = \frac{\text{Feed consumed in g or kg}}{\text{Body weight gain in g or kg}}$$

The FE is calculated as follows:

$$FE = \frac{\text{Body weight gain in g or kg}}{\text{Feed consumed in g or kg}}$$

1.5.2 Layer Chicken

The feed intake and feed utilization of layer chicken are detailed below:

(a) Feed intake: Generally, a White Leghorn hen consumes 8 kg of feed up to 20 weeks of age and 39 kg during 360 days (about 100 g/bird/day or 130 g/egg if producing 300 eggs per year) of laying period. Normal feed intake and weekly body weight of layers at different ages is given in Table 1.5 and 1.6.

Table 1.5: Body Weight and Feed Intake of Egg Type Starter and Grower Chicken

Age (weeks)	Body Weight (g/bird)	Daily Feed Intake (g/bird)	Cumulative Feed Intake (g/bird)
Day old	40	-	-
1	65	8	60
2	100	13	150
3	140	15	260
4	200	27	450
5	270	36	700
6	350	43	1000
7	430	46	1325
8	520	46	1650
9	610	50	2000
10	710	50	2350
11	810	54	2725
12	900	57	3125
13	960	61	3550
14	1010	64	4000
15	1050	68	4475
16	1090	68	4475
17	1130	71	5450
18	1160	71	5950
19	1200	75	6475
20	1260	75	7000
21	1290	79	7550

Table 1.6: Hen-Day Egg Production and Feed Intake of Layer Chicken

Age (weeks)	Hen Day Egg Production (%)	Daily Feed Intake (g/bird)	Cumulative Feed Intake (g/bird)
21-24	23.2	95	2660
25-28	65.2	100	5460
29-32	79.2	130	9100
33-36	78.5	129	12712
37-40	76.8	127	16268
41-44	75.4	125	17768
45-48	74.2	123	23212
49-52	72.7	121	26600
53-56	67.5	119	29932
57-60	64.2	117	33208
61-64	61.4	115	36428
65-68	58.9	113	37592
69-72	55.4	111	42700

(b) **Feed utilization:** A reduction of about 0.1 unit in FCR will provide opportunity to produce 5% more eggs within the quantity of feed being used. The FCR of laying birds means the amount of feed consumed or required for production of one dozen of eggs or one kg egg mass (average egg weight multiplied by number of eggs produced). It is generally calculated as follows:

$$\text{FCR (Feed/dozen eggs)} = \frac{\text{Feed consumed in gram} \times 12}{\text{Number of eggs produced}}$$

$$\text{FCR (Feed/egg mass)} = \frac{\text{Feed consumed in kg}}{\text{Number of kg eggs produced}}$$

The FE is calculated as follows:

$$\text{FE (Dozen eggs/feed)} = \frac{\text{Number of dozen eggs produced}}{\text{Feed consumed in kg}}$$

$$\text{FE (Egg mass/feed)} = \frac{\text{Number of kg eggs produced}}{\text{Feed consumed in kg}}$$

Check Your Progress 4

Note: a) Use the spaces given below for your answers.
 b) Check your answer with those given at the end of the unit.

- 1) Write True or False
 - i) Adult bird needs less feed than young chicks.
 - ii) Broilers need more feed than layers.
 - iii) Growers need more feed than starters.
 - iv) Layers need more feed than growers.
 - v) Feed accounts for 65-75% of total cost.
- 2) Give the formula for calculation of feed conversion ratio based on feed per dozen eggs in layers.

- 3) Give the formula for calculation of feed efficiency in broiler.

Activity 2

Calculate the Feed Conversion Ratio (FCR) and Feed Efficiency (FE) for the following:

- a) Feed consumed = 5 kg, number of eggs produced= 24, no. of dozen eggs produced= 2
- b) Feed consumed = 3 kg, body weight gain = 1.5 kg

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1.6 LET US SUM UP

In order to achieve a cost-effective diet for poultry, there is a continuing need to have knowledge on the ways to curtail feeding cost and wastage of nutrients, to utilize a vast feed-inventory and to ensure efficient utilization of nutrients through feed processing, use of additives and sustaining the quality of raw materials and compounded feed. The recommendations of Bureau of Indian Standards (BIS) acts as guidelines for feed manufacturers but may not correlate with the production status of birds. Poultry diets are composed primarily of a mixture of several feedstuffs such as cereal grains, vegetable proteins, animal by-product meals, fats, and vitamin and mineral premixes. Those intended for the production of eggs for human consumption

(Leghorn-type) have a small body size and are prolific layers, whereas, those used as broilers or broiler breeders (meat-type) have rapid growth rates and a large body size are less efficient egg layers. The important points to be considered during feed formulation are nutrient content of feedstuffs, nutrient requirements, availability, cost and quality of feedstuffs. FCR of broilers is defined as the amount of feed consumed for one kg gain in live weight of broilers. FCR of laying birds means the amount of feed consumed or required for production of one dozen of eggs or one kg egg mass (average egg weight multiplied by number of eggs produced).

1.7 GLOSSARY

Balanced Ration	: A balanced ration supplies all the nutrients in proper quantity and proportion that support optimum growth, egg production and health maintenance.
BIS	: Bureau of Indian Standards suggesting various specifications for different items used by the consumers.
Feed Conversion Ratio	: It is the ratio of kg feed consumed to produce kg gain in live weight of young/growing chicks.
Feed Efficiency Ratio	: It is the ratio of one kg gain in live weight of chicks to one kg feed consumed.
Feed Efficient Economic Diet	: A balanced one in all nutrients at a low cost.
Feed Formulation	: A mathematical calculation to prepare a balanced ration.
NRC	: National Research Council of United States of America suggesting various specifications for different items used by the consumers.
Pearson Square Method	: This is a simple technique of feed formulation that helps in achieving desired nutrients by mixing two ingredients.

1.8 SUGGESTED FURTHER READING

Banday, M.T. and Mondal, S.S. 2002. *Poultry Feeding and Nutrition*. Pixie Publication India (P) Ltd., Karnal.

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1.10 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

- 1) As per BIS (1992), calcium is recommended @ 1% for starter and grower but 3% for layer. The requirement of Ca is increased (3.0 to 4.5 g/bird/day) in diet, just prior to initiation of egg production in order to store huge amount of Ca in bones, which will be sufficient for producing 6 to 30 eggs. Therefore, Ca concentration is increased to about 2% of diet a week before onset of egg production. Once egg laying is started, the birds adjust Ca requirements from dietary intake and also by drawing from the body reserve. Half of the calcium in diet should be supplied through coarsely ground powder and remaining half as grit so that the needy hens may select and consume calcium as per the need and palatability of feed is also maintained.
- 2)
 - i) 20%
 - ii) 23%
 - iii) 16%
 - iv) 18%
 - v) 20%

Check Your Progress 2

- 1)
 - i) True
 - ii) True
 - iii) False
 - iv) False
 - v) False
- 2)
 - i) 4-6%
 - ii) 3-5%
 - iii) 20-30%

iv) 5-10%

v) 5-10%

Check Your Progress 3

- 1) The important points to be considered during feed formulation are nutrient content of feedstuffs, nutrient requirements, availability, cost and quality of feedstuffs.
- 2) The two methods of feed formulation are by pearson square method and using computer software.

Check Your Progress 4

- 1) (i) False
(ii) False
(iii) True
(iv) True
(v) True
- 2) FCR for Feed/dozen eggs in layers:

$$\text{FCR (Feed/dozen eggs)} = \frac{\text{Feed consumed in gram} \times 12}{\text{Number of eggs produced}}$$

- 3) FE for broilers:

$$\text{FE} = \frac{\text{Body weight gain in g or kg}}{\text{Feed consumed in g or kg}}$$