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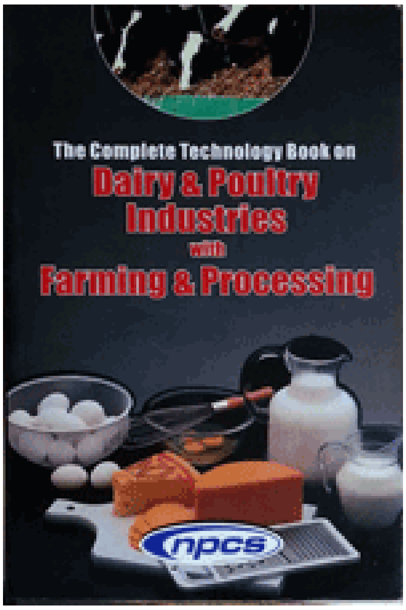
The Complete Technology Book on Dairy & Poultry Industries With Farming and Processing (2nd Revised Edition)



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Dietary habits of people have changed over the last few decades. Growing consciousness for protein rich food has given an impetus to both the dairy industry and poultry farming. Today, the dairy industry is a large organized sector with both private and government participation whereas poultry farming has indicated a rapid growth of 20% in the past few decades as well. Poultry is one of the fastest growing segments of the agricultural sector in India today. The production of agricultural crops has been rising at a rate of 1.5 to 2 % per annum that of eggs and broilers has been rising at a rate of 8 to 10 % per annum. From a backyard hobby it has culminated into an industry. The venture has largely been entrepreneurial and poultry farmers prefer to target their efforts to breeding & broiler farming for sale of ready broilers or layer farming for eggs. Poultry is the second most widely eaten meat in the world, accounting for about 30% of meat production worldwide. Dairy plants process the raw milk they receive from farmers so as to extend its marketable life. India has only a few specialized dairy farms. It is the production that characterizes the dairy industry. India is the worlds highest milk producer and all set to become the worlds largest food factory. Dairying is an important source of subsidiary income to small/marginal farmers and agricultural labourers. The manure from animals provides a good source of organic matter for improving soil fertility and crop yields. Since agriculture is mostly seasonal, there is a possibility of finding employment throughout the year for many persons through dairy farming. Thus, dairy also provides employment throughout the year. The main beneficiaries of dairy programmes are small/marginal farmers and landless labourers. Developments in the dairy and poultry industries during the last decade have been important enough to bring out a considerable amount of materials on dairy and poultry farming; processing of milk and poultry related products.

The major contents of the book are dairy farming, poultry production, breeding, fertility, forage grass and concentrates, cow behaviour and health, manufacture of butter and cheese, process measurements and controls, components of poultry diets etc. This book also describes about the feed manufacturing process, butter and cheese manufacturing processes with diagrams, housing system and management of broilers and more.

The first book of its kind which covers complete details of dairy and poultry farming, processing how to feed cows, birds in dairy and poultry, kind of diseases and their cure and other information related farming. This book will be an invaluable resource to dairy and poultry technology, institutions and for those who want to venture in this field.

Tags

How to Start Dairy Farming and Manufacture of Milk Products, Book on Dairy and Poultry Industries, Book on Dairy Farming and Processing, feed manufacturing process, Broiler Feeds, Modern Breeds of Broiler Chicken, Breeding and Fertility, Milking Parlours and Cowsheds, Manufacture of Butter and Cheese, Milk Production and per capita availability of Milk in India, Per capita availability of Milk by States, Are you ready for Dairy Farming Business?, Uses of Milk, Buffalo breeds in India, Bulls, Cows and How to Breed Cattle, Business consultancy, Cattle Breeding and Dairy Farm to Produce Milk, Dairy Business, dairy farm management, Dairy Farming a lucrative business in India, dairy farming business plan, dairy farming business plan pdf, Dairy Farming in India, Dairy Industry, Dairy Equipment, Milk Processing, Dairy Production, Dairy production and products: Milk composition, Do you think Dairy Farming Profitable?, nurturing, breeding of cows, fully automated international standards dairy plant, fully automatic milking machines, Fully-Automated Dairy Farm in India, Getting Started in Small-Scale Dairy Farming, Green milk, Hand milking process, how to start a cattle breeding business?, How to Start a Cattle Farming Business?, How to start a successful Dairy business, how to start breeding cattle, How to Start Dairy Cow Farming

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Poultry Production

The term poultry includes a number of avian species such as chicken, ducks, turkeys, geese, guinea fowls and peafowls which have been domesticated, but is very often used as synonymous to chicken. Most of these species thrive well under a variety of agroclimatic conditions and can be raised successfully almost anywhere provided certain minimum management and nutritional requirements are met with. They are also efficient convenors of feed into animal protein compared to other livestock species. While chicken, ducks and quails are used for commercial production of eggs and meat, turkeys, guinea fowls, peafowls, etc. are used only for meat production. Keeping poultry for eggs, raising broilers, fryers, roasters, etc. for meat, basic breeding farms for development of elite strains of layers and broilers, and commercial hatcheries for production and sale of day-old commercial chicks are the most common poultry enterprises. Other allied professions include processing of eggs and meat, marketing of poultry and poultry products, compounding and sale of poultry feed, poultry equipments, poultry biologicals, pharmaceuticals, feed additives, etc. Chicken alone account for about 90% of the total poultry. We have a fairly good knowledge and understanding with regards to its breeding and husbandry practices. In this chapter information available on fowl production has been presented as a standard. A brief description has been provided on the breeding of ducks, turkeys, quails and guinea fowls at the end.

Modern domestic breeds of chicken are considered to be the descendants of jungle fowl, found in India and its neighbouring countries Sri Lanka, Burma and China. Most of the development of poultry breeds, however, has taken place in the west and not in the home tract. Our apathy towards poultry improvement was primarily due to their poor productivity, low prices for egg and meat, and inadequate knowledge of control and prevention of contagious poultry diseases. Inadequate knowledge about scientific methods of feeding and management, lack of appreciation for nutritive value of egg and meat and above all the prejudices of a large section of Indian society against rearing of chicken and consumption of their eggs and meat, were the other factors. Most of these factors are not important any more.

Poultry farming has now become very popular. It is recognized as an organized and scientifically based industry with tremendous employment potential. Many of the present-day farms have several thousand layers or broilers with comparable levels of performance of those in the most advanced countries in the world. Age-old methods of hatching and rearing of chicken using broody hens has become a thing of the past. Desi birds have given way to improved commercial layers and broilers. Many farms with small number of birds unable to survive competition have closed down doors in favour of large commercial establishments. A network of franchise hatcheries have been set up all over the country to supply quality chicks for commercial egg and meat production. Most of these hatcherymen receive grand parent or parent stocks from reputed foundation breeders in USA, Canada, UK or Germany. However recently a few breeding companies have been set up within the country for basic breeding work consistent with the government's policy of self sufficiency in the availability of pure-line egg and meat-type stocks. Most of these private breeding companies have the typical characteristics of large business firms with trained personnel in charge of various departments such as basic breeding, commercial chick production, sales and sales promotion, and personnel management. The Indian Council of Agricultural Research as well as the central and state governments have also initiated massive breeding programmes for the development of pure-line layer and broiler germplasms. Some of the factors which have favoured the growth of poultry farming in the country are : small initial investment; availability of quality chicks; short generation interval; quick, assured and better returns compared to other livestock species; availability of trained man power; better understanding and knowledge of the improved and scientific methods of feeding, management and health control; and poultry's social role as a tool to overcome poverty and malnutrition.

The growth and development of Indian poultry industry during the last decade is unparalleled in the history of animal agriculture and has been described as a textbook example of modernization and industrialization. India today ranks eighth in the world in egg production behind China, the USA, the USSR, Japan, England, France and Spain. In broiler production however we are far behind.

Application of improved methods of breeding, feeding, management and disease control are very much essential to increase the efficiency of poultry production.

COMMON POULTRY BREEDS

Breed refers to a group of domestic fowls with a common ancestry, and having similarity in shape, conformation, growth, temperament, shell colour of egg and breed true to type. Variety is a subdivision of breed and within a breed there may be several varieties. The term variety is used to distinguish fowls having the characteristics of the breed to which they belong but differing in plumage colour, comb type, etc. from other groups of the same breed. A breed/variety may also have several strains or lines identified by a given name and produced by a breeder through at least 5 generations of closed flock breeding for a particular purpose. Several strains within a breed/variety phenotypically may look alike but often differ in their production performance depending upon their breeding history.

The most common method of classifying chicken has been the basis of their origin, viz. American, Asiatic, English and Mediterranean. A brief description of each class with breed characteristics for some of the important breeds is given below.

American Class

The most popular American breeds are the dual-purpose Plymouth Rock, New Hampshire, Rhode Island Red and Wyandotte. These breeds are characterized by yellow skin, clean shanks, free from feathers and red ear lobes. Eggs are brown-shelled, except in Lamana.

Plymouth Rock: Plymouth Rock is a much sought after American breed because of its egg size and fleshing properties. Barred and White Plymouth Rocks are very popular. A number of other varieties such as Buff, Silver Pencilled, Partridge, Columbian and Blue are also recognized. White Plymouth Rock with a long body of good depth, and broad and prominent breast is especially favoured for broiler production. The breed has a single comb. Barred Plymouth Rock possesses greyish-white plumage. The feathers are crossed by black bars even in width, straight and extending down to the skin. Each feather ends in a narrow dark tip. Alternate dark and light bars give a bluish cast to the surface colour. The barring in hackle and saddle of the male is narrower than in the other sections of the body. Solid black or partly black feathers are seen in a few birds only. Black spots on the shanks are common, particularly in females. Males are lighter in colour than females due to equal width of black and white bars. In females the black bars are about one and a half times as wide as the white bars. The gene for barring (B) is located in the sex chromosome and is used for autosexing.

Standard weight (kg) : Cock, 4.3; hen, 3.4; cockerel, 3.6; pullet, 2.7.

Rhode Island Red : This is dual-purpose breed developed by farmers of Rhode Island in America ; contains varying amounts of Malay game, Red Shanghai, Brown Leghorn, Cornish and Wyandotte blood. Single and Rose comb are the common varieties. Some single-comb Rhode Island Red are still very popular for commercial production of brown-shelled eggs. The most common colour is red buff; white and brown varieties are also found. The birds are characterized by long body, broad and deep breast carried well forward, flat back with red eyes and red ear lobes. Legs and feet are deep yellow but may show brown colour. The male is dark red with black tail, black colour can be seen in both primary and secondary feathers of the wing when open. The female is rich even red, with wing and tail markings as in male. Neck hackle shows a little black marking at the base.

Standard weight (kg): Cock, 3.8; hen, 2.9; cockerel, 3.4; pullet, 2.5.

New Hampshire: This breed was developed from Rhode Island Red by New Hampshire poultry farmers of America for early maturity, rapid feathering, large egg size and good quality meat. It is a popular breed. Some strains are used for broiler production and others for commercial production of brown-shelled eggs. The birds are characterized by chestnut red plumage, single comb and less rectangular body than the Rhode Island Red.
Standard weight (kg): Cock, 3.8; hen, 2.9; cockerel, 3.4; pullet, 2.5.
Asiatic Class
Brahma, Cochin and Langshan, the three recognized Asiatic breeds which are virtually extinct now, are characterized by large body with heavy bones, feathered shanks, red ear lobes and yellow skin (except Black Langshan in which the skin is pinkish white). They arc classed as broody and poor layers. These Asiatic breeds have contributed significantly to the development of American breeds.
Brahma: Brahma originated in the Brahmaputra Valley. It is known for its massive, well-feathered and proportioned body. Pea comb is one of the breed characteristics. Light, dark and buff are the most common varieties.
Standard weight (kg): Light Brahma - cock, 5.4; hen, 4.3; cockerel, 4.5; pullet, 3.6.
Dark Brahma - cock, 4.9; hen, 3.6; cockerel, 4.0; pullet, 3.1. Buff Brahma which is similar in plumage pattern to that of Columbian Plymouth Rock, except that golden buff or buff is replaced by white, shows buff feathers on shank and on the outer toe of each foot.
Cochin: It is also known as Shanghai fowl. It originated in Shanghai (China). Characterized by massive appearance, thickly feathered shanks, single comb and a cushion-like structure at the base of the tail. The popular varieties are buff, partridge, white and black.
Standard weight (kg): Cock, 4.9; hen, 3.8; cockerel, 3.6; pullet 3.1.
Langshan : This is a graceful bird with a well-proportioned body. It originated from Langshan region of China. The principal breed characteristics are shorter but deeper body than Brahma or Cochin, large tail feathers, tail carried high, long legs and single comb. Black and White are the two main varieties. Black Langshan is known for its dark brown beak, bluish-black shanks and toes, and pinkish-white toe. White Langshan has the plumage colour as that of White Plymouth Rock except slaty white to pinkish-blue back, slaty blue shanks and toes with pink between scales.
Mediterranean Class
The Mediterranean breeds of Italian origin include Leghorn, Minorca, Andalusian, Spanish and Ancona. They are light bodied and are developed for high egg production.
Leghorn : Leghorn is characterized by compact and light body, uniform blending, pretty carriage, long shanks, small head with well-set rose or single comb and early maturity. Popular varieties are White, Brown and Black. White Leghorn is most popular for its excellent laying performance.
Standard weight (kg): Cock 2.6; hen, 2.0; cockerel, 2.2; pullet, 1.8.
Minorca : Minorca is also known as Red-faced Spanish because of its resemblance and appearance to Black Spanish. They probably originated from the same common ancestors. Single Comb Black, Rose Comb Black, Single Comb White, Rose Comb While and Single Comb Buff are the 5 varieties. Comb is erect with 6 evenly and deeply serrated points. Beak is black, and shanks and toes are black or dark slaty.
Standard weight (kg): Cock, 3.5; hen, 2.9; cockerel, 2.9; pullet, 2.5.
English Class
The breeds of English origin are mostly utility breeds noted for their excellent fleshing properties. With the exception of Cornish, all the English breeds have white skin and red ear lobes. Except Dorking and Red Cap all other breeds of this class lay brown-shelled eggs. All are classed as broody, but this defect has been gradually eliminated by selective breeding.
Cornish: The Cornish, originally known as the Cornish Indian Game, appears to have been developed in

England about the middle of the last century from crosses involving the Aseel, the Malay, and English game breeds. It is noted for its close and compact feathering and heavy flesh with distinctive shape. The breast of the Cornish is very deep and broad, giving the shoulders great width. Cornish birds in general have pea comb. Red Cornish developed at the CARI have both single and peacomb.

Standard weight (kg) : Dark and White varieties : cock, 4.5; hen, 3.4; cockerel, 3.6; pullet, 2.7. The standard weights of the white-laced Red variety (kg) are : cock, 3.6; hen, 2.7; cockerel, 3.1; pullet, 2.2.

Australorp : This breed originated from the Black Orpington and, as the name suggests, was developed in Australia. It is more upstanding and less massive in appearance than the Black Orpington, and has been developed as a layer bird. The back is rather long, with a gradual sweep to the tail. The body has good depth; but the feathering fits more closely to the body than it does in the Orpington. The comb is single, the beak is black, and the shanks and toes are black or lead-black. The bottom of the feet and toes are pinkish white. The plumage is lustrous greenish-black in all sections, the under colour is dull black. Standard weight (kg): Cock, 3.8; hen, 2.9; cockerel, 3.4; pullet, 2.5.

Indigenous Breeds

The common country hen, the desi, is as a rule the best mother for hatching. She is a good forager. Some of the Indian fowls resemble the Leghorn in size and shape, but have poor laying qualities. They are found in various colours. One variety found in India resembles the Sussex or Plymouth Rock in shape, but is smaller. These birds lay fairly well and are more common in the eastern parts of the country.

The Indian birds are mostly non-descripts, and are of very little value as layers. They have several local breed names such as Tenis, Naked Neck, Punjab Brown, Ghagus, Lolab, Kashmir Faberella, Tilri, Busra, Tellichcrry, Danki, Nicobari and Kalahasti. There are only 4 pure breeds of fowls indigenous to India. They are the Chttagong, the Aseel, the Karaknath and the Busra. The last occurs in western India. A large number of fowls of different sizes, shapes and colours, and for the most part resembling the jungle fowls, are found all over India. They vary in appearance according to the locality in which they have been bred. These with Chittagong, Aseel, Langshan or Brahma blood in them are bigger in size and better in meat quality than the common fowls.

Aseel: Aseel is noted for its pugnacity, high stamina, and majestic gait and dogged fighting qualities. The best specimens of the breed, although rare, are encountered in parts of Andhra Pradesh, Uttar Pradesh and Rajasthan. The most popular varieties are Peela (golden red), Yakub (black and red), Nurie (white), Kagar (black), Chitta (black and white spotted), Java (black), Sabja (white and golden or black with yellow or silver), Teekar (brown) and Reza (light red). Although poor in productivity, the birds of this breed are well known for their meat qualities. Broodiness is most common and the hen is a good sitter and efficient mother. They possess pea combs which are small but firmly set on head. Wattles and ear lobes are bright red, and the beak is short The face is long and slender, and not covered with feathers. The eyes arc compact, well set and present bold looks. The neck is long, uniformly thick but not fleshy. The body is round and short with broad breast, straight back and close-set strong tail root. The general feathering is close, scanty and almost absent on the breast. The plumage has practically no fluff and the feathers are tough. The tail is smalll and drooping. The legs are strong, straight, and set well apart.

Standard weight (kg) : Cocks, 4 to 5; hen, 3 to 4; cockerels, 3.5 to 4.5; pullets, 2.5 to 3.5.

Busra : This is a small- to medium-sized bird and found in small numbers in some parts of Gujarat and Maharashta. The body conformation is typical of layers. Deep bodied, light feathered and alert. Wide variation in body colour. A poor layer and not much resistant to parasitic and other diseases.

Chittagong : It is also known as the Malay. This breed is found mostly in eastern India. These birds are large, the cock measuring sometimes 75 cm from beak to toe. A dual-purpose breed with poor mothering ability. The adult birds are very strong and hardy with a quarrelsome temperament. The small pea comb resembles a small lump of tiny warts. The head is long; the beak is long and yellow. The wattles are red and very small, and hardly visible in the hen. The car lobes are small, usually red and at limes admixtured with a little white. The eyebrows are prominent and over-hanging. The breast is broad, deep and fleshy; the shoulder is broad with slight narrow loins. The wings project at the shoulders and are carried high. The legs are yellow and feather-less. The plumage is close to the body, firm, short and glossy. Standard plumage colour is lacking but the buff, white, black, dark brown and grey varieties are recognized.

Karaknath

The original name of the breed seems to be Kalamasi, meaning a fowl with black flesh. However, it is popularly known as Karaknath. It is bred by the tribals in Jhabua and Dhar Districts in western Madhya Pradesh. The eggs are light brown. The day-old chicks are bluish to black with irregular dark stripes over the back. The adult plumage varies from silver and gold-spangled to bluish-black without any spangling. The skin, beak, shanks, toes and soles of feet are slate like in colour. The comb, wattles and tongue are purple. Most of the internal organs show intense black colouration which is pronounced in trachea, thoracic and abdominal air-sacs, gonads and at the base of the heart and mesentery. Varying degrees of black colouration are also seen in the skeletal muscles, tendons, nerves, meninges, brain, etc. The blood is darker than normal blood. The black pigment has been due to deposition of melanin. The flesh, although repulsive to look at, is delicious. A medium layer, lays about 80 eggs per year. The bird is resistant to diseases in its natural habitat in free range but is more susceptible to Marek's disease under intensive rearing conditions.

Standard weight (kg): Cock, 1.5; hen, 1.0.

GENETIC PRINCIPLES

The phenolypic expression of an individual is due to its genotype and the influence of the environment to which the genotype is subjected. The genotype refers to the genes it contains. The genes are the basic units of inheritance and are arranged linearly on the chromosomes. They constitute the link between parent and offspring, and are passed from one generation to the next through gametes, viz. ovum in case of female and sperm in case of male. Ovum and sperm contain only half the number of chromosomes, characteristic of the species. As the chromosome numbers are halved so also the genes during the process of germ cell division (meiosis). The chromosome number, however, is restored in the zygote due to union of sperm with the ovum at the time of fertilization.

Qualitative and Quantitative Characters

The influence of environment on genotype varies greatly almost from nothing to a very great extent depending upon the character. The characters which are least influenced by environment, are governed by one or a few pairs of genes, show discontinuous variation and are known as qualitative characters. Comb type, plumage pattern, plumage and shank colour are examples of qualitative characters in poultry.

The characters determined by many pairs of genes, each with a small effect and influenced by environment to a varying extent, are known as polygenic traits. These traits show continuous variation, which can be measured or quantified and hence known as metric or quantitative traits. Most of the economic traits in poultry like egg production, egg weight, body weight, viability, fertility and hatchability are the examples of the quantitative traits.

Dominant and Recessive Characters

Qualitative characters are inherited in a simple Mendelian way. When a cross is made between a true breeding Rose Comb type and true breeding single-comb type, all the resultant offsprings are Rose Comb type. Similar results are also obtained when cross is made between homozygous individuals possessing any other contrasting characters. The character which appears in the cross (F1) is called dominant and other recessive. The recessive genes although do not express themselves in F1 generation are not lost as they do appear in F2 generation when cross is made between two F1 individuals. In some cases, however, neither of the two characters enter into the cross but somewhat intermediate between the two appears. As for example when a cross is made between frizzle and normal plumage chicken, the resultant progeny is semifrizzle. This condition is usually known as incomplete or lack of dominance.

Chromosomes

Chromosomes occur in pairs and their number varies from species to species. There are 39 pairs of chromosomes in chicken, 41 pairs in turkeys and 39 pairs in Japanese quails. Only one of the several pairs of chromosomes, characteristic to a species, are sex chromosomes and the rest are autosomes. In avian species sex chromosomes are designated as Z and W corresponding to X and Y chromosomes in the mammals. In avian species the male is homogametic (ZZ) and the female is heterogametic (ZW).

Any character whose genes are located on sex chromosome is called a sex-linked character, e.g. rapid and slow feathering, low barring and non-barring in chicken. A hen can transmit her sex-linked characters to her son but not to her daughter but the cock transmits the character to both sons and daughters. This behaviour of sex-linked genes are utilized for autosexing at day-old stage. As for example when homozygous males for rapid feathering (kk) are mated to hens with slow feathering (K-) all the female chicks will have rapid feathering and male chicks slow feathering.

One of the common methods of estimating the importance of sex-linked genes in the inheritance of quantitative traits is to make reciprocal crosses between two strains or lines. When sex linkage is important the mean of cross approaches more towards the sire line than the dam line.

Sex-limited trails like egg production need to be differentiated from sex-linked traits. Sex-limited traits are those which are expressed in one sex but not in the other.

Inheritance of Quantitative Traits

The quantitative characters are determined by many pairs of genes. Although inheritance pattern remains Mendelian with respect to individual pairs of genes it becomes difficult to identify one phenotype from the other. This is because the phenotypic ratios become numerous, and the differences among phenotypic classes reduce considerably and overlap. The number of phenotypes in such cases becomes 2n where n is the number of gene pairs involved.

The multiplicity of gene pairs and the environmental effects complicate the study of inheritance of quantitative traits. Environment here includes all the nongenetic effects such as feeding, management and disease exposure. An approximate method of separating the genetic effects from the environmental influences is to estimate the heritability of the trait. When the heritability is high it is presumed that the environmental influences are less important than the genetic effects and vice versa. Heritability is an important attribute of a quantitative trait and is necessary for almost all breeding work connected with improvement of the species. The heritability of a trait ranges from 0 to 1. Traits connected with fitness of the organism such as egg production, viability, fertility and hatchability are lowly heritable and those with luxuriance or size are highly heritable. Examples of highly heritable traits in poultry are body weight, egg weight and egg quality traits.

When several traits are considered together in a breeding programme it is essential to know the relationship among them. The relationship among two biological traits is best expressed in terms of their genetic and phenotypic correlations. Genetic correlation between two traits is due to same genes affecting the two traits (pleiotropy). Phenolypic correlation is due to simultaneous action of genes as well as environment. The magnitude of genetic and phenotypic correlations ranges from -1 to +1. Knowledge of genetic correlation enables us to predict how selection for one trait will bring about simultaneous changes in other traits.

Objective of a Breeding Programme

The primary objective of a poultry-breeding programme is to improve product output per individual bird, to increase the efficiency of production and to improve the quality of existing product. Improvement in egg yield, fertility, hatchability, growth rate, viability, etc. are different aspects of these three broad goals. Both choice of individuals to reproduce the next generation (which constitutes selection) and the manner in which they will mate (mating system) have been successfully used to bring about improvement in desirable direction.

Basis of Selection

For highly heritable traits like body weight and egg weight selection of individuals is adjudged best on the basis of their phenotypic performance; it yields satisfactory results. This is known as individual selection. Selection on the basis of family averages, i.e. family selection, is advocated for improving lowly heritable traits. Larger the family size better is the estimation of breeding value and hence response is better. Sire family selection is preferred over dam family selection for traits of low heritability like egg production. Dam family selection may have advantage over sire family selection only when the reproductive rate is high. Combining information on the individual phenotype value and its sire and dam family averages and other relatives with appropriate weights attached to each of the components increases the accuracy of selection, and has been found to be superior to individual as well as family selection as it combines the advantages of both individual and family selection. This method of selection is known as combined selection. For sex limited traits the selection of the individuals of the sex not expressing the trait is done based on the performance of the relatives like full or halfsibs of other sex. This is called sib selection.

Selection of parents based on average performance of progeny, called progeny testing, results in greater response than the selection methods presented above. Progeny testing has been effectively used for the development of high producing commercial egg laying strains. It is not very popular at present since it increases the generation interval and reduces the progress per unit of time compared to family selection.

Selection Methods

Three selection methods, viz. tandem selection, independent culling level selection and Index selection have been described in the literature for simultaneous improvement of several traits.

Index selection has been shown to be superior to tandem and independent culling level selection for simultaneous selection of several traits to optimise genetic gains. Each of the three selection methods or a combination of them however has often been used. Culling level selection in which culling level is fixed for each trait is easier to practice and requires less rigid assumption than index method. Culling level selection also permits selection at different stages for different characters and helps in the reduction of breeding costs. Selection on the basis of an index however is a more balanced approach since it combines information on various traits on the basis of their economic importance. Efficiency of the index selection increases, as the number of traits to be selected increases but the response in the individual traits becomes less. Tandem selection which involves selection for different traits at different times is least efficient among the three methods.

Selection of individuals within a population to reproduce the next generation using one or combination of the methods presented above is known as intrapopulation or closed flock selection. Two or more such populations are crossed to produce the cross progeny for commercial egg or meat production. Selection in pure strains results in concomitant improvement in crosses is the underlying principle of closed flock selection to improve cross performance.

Selection on cross performance (either on the cross progeny performance or crossbred collateral relatives) is often advocated for development of elite crosses. This method of selection, known as inter-population or interline selection although not a widely used method, has been used successfully for developing high productive strains. Of the two interline selection methods reciprocal recurrent selection is preferred over recurrent selection. Reciprocal recurrent selection increases the frequency of both additive and non-additive genes, hence improves both pure as well as cross-line performance. For obtaining desirable results from reciprocal recurrent selection both populations should be open bred with history of nicking.

Theoretical studies have shown beyond doubt the superiority of RRS when over dominance is important. Use of RRS would seem desirable for the populations which have ceased to respond to conventional closed flock selection methods. In recurrent selection only one of the two populations is purebred and is improved upon in reference to other population which is called a tester or test population. The tester line is either an inbred line or cross of two inbred lines. The success of recurrent selection depends upon the test populations and is practised for utilizing non-additive genetic variance. Commercial crosses in this scheme of selection are produced using the two lines involved in the improvement programme.

In order that selection operates as desired, the population size should be fairly large, inbreeding should be kept to minimum and intensity of selection should be fairly high.

Mating Systems

The manner in which the selected individuals (both males and females) mate is also of considerable significance in realising response to selection. Mating systems do not change the gene frequency like selection but depending upon the procedure used rearrange the genotypic frequency. Random mating, positive assortative mating, inbreeding and out breeding are the most commonly used mating systems in poultry. Random mating means that any individual of one sex has an equal chance of mating with any other individual of the opposite sex in the population and is the most commonly used method in selection experiments as it holds inbreeding to the minimum. Positive assortative mating refers to mating of likes to likes. Initially the response is usually greater than random mating. Positive assortative mating leads to similar consequences as that of inbreeding and hence response to selection slows down as the generations advance.

Inbreeding refers to mating among the closely related individuals. The closest form of inbreeding in poultry is full or half brother-sister mating or constant parent-offspring mating. Inbreeding increases the frequency of homozygotes at the cost of heterozygotes. The decrease in fertility and hatchability, increased mortality, delayed maturity, slow growth, decrease in egg production and increase in the frequency of defects due to inbreeding are called inbreeding depression. The primary objective of inbreeding is to develop lines which can be commercially used. A line to be called inbred should have at least 50% of inbreeding coefficient. Three generations of full brother-sister mating or 6 generations of half brother-sister mating produces inbred lines with 50% coefficient of inbreeding.

Outbreeding is opposite of inbreeding and refers to the mating among unrelated individuals. Crossing among breeds, varieties, strains/lines are different types of outbreeding. The main purpose of outbreeding is to overcome the deleterious effects of inbreeding which arise due to small flock size. Outbreeding is sometimes practised to introduce some desirable characteristics not present in the flock. However care should be taken not to introduce germplasm from an inferior flock.

Crossing among breeds is usually called crossbreeding. Similarly crossing between strians is called strain crossing and so on. When a cross is made between two inbred lines belonging to same breed it is called an incross, and between those belonging to different breeds in-crossbred. Top crossing is a method of outbreeding in which inbred males of one line are crossed to females of an outbred population. Grading refers to the mating of an improved breed to the indigenous mongrel females. Offspring resulting from this cross are called grades. The first cross shows marked improvement over the indigenous stocks. Halfbred females are sometimes crossed to the males of exotic breed again and again to increase the inheritance of exotic breed.

Commercial crosses used for egg and meat production may result from crossing of 2 or more lines/strains/breeds. When cross involves 2 lines only it is a single cross, 3 lines 3-way cross, 4 lines 4-way cross and so on. All other crosses except single cross are known as multiple crosses. Although single crosses may be superior than multiple crosses in their production performance, multiple crosses are often used for viability of commercial operation. Diallel crossing system, in which the available lines are crossed in all possible combinations, helps to identify the best cross for commercial use, and to identify as to which line should be used as male parent and which one as female parent.

Methods of Mating

Flock and pen matings are the two commonly used methods. In flock mating a number of males and females are bred together in a large poultry house. Pedigree records arc not maintained. One male is mated to 10 to 15 females for egg type stocks and 1 male to 8 to 10 females for meat type stocks, to obtain desired fertility. When mating is done in single sire pens 1 male is mated to 10 to 12 females at the most. Single sire pen mating permits maintenance of pedigree by use of trapnests. When birds are housed in cages mating is done by artificial insemination. Although semen can be diluted, undiluted semen is very often used immediately after collection. In case of chicken 0.1 ml semen is given. Twice insemination in the first week followed by single insemination in subsequent weeks gives optimum fertility levels. Insemination is usually done in the afternoon when hard-shelled egg is not in the uterus.

IMPORTANT ECONOMIC TRAITS IN POULTRY

Egg Production

A modern layer starts to lay around 20 weeks of age and continues to lay till it dies. Egg production drops sharply after the first year of lay below the economical level. The peak production is reached about 5 to 6 weeks after the first egg is laid and then the egg production gradually declines. The number of eggs a hen will lay during a year depends upon (i) age at which a hen becomes sexually mature, (ii) the length of time over which she continues to lay (persistency), (iii) the rate of egg production (intensity of lay), (iv) number of pauses during which no egg is laid, and (v) number and duration of broody periods.

A pullet is said to be sexually mature when she lays her first egg. Light breeds like Leghorn mature about a month earlier than heavy breeds. Probably many genes are involved in its inheritance and some of these are sex-linked. Use of early maturing strains as sire line in the production of commercial crosses is preferred to obtain early maturing commercial chicks. Poor nutrition and sub-optimal management retard the onset of egg production. Date or season of hatch is also important. Chicks hatched during March to May come into production earlier than those hatched in other seasons. Too early maturity may not be desirable in commercial laying flocks as it affects egg weight. It is easier to improve age at sexual maturity as it is moderately heritable.

Persistency refers to the onset of moulting at the end of the laying cycle. A hen which moults late or continues to lay during the moulting period is considered to be a good layer. Persistency is an inherited trait, hence it is possible to improve this trait by appropriate selection.

The intensity or rate of production is measured by the number of eggs laid by a hen during a standard time interval or by the percentage of eggs laid during a variable time interval. The number of eggs laid by a bird is determined by the nature of its egg cycle, i.e. the number of eggs laid without a break. This is called a clutch. The clutch size is highly variable, while some birds lay 1, 2 or a few eggs in a clutch, others lay fairly large number of eggs. After each clutch there is an interval which varies from 1 to several days. Clutch size is longer and inter-clutch interval shorter for the good layers. Clutch size is related to oviposition. The time interval between two consecutive ovipositions varies from 24 to 26 hours. When interval between consecutive ovipositions is smaller, clutch sizes are bigger. Clutch size is moderately heritable while that of rate of lay is lowly heritable.

Broodiness refers to that condition in which females of the avian species stop laying and show tendency for nesting. Broodiness has been completely eliminated from modern elite layers by continuous selection. Heavy breeds like RIR, Australorps and White Rocks still show varying amount of broodiness. Interbreed crosses tend to be more broody than either of two parental breeds suggesting interaction among the genes influencing broodiness. Broodiness is determined by complementary genes; also it has a sex-linked basis.

To eliminate broodiness from commercial crosses, it is necessary to select pure lines on the basis of their cross performance.
Some hens lay well for some time and then stop laying for a few days. When the period of non-laying between two clutches exceeds more than 7 days it is called a pause and that which occurs in winter months is called winter pause. Winter pause which occurs in temperate climates does not seem to be a problem in tropical countries like India. On the other hand, pauses are more common in summer months or immediately thereafter due to hot and humid climates. Stress as well as diseases of various kinds induce pauses. It has also a genetic basis. Selection of birds with less number of pauses with shortest duration will be desirable for breeding purposes.
Egg production is measured either as number of eggs or rate of lay and expressed as hen housed, hen day and survivor's production. Hen housed egg number is calculated by dividing the total number of eggs produced by the number of birds housed in the laying pens. Hen day egg number is calculated in similar manner but obtaining the birds number on the basis of functional days basis. Survivor's egg production refers to the average number of eggs laid by each survivor and is calculated by dividing the total number of eggs laid by survivors by the number of surviving birds.

Egg Weight

This is also referred to as egg size, and is a highly heritable trait. The first egg laid is smallest and about 75% of the maximum weight that can be reached. Final egg weight is influenced by age at sexual maturity, body weight and rate of lay. Those which mature earlier lay small size eggs. Birds with high production potential tend to lay smaller eggs. Egg weight is higher for heavy breeds than light breeds. Other factors which have been known to affect egg size are nutrition, season and disease conditions. Birds housed in cages may lay larger eggs than those housed on floor. Egg weight may be influenced either by maternal or sex-linked effect depending upon the strain.

Egg Quality

External quality of the eggs is judged from its colour, shape, texture and breaking strength (or shell thickness). The internal quality is assessed from the quality of albumen, yolk and presence or absence of blood and meat spots. Most of the egg quality traits are highly heritable.
White and brown are the two most common egg colours. Colour does not make any difference in the nutritive value; some people however prefer brown-shelled eggs to white-shelled eggs. As egg colour is a characteristic of a breed, the breeding material has to be different depending upon the preference of the shell colour.
Hens that lay rough or poorly textured eggs or eggs with thin shells are usually selected against. Shell thickness provides a measure of breaking strength. Breaking strength of the commercial eggs should be fairly high as they are likely to be transported over long distances in the marketing channels. Feeding and environment affect shell thickness. Shell thickness decreases in summer and in some disease conditions. Calcium carbonate should be available in required quantity for obtaining eggs with better shells. Utilization of calcium depends upon proper calcium: phosphorus ratio and availability of vitamin D-3.
Thick albumen is preferred over thin albumen; so also eggs with high proportion of yolk. Albumen quality can be judged either by measuring the height of thick albumen or by determining Haugh unit. Yolk quality is determined by yolk index. Good layers lay eggs with more of thin than thick albumen. Small eggs comparatively have more yolk than large eggs. Variation is noticed among strains, among family and individuals within a family for blood and meat spots. Although the nutritive value is not affected blood and meat spots do not present a pleasing appearance.

Body Size

Large body weight is of primary importance in broilers. Small or intermediate body weight is preferred in layers, although optimum body size is essential in egg laying chicken to obtain eggs of satisfactory size.

Body weight at all ages is highly heritable and can be improved by simple mass selection. Body size involves both bones as well as fleshing. Bone size is more heritable than degree of fleshing. Husbandry practices like feeding, management and disease have a large effect on fleshing and a small effect on bone size.

Conformation

Conformation refers to body proportions and is more important in chicken broilers and turkeys. It is of secondary importance if broilers are not sold as whole birds. Both bone structure and fleshing influence conformation. It is measured either by ratio of body weight/shank length or by 3 body weight/shank length.

Growth

Rapid juvenile growth is very essential in meat type birds. It helps to reduce the cost of production by saving labour, time and feed. Growth rate is fairly high up to approximately 12 weeks of age in broilers, 5 weeks of age in quails and 16 weeks of age in turkeys after which it slows down. Growth rate is moderate to highly heritable and can be improved by mass selection.

Feed Efficiency

Feed efficiency is a ratio of feed consumption to weight gain in broilers. Better understanding about the nutritional requirements and formulation of high-energy rations has contributed significantly to improving feed efficiency. Feed efficiency although moderately heritable is laborious to measure. . Most of the improvement in feed efficiency in commercial stocks has been achieved as a correlated response to selection for high growth rate or egg production.

Feed efficiency in layers is measured either as amount of feed consumed in kg/dozen eggs or as amount of feed consumed in kg/kg egg mass. Small-bodied birds are considered to be most efficient for egg production as they consume less feed. It is possible to measure feed efficiency in laying stocks simply by measuring egg mass output and body weight without direct measurement of feed consumption.

Fertility and Hatchability

Fertility and hatchability for a flock are expressed as percentage in relation to total eggs set. Hatchability can also be expressed in percentage as a proportion of fertile eggs set. Differences have been reported among breeds, strains, family as well as individuals within a family. Inbreeding depresses while outbreeding increases. Age of birds, season, nutritional status of flock, diseases and management conditions affect both fertility and hatchability. To improve fertility the ratio of male to females should be kept optimum. This ratio should be narrow for heavy breeds than light breeds. Artificial insemination and mating in single sire pens is advocated to overcome preferential mating and social order. Flocks in high rate of lay have better fertility and hatchability.

Both fertility and hatchability are lowly heritable trails but can be improved by appropriate breeding methods.

Size and shape of the eggs, and conditions of egg shell are important for hatchabilily. Extremely large or very small eggs do not hatch well. Eggs having abnormal shapes show low hatchability.

Breeder flocks need special attention. Their ration should be fortified with minerals and vitamins for obtaining better fertility and hatchabilily. Very high or low temperature in the house affects fertility and hence hatchability.

COMMERCIAL POULTRY BREEDING PRINCIPLES AND PRACTICES

Commercial Hybrid Chicken

More than 90 per cent of the commercial layers, broilers, turkeys, guinea-fowls, etc. found in the market today are crosses of one kind or the other, viz. strain crosses, breed crosses and inbred hybrids. Crossing results in improved performance in the progeny. The cross progeny not only perform better than the average performance of two strains but also sometimes exceed the better parent (overdominance). The observed superiority of crosses over the average performance of their parent or over the better parent is called heterosis.

For the production of commercial crosses one line is used as male line (sire line) and other as female line (dam line). Sire and dam lines are those which supply male parent and dam line female parent, for the production of commercial chicks. When commercial chick is a single cross each line entering into the cross is called a parent line. When 4 lines are used each line is called a grandparent line.

Production economics of a commercial layer is entirely different from that of a commercial broiler, thus needing breeding of specialized type of chickens for these two purposes. While the main attributes of a commercial layer are high egg production, low body size, less feed consumption, optimum egg size, good egg quality and high viability, that of a commercial broiler are high juvenile body weight especially at the marketing age, better feed efficiency and low brooder house mortality. The foundation or basic breeder concerned with the development of pure line stocks however has a different production economics. He is not only concerned with the production of good quality commercial chicks but also should produce sufficiently large number of desirable chicks from each parent to make the business of poultry breeding a commercially remunerative enterprise. To achieve this end he should develop parent stocks for high production and reproduction performance. Although this objective of breeder is not in conflict with the commercial layer production it goes against the production of commercial broilers. This is because production and reproduction traits are negatively correlated genetically with broiler traits. Hence the development of specialized sire and dam lines is of utmost importance for production of commercial broilers. Sire and dam lines contribute differentially to commercial chick production as only less number of males are required than females. For commercial broiler production while the sire lines are exclusively developed for high growth and confirmation traits, the selection on female line is concentrated on production and reproduction traits in addition to growth rate. This helps to bring down the production cost of commercial broiler chicks.

Breeding Systems

Two methods are generally used for the production of commercial hybrid chicks.

1. Development of strains/lines using closed flock selection or selection on cross line performance and crossing among such improved strains to produce strain cross commercial chicks.
2. Development of inbred lines with inbreeding coefficient of at least 50% and crossing among those lines which nick well for production of inbred hybrid commercial chicks.

Both the above methods have been successfully used by the industry for the production of commercial layers. Inbreeding and hybridization however is of little value for commercial broiler production as most of the broiler traits are highly heritable.

Strain cross or inbred hybrids of White Leghorn origin are used for the production of white-shelled eggs. Crossbreeding involving White or Red Cornish, White Rock and New Hampshire breeds is undertaken for the production of commercial broilers. Cornish strains or synthetic populations containing variable amounts of Cornish, Rock and Hampshire blood are used as male line and closed flocks of Rock and Hampshire strains or their strain crosses are used as female lines. Crossbreeding involving White Leghorn as male parent and Rhode Island Red or New Hampshire or Black Australorp as female parent is employed for the production of commercial layers for brown-shelled eggs.

PERFORMANCE TESTING OF COMMERCIAL CROSSES

When any new product is developed by the foundation breeder it is customary to ascertain its relative merits over the already established commercial varieties available in the market. The testing of the new variety is carried out in several locations representing several agro-climatic conditions. Testing over years is also necessary to avoid chance factors due to disease exposures. Testing at least in 5 locations for 2 to 3 years has been recommended as the essential prerequisite for such purposes.

Random sample tests for layers and broilers are conducted by the Government of India or its agency, where all commercial varieties available in the market are tested under uniform conditions of feeding and management. This permits the foundation breeder to know where he stands as compared to other breeders and enables the poultry farmer to decide about the stocks he wants to purchase. Random sample tests are being conducted at present by the Government of India at its Central Poultry Breeding farms at Bangalore, Bombay and Bhubaneshwar. A fourth centre is being established at Gurgaon.

CULLING FOR BETTER RETURNS

Birds which do not perform well are culled to optimise profits. Culling is practised on the basis of outward appearance or available records. Stunted growth and physical deformity do not pose any problem. Culling for poor production or non-production requires handling of all the stocks in the laying pen. Since culling may be a source of annoyance to the flock thereby causing a drop in production, it should be practised in the night.

CULLING FROM OUTWARD APPEARANCE

The appearance of a bird though not an index of its laying ability gives an idea about its health and vigour. The main characteristics for distinguishing a layer from a non-layer is given on the next page.

Culling on the Basis or Moulting

Moulting which refers to the shedding of feathers provides some indication about the laying capacity of a bird. Good layers not only moult late but also complete the moulting period quickly and sometimes continue to lay even during moulting. Poor layers on the other hand moult early, take a long time to complete the process and do not lay any eggs during the moulting period. It is possible to determine the beginning of moulting by counting the stiff primary feathers in the wing. The first one to be dropped is the inner one next to the axial feather which separates the primaries from the secondaries. It takes about 6 weeks for the first new primary feather and 2 weeks for each additional full-grown feather. A wing having 4 new primaries during moulting season indicates that the bird has been in moulting for 12 weeks.

Culling on the Basis of Pigmentation

Yellow pigmentation of the skin surface especially vent, eye rings, ear lobes, beaks, shanks, etc. of a hen provide an indication about its laying ability. Yellow pigmentation of the skin, especially in yellow-skinned breeds like White Leghorn and Rhode Island Red, is due to carotenoid pigment known as xanthophyll from the ration containing yellow maize. Birds in lay lose their pigments and the exposed parts present a bleached appearance. Vent loses the pigment earliest as compared to other parts. A white or pink vent in yellow-skinned variety is an indication that the bird is laying. The inner edges of the eye-lids lose their yellow pigment more slowly than the vent. The ear lobes in the Mediterranean breeds lose their pigment even more slowly. The beak is next to lose colour, starting at the base and gradually extending to the tip. Normally the beak loses its colour 4 to 6 weeks after heavy laying. The shanks are the last to lose their colour. The appearance of bleached shanks indicate that a bird has been laying at a good rate for the last 3 to 4 months. When a bird stops laying the yellow pigment reappears in the same order as it disappeared and comes back twice as fast. The approximate period for which a bird has been in production may be judged from the disappearance of yellow pigment from different parts of body in the following order : vent, 1 to 2 weeks; eye rings and ear lobes, 2 to 4 weeks; beak, 6 to 8 weeks; and shanks, 12 to 20 weeks.

HATCHING OF EGGS

Hatching of eggs refers to the production of baby chicks. In early days eggs were hatched by placing them under broody hens. Desi hens proved to be ideal for this purpose. Only 10 to 12 eggs can be put under 1 hen. This method of hatching is highly unsatisfactory for large-scale production of baby chicks. Incubators, which provide similar environment as that of broody hens, but more efficiently, are used at present for

hatching of eggs.
Embryonic development has already started by the time the fertile eggs are laid. To prevent further embryonic development outside the body fertile eggs should be collected as frequently as possible and stored in a cool place, especially so in hot and rainy months. Optimum temperature for holding the fertile eggs before incubation varies from 50Â° to 70Â° F (10.0Â° to 21.1Â°C). Better results can be obtained when eggs are stored for 7 days or less at 60Â° F (15.6Â°C). When eggs are stored for more days storage temperature should be around 50Â° F (10Â°C). When temperature is too low eggs do not hatch well. Duration of storage after a week is inversely proportional to per cent hatchability. Relative humidity of storage chamber should be maintained at 70 to 80 per cent as less humidity promotes loss of water from eggs. Soiled or dirty eggs should not be used for hatching; when used they should be properly cleaned with a dry cloth before storage.
Incubation
The physical factors necessary for successful incubation are temperature, humidity, gaseous environment and turning of eggs. Optimum and uniform temperature inside the incubator is very essential for obtaining satisfactory results. The incubator temperature should be maintained as recommended by the manufacturer. It usually varies from 99.5Â° to 100.5Â°F (37.2Â° - 37.8Â°C) for forced draft-type incubators and about 1Â°F higher for still-air incubators. Low temperature slows down the development of embryo and higher than optimum temperature hastens the embryonic development. When abnormal temperature conditions extend over a long period, hatchabilily is adversely affected by increase in embryonic mortality and weak and deformed chicks.
Humidity in the incubator affects hatchability. Dry and wet bulb thermometers are used for measuring humidity. In fowls egg takes about 21 days to hatch. The relative humidity should be around 60 per cent during the first 18 days of incubation and 70 per cent in the last 3 days for optimum hatchability. In the forced draft-type incubators the temperature requirement decreases as the humidity increases.
Developing embryos require oxygen for their metabolism, oxygen (21%) in the atmospheric air seems to be satisfactory for this purpose. Flow of fresh air in the incubator therefore should be adequately ensured. Oxygen concentration above or less this amount affects hatchability. Reduction in hatchability in high altitudes is due to reduction in partial pressure of oxygen. Inside the incubator the carbon dioxide concentration should not exceed 0.5 per cent. Higher concentration decreases hatchability. Hatchability becomes zero when carbon dioxide level is 5 per cent. For the same reason it is essential that the room in which the incubator is installed has adequate ventilation.
Fertile eggs are loaded into the incubator with broad end up. Hatchability decreases when eggs are placed in the incubator with narrow end up as the embryo develops with its head in the small end. Turning of eggs in the incubator improves hatchability. Eggs should be turned at least 4 times during a day when turning is done by hand. Modern incubators are provided with devices for automatic turning of eggs at least 8 times or more during 24 hours. In this egg trays turn through an angle of 900. No turning is required after 18 days of incubation.
Use of separate hatcher improves hatchabilily. When separate hatcher is used temperature is maintained at about 980F and relative humidity at 70 to 80 per cent to obtain good hatch. Use of separate hatcher facilitates cleaning, disinfection and fumigation without disturbing other eggs.
Testing of Incubated Eggs
The eggs are candled from fifth to seventh days of incubation to remove infertile eggs and on 18th day to remove dead germs. Although infertile eggs or eggs with dead germ do not serve any useful purpose, removal of such eggs from the incubator makes the room available for setting of more eggs. In most commercial establishments, candling is done on 17th or 18th day of incubation to save labour. Depending upon the passage of light through the egg, the eggs are classified as infertiles when transparent, dead

germ when translucent and eggs with live embryos when opaque. Eggs with live embryos only are transferred to the hatcher. For pedigree hatching of eggs they are to be set sire and dam wise in the incubator and also should be placed in the hatcher compartment wise, one compartment for each dam.

Hatchery Management

At the beginning of hatching season the incubator and hatchers should be thoroughly checked for their functioning and defects, if any, rectified. They should be properly cleaned, disinfected and fumigated to kill disease organisms before storing and after transfer of eggs to the hatcher. This reduces the incidence and spread of diseases. Fumigation is usually done with formaldehyde gas using 40 ml of 40 per cent commercial formalin and 20 g of potassium permanganate for each 2.8 m3 of space inside the incubator or hatcher. Potassium permanganate may be placed in a glass or earthenware container and formalin poured over it. Fumigation should preferably be done at the end of the working day and then the rooms closed. It is a good practice to start the incubator and the hatcher at least 24 hours before setting the eggs to maintain a constant temperature.

Entry to the hatchery complex should be restricted as far as possible. Persons working in the hatchery should use showers, and change clothes and shoes before entering. Receipt of eggs from the farm and the delivery of chicks should be away from each other to reduce infection. When electric supply is uncertain use of a standby generator is advocated.

Sexing of Chicks

Sexing of chicks when day old has been the most common practice with the hatcheries dealing with egg-type chicken. Japanese or vent method of sexing is commonly used. This involves identification of rudimentary testes in the cloaca of male chicks. Since this structure is very small at day-old stage, considerable amount of skill and experience is necessary. While all the female chicks are saved, the male chicks are usually destroyed. Sexing of day-old chicks can also be done with the help of sex-linked characters such as rapid and slow feathering, barring and non-barring, etc. For example when a Rhode Island Red male is mated to Barred Plymouth Rock female all the female progeny will be black and male progeny barred. When straight run chicks are reared, sexing should be practised by 8 weeks and both the sexes reared separately. Combs are more developed in males than in females. In White Leghorns where comb development is very fast in males, sexing can be done as early as 4 weeks.

POULTRY MANAGEMENT

Poultry management usually refers to the husbandry practices or production techniques that help to maximize the efficiency of production. Sound management practices are very essential to optimize production. Scientific poultry management aims at maximizing returns with minimum investment.

Brooder Management

Brooder house: Brooder house should be draft-free, rainproof and protected against predators. Brooding pens should have windows with wire mesh for adequate ventilation. Too dusty environment irritates the respiratory tract of the chicks. Besides dust is one of the vehicles of transmission of diseases. Too much moisture causes ammonia fumes which irritate the respiratory tract and eyes. Good ventilation provides a comfortable environment without draft.

Sanitation and hygiene : All movable equipments like feeders, waterers and hovers should be removed from the house, cleaned and disinfected. All litters are to be scraped and removed. The interior as well as exterior of the house should be cleaned under pressure. The house should be disinfected with any commercial disinfectant solution at the recommended concentration. Insecticide should be sprayed to avoid insect threat. Malathion spray/blow lamping or both can be used to control ticks and mites. New litter should be spread after each cleaning. The insecticides if necessary should be mixed with litter at recommended doses. Poultry diseases are highly contagious. All-in-all-out system helps in the control and prevention of diseases. If this is not possible the chicks should be allowed to brood in the neighbourhood of older birds. The movement of workers and equipments from building to building should be restricted. Attendants should change to clean over-all and shoes when possible. A footbath of a recommended disinfectant should be kept at the entrance of each building. The disinfectant solution should be used regularly as instructed. Visitors to the farm should be restricted.

Litter : Suitable litter material like saw dust and paddy husk should be spread to a length of 5 cm depending upon their availability and cost. Mouldy material should not be used. The litter should be stirred at frequent intervals to prevent caking. Wet litters if any should be removed immediately and replaced by dry new litter. This prevents ammoniacal odour.

Brooding temperature: Heating is very much essential to provide right temperature in the brooder house. Too high or too low a temperature slows down growth and causes mortality. During the first week the temperature should be 950 F (350 C), which may be reduced by 50 F per week during each successive week till 700 F (21.10 C). The brooder should be switched on for at least 24 hours before the chicks arrive. As a rule of thumb the temperature inside the brooder house should be approximately 200 F (-6.70 C) below the brooder temperature. Hanging of a maximum and minimum thermometer in each house is recommended to have a guide to control over the differences in the house temperature. The behaviour of chicks provides better indication of whether they are getting the desired amount of heat. When the temperature is less than required, the chicks try to get closer to the source of heat and huddle down under the brooder. When the temperature is too high, the chicks will get away from the source of heat and may even pant or gasp. When temperature is right, the chicks will be found evenly scattered. In hot weather, brooders are not necessary after the chicks are about 3 weeks old. Several devices can be used for providing artificial heat. Hover type electric brooders are by far the most common and practical these days. The temperature in these brooders is thermostatically controlled. Many a times the heat in the brooder house is provided by use of electric bulbs of different intensities. Regulation of temperature in such cases is difficult although not impossible. Infra-red lamps are also very good for brooding. The height and number of infra-red lamps can be adjusted as per temperature requirement in the brooder house.

Brooder space: Brooder space of 7 to 10 sq inch (45-65 cm2) is recommended per chick. Thus a 1.80 m hover can hold 500 chicks. When small pens are used for brooding, dimension of the house must be taken into consideration as overcrowding results in starve-outs, culls and increase in disease problems.

Brooder guard: To prevent the straying of baby chicks from the source of heat, hover guards are placed 1.05 to 1.50 m from the edge of hover. Hover guard is not necessary after 1 week.

Floor space: Floor space of 0.05 m2 should be provided per chick to start with, which should be increased by 0.05 m2 after every 4 weeks until the pullets are about 20 weeks of age. For broilers at least 0.1 m2 of floor space for female chicks and 0.15 m2 for male chicks should be provided till 8 weeks of age. Raising broiler pullets and cockerel chicks in the separate pens may be beneficial.

Water space: Plentiful of clean and fresh water is very much essential. A provision of 50 linear cm of water space per 100 chicks for first two weeks has to be increased to 152-190 linear cm at 6 to 8 weeks. When changing from chick fountain to water trough the fountains are to be left in for several days till the chicks have located the new water source. Height of the waterers should be maintained at 2.5 cm above the back height of the chicks to reduce spoilage. Antibiotics or other stress medications may be added to water if desired. All waterers should be cleaned daily. It may be desirable to hold a few chicks one at a time and teach them to drink.

Feeder space: The requirement of feeder space varies from 2.5 to 0.3 cm per bird from 0 to 8 weeks of age. Chicks should be fed only after 3 to 4 hours after arrival in the brooder house. To avoid feed loss feeders should not be more than one-third full at any particular time.

The brooding equipments should be spaced around the hover like the spokes of a wheel to offer all chicks equal opportunity for warmth, feed and water. Sound management practices and practical and judicious use of medicines are essential to tackle disease hazards. Stress medication like nitrofurozone and coccidiostats may be given in the feed as and when necessary as per recommended doses and courses. All night light with uniform distribution of light is essential up to 8 weeks of age. For broilers all night-light is essential for first 2 days to allow them to find their way and to get organized. It also helps poultrymen to observe the chicks in their new home. Lighting programme for rest of the period in broilers varies considerably from farm to farm. Many prefer light followed by darkness of different durations to allow maximum weight gain.

Grower Management

Floor, feeder and water space recommended for a grower are 950 to 2,350 cm2, 7.5 to 12.5 cm and 2.0 to 2.5 cm respectively. Water consumption is influenced by temperature, humidity, age, dietary constituents, activity and air movement. Water consumption increases rapidly when temperature exceeds 85o F (29.4o C). Deworming is very much essential at least once bi-monthly to keep the birds free from parasitic diseases. Deworming should be done either in the evening or early in the morning. If necessary top 0.6 cm of litter is scraped and removed to prevent reinfection. A decreasing lighting schedule needs to be followed for the growers till 20 weeks of age. Growing pullets should never be exposed to increased lighting schedule. Debeaking is recommended between 12 and 16 weeks although it can be done earlier depending upon convenience.

For broiler breeders feed restriction is very much essential during the growing period to control body weight and maturity. Improper restriction results in increased feed costs, reduced egg production and hatchability.

Layer Management

The flock should be transferred from grower to layer house at 18 to 20 weeks of age. In breeding flocks males should be placed in the laying quarters 1 to 2 days prior to housing the females if they have been grown separately to housing time. Floor space of 0.23 to 0.28 m2 feeder space of 10 cm and water space of 2.5 cm per bird is recommended in floor house. For commercial cage operation the floor requirement is 465 cm2 per bird. One laying nest for every 4 pullets is necessary. A platform in front of the nest entrance helps the birds to have easy access to the nest.

Lighting is very essential for optimum production. From 21 weeks onwards the lighting should be increased gradually till it reaches 16-17 hours per day and maintained at that level thereafter. Correct lighting boosts up egg production by 5 to 10%; Irregular light results in drop in egg production. For correct light stimulation a minimum of one-foot candle of light should be provided at bird's-eye level. One 40-watt bulb with a reflector hanged 2.1 m above the floor for each 9.29 m2 of floor space would provide the recommended intensity of light. Light bulbs should be cleaned regularly as very dusty bulbs would give only 1/3 light compared with that given by clean bulbs. Light bulbs should be checked regularly and burnt out ones should be replaced immediately. Duration of light period should not be decreased during the laying period.

Male Management

Breeder male management remains essentially the same as that of layer management except that male breeder's diet should be fortified with extra calcium, manganese and vitamin E to ensure proper fertility.

HOUSING FOR POULTRY

Open-sided poultry houses are very popular in our country. Except where the temperature is exceptionally low open-sided houses work very satisfactorily and are also preferred for economic reasons. The primary objective of providing housing to poultry is to protect them from sun, rain and predators. Housing is also essential to provide comfort. Poultry houses should be well ventilated, reasonably cool in summer and warm during winter, and free from drafts. In hotter parts of the country, the long axis of the house should run from east to west and the sides should face north south to prevent direct sunshine falling into the house. In colder parts of the country it is desirable to construct the houses facing south or southeast to get maximum sunlight. The distance between two houses for birds of same age group should be at least 18 m to allow proper ventilation. But the young stock house should be at least 45 to 100 m away from the houses having adult stocks to prevent diseases. To avoid ventilation problem the width of the house should not exceed 9 m in open-sided houses. The height of the house depends upon temperature of the place. Ordinarily the height of the house should be 2.4 to 3 m from the foundation to roofline. When height is more it helps to reduce the inside temperature.

A poultry house should not be expensive. Durability, comfort and safety of house, however, should not be sacrificed. The floor of the house should be moisture-proof, free from cracks, easily cleaned, rat proof and durable. The different types of floor in use are all-litter floor, all-slate floor, slate and litter floor, wire and litter floor, and sloping wire floor. The walls and partitions must be solid enough to support the roof and withstand heavy winds. Wide variation is possible depending upon agroclimatic conditions, availability and cost of construction materials. The roof must be draft and moisture proof. Insulation of roof helps both in summer as well as in winter. Where summer temperature is high roof should be painted with a reflecting type of paint such as aluminium paint. An over-hang of 0.9 m will help to prevent the rainwater splashing inside the house. The climatic conditions and age group of birds will determine the extent of side opening. Usually half to two-thirds area of the sidewalls are kept open in open-sided house fitted with wire mesh. In areas where temperature is high and continuous, more than two-thirds of the sidewall area may be left open for proper ventilation. In brooder houses half the area is left open, in grower and layer houses two-thirds and in cage houses the maximum. Irrespective of the house, all the poultry houses should be located in well-drained grounds, safe from floodwaters and with easy access from the road.

FEEDING OF POULTRY

Feeding constitutes the fundamental and major managemental concern in poultry production since major expenditure (60-70%) in poultry rising is feed cost. Efficiency in feeding therefore is one of the key factors for successful poultry production. More than 40 nutrients are required by the poultry. They can be arranged into six classes according to their chemical nature, functions they perform and the ease with which they are chemically determined. These groups of nutrients are: water, proteins, carbohydrates, fats, minerals and vitamins.

Carbohydrates and fats are the principal sources of energy. Fats are the concentrated form of energy and yield 2.25 times more energy than carbohydrates, on weight basis. Fats are also the source of essential fatty acids, i.e. linoleic, linolenic and arachidonic acids. The requirement for protein is essentially the requirement for amino acids. The essential amino acids for poultry are: arginine, glycine, histidine, leueine, isoleucine, lysine, methionine, cystine, phenylalanine, threonine, tryptophan and valine. Out of these, the ones critical in practical diets are arginine, lysine, methionine, cystine and tryptophan.

Minerals and vitamins do not supply energy but they play an important role in the regulation of several essential metabolic processes in the body. The minerals and vitamins that are critical in practical poultry diets are as follows:

Minerals: Calcium, phosphorus, sodium, copper, iodine, iron, manganese and zinc.

Vitamins: Vitamin A, vitamin D3, vitamin E, pyridoxine, riboflavin, pantothenic acid, niacin, folic acid, B12 and cholinc.

A balanced ration is the one which will supply different nutrients in right proportions according to the requirements for maintenance and various productive functions. The nutrients required by poultry must be supplied in rations through the ingredients available in sufficient quantity economically.

Feed Ingredients

Conventional poultry rations usually include many cereals like maize, rice, wheat, oat, barley; and a few cereal by products such as wheat-bran or rice polish, animal and vegetable protein sources like fish-meal, meat-meal, soybean-oil-meal, groundnut-cake, etc. according to their availability. The whole ration is fortified with adequate minerals and vitamins either in chemically pure or through ingredients known to be rich in these nutrients.

With the cost of feed soaring high and the availability of conventional ingredients becoming scarce, intensive and continuous efforts are being made to determine the nutritive value of agro-industrial by products to replace more costly ingredients in poultry rations. The following are some of the common feedstuffs used for making poultry rations in this country.

Conventional Poultry Feeds

Maize: It is highly digestible and contains very little fibre. It is used as a source of energy and is low in protein, especially lysine, and sulphur-containing amino acids. The yellow varieties are a good source of vitamin A and xanthophyll. The latter is responsible for the yellow skin in certain breeds of fowl.

Barley: Barley is not very palatable because of its high fibre content and should not constitute more than 15 per cent of the ration.

Oat: Oat is not very palatable because of its high fibre content. It should not constitute more than 20 per cent of the ration. Because of its manganese content, it may help in preventing hock disorders, feather pulling and cannibalism. Wheat: Wheat can be used for replacing maize as a source of energy.

Wheat bran: It is bulky and quite laxative on account of its high fibre, manganese and phosphorus content.

Pearlmillet: This is a very useful feedstuff, similar to wheat in its nutritive value.

Rice: Broken grains of rice can be used for replacing maize. Rice polish: This is a very good substitute for cereal grains and can be used up to 50 per cent of the ration. Because of the high oil content, it is likely to become rancid on storage under warm conditions.

De-oiled rice polish: Energy content of de-oiled rice polish is low because of the removal of fat, but it is rich in protein and ash content.

Sorghum: The feeding value of sorhum is similar to that of maize. But it has higher protein content, quite palatable and may be used in place of maize. Sorghum-meal is a good source of some amino acids, but costlier than other oilcakes.

Groundnut-cake: It is quite palatable and is widely used as a source of protein in poultry rations. It contains about 40 per cent protein.

Fishmeal: Fish-meal is one of the best poultry feedstuffs as a source of animal protein. Its composition varies widely depending upon whether it is made from whole bony fish or fish cannery scraps. Most Indian fishmeals contain 45 to 55 per cent protein. The presence of fish scales reduces its feeding value.

Limestone: Limestone is a source of calcium. It should not contain more than 5 per cent magnesium.

Oyster-shell: Oyster-shell contains more than 38 per cent calcium, and is a good substitute for limestone. It is quite palatable.

NON-CONVENTIONAL POULTRY FEEDS

Energy Sources

De-oiled salseed-meal: It is a by-product from processing of sal fruits for oil. The composition of meal resembles cereals. But its use is very much limited to poultry because of high tannin content and certain other factors.

Tapioca-meal: It is obtained from the tubers of tapioca. The meal is a good source of energy. Certain varieties contain cyanogenic substances. These can be removed during the processing of tapioca by sun drying or healing.

Dried poultry waste: Uncontaminated caged layer dropping is generally high in calcium and phosphorus and contains about 10 to 12 per cent true protein. If treated properly it can be included in the diet up to 10

per cent without any detrimental effect.
Molasses: May be used to replace cereal grains up to 4-5% of the ration. Higher percentage produces loose excreta because of high mineral content of molasses.
Small millets : Small millets such as kodon and sawan can be used in place of maize up to 20 per cent in the ration. Ragi, kambu and cholam, available in southern India, may also be satisfactorily used to replace maize to an extent of 50 per cent.
Vegetable Protein Sources
Mustard-cake: It is superior to groundnut-cake in protein quality and lysine content. Its use in poultry ration is limited because of the presence of glycosides and goitrogens. Even after treatment its use should be limited to 5% in chick and 10% in laying hen diets.
Soybean-meal: Soybean contains about 35 to 40% protein and 18 to 21% fat. The oil may be removed in several ways. Expeller processings of the beans yielded a meal which contained 42% protein and 5% fat. Suitable heat treatment improves the protein quality of the meal. It is a high-quality vegetable protein rich in lysine, arginine, glycine, tryptophan and cystine. The limiting amino acid is methionine.
Sesame-meal: It is a good source of protein supplement and a good source of arginine, methionine and tryptophan, but poor in lysine, cystine and glycine.
Clusterbean: It is a by-product in the manufacture of vegetable gum from the seeds of clusterbean plants. It is rich in protein but its use is limited by residual clusterbean gum and due to the presence of trypsin inhibitor.
Sunflower seed-meal: It is superior to groundnut-meal in nutritive value. But because of high fibre content its use is restricted in poultry rations. Compared to soybean-meal it is richer in methionine and arginine but poor in lysine. It is an excellent source of pantothenic acid and niacin.
Safflower-meal: It is a good substitute to groundnut-cake up to 25 per cent level in the ration. Lysine deficiency appears to be one of the main limitations in total utilization of this cake.
Ramtil cake: It can replace satisfactorily up to 50 and 100 per cent of groundnut-cake in chicks and layer rations respectively.
Cotton-cake: High in protein content but deficient in lysine. It can be used up to 15 per cent as a substitute for groundnut-cake. Continuous use causes yolk mottling on stored eggs due to the presence of gossypol in the cake.
Maize gluten-meal and feed: A by-product of maize starch industry it is rich in protein and xanthophylls but deficient in lysine, tryptophan and arginine.
Linseed-meal: It is a good source of tryptophan but contains cyanogenic glycoside and antipyridoxial factor. Cannot be used more than 5% if not processed. The meal can be rendered non-toxic by boiling.
Penicillin mycelium waste: It is a byproduct from the manufacture of penicillin. It is a good protein source and contains some residual antibiotic activity. It can be used at levels of 5 per cent in the ration.
Animal Protein Sources
Blood-meal: It contains 80 per cent protein and is rich in lysine, arginine, methionine, cystine and leucine, but deficient in isoleucine. The maximum dietary level of inclusion is not greater than 2 to 3 per cent due to unpalatability and low biological value of its protein.
Liver residue-meal: It is a good source of lysine, methionine, cystine and tryptophan, and an excellent source of riboflavin, choline and vitamin B12. It can be satisfactorily used to replace all fishmeal.
Silkworm pupae-meal: Deoiled silkworm pupae-meal is a good protein supplement. Because of high fibre content and poor protein digestibility its use is restricted in poultry rations.
Hatchery byproduct-meal: This consists of infertile eggs, dead embryos, killed chicks and egg shells collected as waste during hatchery operations, and have been cooked, dried and grounded with or without removal of part of its fat. It contains approximately 25-34 per cent crude protein depending upon the

material that goes into its making.
Table 1. Suggested rations chicken for various age groups of egg-type chicken
<td colspan='2' align='center'> Starter<td colspan='2' align='center'>Grower<td colspan='2' align='center'>Layer

Ingredients(kg/100 kg)

1

2

1

2

1

2

Maize

32.00

44.10

27.10

-

35.00

20.80

Sorghum(white variety)

11.00

-

-

41.00

-

-

Pearlmillet

-

-

-

-

-

20.00

Rice polish

16.80

18.00

40.00

40.00

30.00

30.00

Wheat bran

-

6.80

15.00

-

3.30

-

Salseed-meal(deoiled)

5.00

-

-

-

-

-

Groundnut-cake

11.00

-

-

11.00

10.00

7.00

Maize glutenmeal

-

6.00

-

-

10.00

12.00

Sunflower-cake

11.00

6.00

5.00

-

-

-

Mustard -cake(solvent-extracted)

-

6.00

5.00

-

-

-

Fish-meal

12.00

12.00

6.00

6.00

4.00

-

Meat-meal

-

-

-

-

-

2.00

Bone-meal

0.70

0.50

0.60

1.00

1.60

1.00

Limestone

-

-

0.80

0.50

5.50

5.60

Salt

0.40

0.50

0.40

0.40

0.50

0.50

Mineral* and vitamin** mixture

0.10

0.10

0.10

0.10

0.10

0.10

Total

100.00

100.00

100.00

100.00

100.0

100.00

*Mineral mixture per 100 kg : Ferrous sulphate, 20 g: manganese sulphate, 25 g; zinc sulphate, 25 g; copper sulphate, 1.5 g; and potassium iodate, 100 mg.

**Vitamin mixture per 100 kg: Vitamin A, 800,000 IU; vitamin D3 100,000 ICU; riboflavin, 400 mg; and folic acid, 100 mg.

Feather-meal: It contains 80-85 per cent of crude protein and may be used up to 5 per cent level in poultry rations.

Poultry byproduct-meal: It is a product from poultry processing plants, and includes heads, feet and entrails. It must not contain more than 16 per cent ash and no more than traces of feathers. The meal may contain 55 to 60 per cent protein and 12 per cent fat if not extracted.

Meat and meat-cum-bone-meal: Besides a good source of high quality protein, it is a good source of calcium and phosphorus. The quality of meal is variable depending upon the processing methods and the proportion of gelatin it contains. The variable quality and content of phosphorus limit the use of these meals to 5 to 10 per cent of the diet.

ECONOMISING FEED COST

Keeping the feed cost low and at the same time providing a balanced diet to poultry has been the main concern of both the poultry producer and the feed manufacturer. Economization of feed cost without impairing poultry production can be achieved by formulating low-cost diets by appropriate selection of feed ingredients, by imposing feed restriction at the desired level, by minimising feed wastage, by making nutritional adjustments during extreme weather and by reducing stress and diseases.

Table 2. Suggested rations for broilers

<td colspan='2' align='center'>Starter<td colspan='2' align='center'>Finisher

Ingredients (kg/ 100 kg)	1	2	1	2
Maize	43.75	57.10	65.10	44.10
Rice polish	10.00	-	-	20.00
Groundnut-cake	14.00	-	-	11.00

Sunflower-cake

14.00

15.00

12.00

11.00

Mustard-cake(solvent extracted)

-

10.00

10.00

-

Fish-meal (43% protein)

10.00

6.00

5.00

5.50

Meat-meal (56% protein)

-

7.00

5.00

5.50

Silkworm pupae-meal(40% protein)

-

3.00

1.20

-

Blood-meal (73% protein)

3.50

-

-

-

Animal fat

3.00

1.00

-

1.25

Bone-meal

1.15

-

0.60

0.60

Limestone

-

0.50

0.60

0.70

Salt

0.50

0.30

0.40

0.25

Mineral and vitamin mixture

0.10

0.10

0.10

0.10

100.00

100.00

100.00

100.00

Nutritional requirements for various classes of poultry have been described in detail in ISI bulletins and also in several textbooks. There is no single feed formula which can be claimed to be best in all the cases. The primary consideration in mixed feed is whether the feed fulfills the nutritional requirements adequately consistent with economy. Examples of layer and broiler rations are given in Table 1 and Table 2 as guideline in formulating efficient diets. However numerous substitutions are possible depending upon the availability of ingredients and their comparative cost. Interrelationship among different ingredients and energy protein ratio however should be kept in mind for formulation of diet.

PROCESSING, PRESERVATION AND MARKETING

Poultry and poultry products are highly perishable. Hence due attention has to be paid to the problems relating to processing, preservation and marketing of poultry and poultry products for the benefit of producers, processors and consumers alike.

Table 3. Interrelationships between nutrients in poultry rations

<td colspan='2' align='center'>Replacement pullets(egg or meat type)<td colspan='2' align='center'>Laying and breeding hens(egg and meattype)

			Broilers
			0-6 wk
	6-9 wk		0-6wk
	6-14 wk		14-20 wk
Calories :			
		protein (C/P)	
139:1		160:1	
145:1		180:1	
241:1		190:1	
Calcium :			
		phosphorus	
1.4:1		1.4:1	

1.4:1

2:1

2:1

4.5:1

Vitamin D3(ICU/kg)

200

200

200

200

200

200

Arginine :

lysine

1.12:1

1.09:1

1.09:1

1.05:1

1.03:1

1.6:1

*Methionine :

cystine

1.15:1

1.14:1

1.14:1

1.14:1

1.14:1

1.12:1

Phenylalanine :

tyrosine

1.14:1

1.16:1

1.16:1

1.1:1

1.16:1

?

Tryptophan (%)

0.2

0.2

0.2

0.16

0.12

0.11

Niacin (mg/kg)

27

27

27

11

10

*Methionine content in ration should not be less than 0.46 per cent for 0.6 week old chicks.

Composition and Nutritive Value of Egg

A shell egg consists of 8-11 per cent shell, 56-61 per cent albumen and 27-32 per cent yolk. Liquid whole egg is made up of about 64 per cent albumen and 36 per cent yolk. The proportion of yolk tends to be higher in small eggs than in large ones. Eggshell consists of 94 per cent calcium carbonate, 1 per cent each magnesium carbonate and calcium phosphate, and 4 per cent organic matter, chiefly proteins. It is a rich source of animal protein of high quality and is often used as a standard for measuring the quality of other food proteins. Egg is also an important source of unsaturated fatty acids, minerals especially iron and phosphorus, and almost all the vitamins with the exception of vitamin C, thus providing a well-balanced source of nutrients. Its high nutrient content, low calorific value and easy digestibility make it a valuable protective food in human diet.

The important quality attributes of eggs are egg size, cleanliness and soundness of shell, albumen and yolk quality, nutritive value, wholesomeness, functional properties etc. Shell colour is determined by the breed of the hen. Egg size can be adversely affected by inadequate level of protein and essential fatty acids in layer's diet and high environmental temperature.

Albumen quality is associated with the quantity and viscosity of thick white, and is influenced by the genetic make up of the birds, high environmental temperature and diseases such as Newcastle, infectious bronchitis and chronic respiratory diseases. Yolk colour can be varied by the amount of alfalfa-meal, yellow maize and other xanthophyll-containing ingredients in the ration. Mottled yolks may result from the continued use of coccidiostats, hot weather and inclusion of cottonseed-meal or oil containing a fat-soluble compound known as gossypol. Blood spot is the characteristic of an individual hen and its incidence may increase from the low level of vitamin A. Off-flavours in the egg can result from poor-quality fishmeal or high level of fishmeal or fish-oil.

Shell quality is of primary importance in marketing of eggs because of losses from cracked and broken eggs. Besides other factors shell quality is highly dependent on the levels of calcium, phosphorus, manganese and vitamin D in layer diet. Respiratory diseases and hot weather also increase the incidence of thin-shelled eggs.

Maintenance of Shell Egg Quality

The quality of egg starts deteriorating soon after it is laid unless proper care is taken to maintain it following better methods of assembly, cleaning, grading, packaging, storage, transport and distribution.

Grading

Grading is the classification of eggs into different categories. It aids in reducing wastage, facilitates uniform packing and pricing, and quality assurance to the consumers. Egg grading involves inspection of the shell for cleanliness and soundness, checking the internal quality such as firmness of albumen, position of yolk, blood- and meat-spots, and the size of air cell and sorting them into categories on the basis of weight. Eggs can be individually or flash candled to detect the above defects. The Agmark standard for table eggs is given below.

Preservation of Shell Eggs

Many of the methods for preservation of shell eggs are based on simple principle of retarding the microbial growth and sealing the pores of the shell to minimize the evaporation of moisture and escape of gases, thus retarding some of the physico-chemical changes in the egg contents for a reasonable length of time. Sometimes, a combination of methods is employed for effective preservation.

Thermal processing: This includes flash heat treatment, thermostabilization and simultaneous coating and thermostabilization. In the former, the eggs are immersed for 2 to 3 seconds in water at 71Â°C. The advantage of flash heat treatment is that it destroys bacteria present on the surface of shell besides coagulating a thin film of albumen immediately beneath the shell membrane and thus seals the shell internally.

In thermostabilization, the eggs are immersed in water at 49Â°C for 35 min or 54Â°C for 15 min or 56Â°C for 10 min or 60Â°C for 5 min to stabilize the thick albumen so that such eggs retain fresh appearance much longer than unheated eggs.

Simultaneous oil coating and thermostabilization complement each other in maintaining the internal quality of shell eggs.

Oil coating: Oil treatment preserves the shell eggs by forming a thin film of oil on the surface of shell and thereby sealing the pores. Washing and subsequent coating preserve eggs much better than coating alone. Vegetable oil such as groundnut-oil mixed with 0.0125% BHT is a good sealing agent but the mineral oils of food grade are preferable. Eggs can be either dipped in oil or sprayed with it.

Cold storage: For short period of storage, fresh eggs should be stored at 55Â°-60Â°F (12.8Â°-15.6Â°C) at 70-80 percent RH, but for long-term storage the temperature of cold room should be 32Â° Â± 1Â° F (-0.6Â° to 0.6Â°C) and the relative humidity 80-90 per cent. Eggs can be oil treated prior to cold storage to enhance their keeping quality.

Preservation of Liquid Eggs

Dehydration and freezing are commonly used methods for the preservation of liquid whole egg, albumen and yolk separately depending on their use in bakery products, confectioneries and other food or non-food products.

Egg Marketing

The Indian egg market is in a disorganized state. Its development has not kept pace with the progress achieved in egg production. The wholesale trade of eggs in big cities, where potential demand exists, is in the hands of a few traders who have monopolized this trade to their own advantage. Egg prices vary from one market to another and from one season to another. In summer, the egg prices crash down to a level which is sometimes less than the cost of production, even though the retail price does not vary proportionately. Therefore, proper attention has to be given to the problem of most efficient disposal of market eggs.

Distribution Channel

The eggs are distributed through different channels, viz. producers to consumers, producers via retailers to consumers, producers via assemblers, whole salers, retailers to consumers, and producers to consumers via co-operative societies/egg marketing organizations. Eggs should be distributed through relatively shorter channels to speed up supply and avoid delay and repeated handling.

Marketing Agencies

Besides the private egg traders, some state poultry corporations, cooperative egg marketing societies and the NAFED are engaged in the marketing of eggs in the country. The NAFED has already taken up egg marketing activities in Delhi, and intends to enter the field in terminal markets like Bombay, Calcutta, Madras, Hyderabad and some of the important industrial centres. The proposed National Co-operative Marketing Federation, linked to its four regional federations at Delhi, Bombay, Calcutta and Madras for organised marketing of eggs is yet to be established.

The tasks involved in egg marketing are many, e.g. procurement of eggs, grading, processing, packing, storage, transport and distribution. All these activities need immediate improvement. The future growth of poultry industry rests on systematic planning for efficient marketing of eggs in the country.

Poultry Meat

Poultry meat is of high nutritional value and is easily digestible. Its protein content is, in general, higher than in most of the red meats. Chicken meat contains all the essential amino acids and qualitatively compares closely with milk and egg proteins. It has less fat than other red meats. Oleic, linoleic and palmitic acids are the major fatty acids which constitute about 97 per cent of the total fat. Carbohydrates contribute to a small portion of the total nutrients present in chicken meat and it is a good source of B-vitamins, iron and phosphorus.

Preservation of Poultry Meat

The primary objective of poultry meat preservation is to inhibit microbial spoilage and arrest physio-chemical processes which bring deterioration in quality. Several methods such as refrigeration, freezing, smoking, curing and smoking, dehydration, freeze-drying, canning and radiation are being used to preserve meat. Antibiotics are also sometimes added to preserve raw meat.

Tenderization

The tough meat of culled and spent layers and breeders can be made tender by using various proteolytic enzymes either alone or in combination. Enzyme solution, with combination of sail and polyphosphates, appears better for tendcrization of poultry meat than enzyme alone.

Poultry By products

In a poultry-processing unit around 27 to 29 per cent of raw materials go as waste in the form of blood, feathers, heads, feet and viscera. Hatchery wastes include infertile eggs, dead embryos, empty egg shell, unhatched chicks and unusable chicks. Similarly in egg processing units around 11 per cent of raw material as shell and around 5 per cent as unsound eggs are obtained. Large quantities of wet droppings from cage houses are also available. Processing and utilization of these byproducts will not only reduce the cost of poultry production but also solve the disposal problem and minimize pollution hazard. A good deal of work has been done for processing of these byproducts into feather-meal, poultry byproduct-meal, hatchery byproduct-meal, egg-shell-meal, albumen flake dried, poultry manure, etc. for poultry feeding.

POULTRY DISEASES

The profit from poultry farming is greatly dependent on the incidence of diseases in the flock. The onset of diseases not only causes mortality but also morbidity. Although significant progress has been made in the control of diseases of baby chicks and growing birds mortality, especially of the laying flock, still remains as one of the great challenges to the poultry breeder.

Poultry diseases may be classified either as infectious or non-infectious. Non-infectious diseases are caused by faulty management. Faulty feed formulation and inadequate diet may be responsible for nutritionally deficient diseases. Infectious diseases are classified according to the type of disease-causing organism described below:

Parasitic: External parasites: lice, mites, ticks and flees.

Internal parasites: Roundworms, tapeworm and hexamitiasis

Protozoan: Coccidiosis in chicken, blackhead in turkeys, and leucocytozoonosis.

Bacterial: Pullorum, typhoid, paratyphoid, fowl cholera, Arizona infection in turkeys, etc.

Viral: Ranikhet disease, fowl-pox, infectious bronchitis, infectious laryngotracheitis, infectious bursitis, avian encephalomyelitis, Marck's disease, leukosis, chronic respiratory diseases, duck virus enteritis, hepatitis, etc.

Fungal: Aspergillosis, Moniliasis

In commercial poultry production treatment of individual bird is not possible. Hence the golden rule "Prevention is better than cure" more appropriately applies to poultry than any other livestock species. As the poultry industry is growing very fast, the hazards of the diseases are obviously great. Efficient diagnostic methods are available for some of the common killer diseases like Ranikhet, and also prevention and available control measures are very successful. With the advancement of science and intensification of poultry production programme, several new diseases have emerged and several more are likely to emerge in the future whatever may be the inciting or precipitating causes. It is important that they are diagnosed and controlled within a minimum spread in the country and minimum loss to economy. Adoption of following practices will help in minimizing loss from diseases.

1. Poultry houses should be thoroughly cleaned and disinfected before the arrival of chicks. Also start with clean and disinfected equipments such as feeders, waterers and hovers.
2. Chicles should be procured from a reliable breeder and a diseases-free flock.
3. All-in-and-all-out system should be preferred. Otherwise birds of different age groups should be reared separately.
4. Optimum floor space should be provided depending upon the age of birds, season of the year and agro-climatic conditions. Overcrowding should be avoided by all means.
5. The litter should be kept dry and the houses should be well ventilated.
6. Ration should be well balanced with respect to various ingredients and available ad lib. Plenty of fresh and clean water should be provided. The waterers and feeders must be regularly cleaned and disinfected.
7. All the poultry houses should be thoroughly checked in the morning and evening to see the condition of the birds. Any abnormal behaviour of the birds will signify the onset of disease. Prompt attention should be paid to diagnose the cause and appropriate measures taken. Dead birds should be removed and disposed off immediately.
8. The birds should be vaccinated against Ranikhet disease and fowl-pox. Vaccines from reliable and authorized sources only should be used. Vaccines are also available for several other diseases. But whether to use all of them or not, will depend on the incidence of diseases in the farm and its surroundings. It may be worthwhile to mention here that vaccination is a stress and more the number of vaccines greater the stress. A veterinarian may be consulted for diagnosis and control of diseases.
9. Breeders should be routinely tested against salmonellosis and all the reactors should be destroyed and not used for breeding.
10. Medicines are expensive. So all the treatments have to be done with care and respect. Manufacturer's recommendations should be followed strictly. It is better not to use antibiotics than to use them incorrectly.

The details with respect to some of the important poultry diseases have been described in some later chapters of this edition.

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