Training Manual

REFRESHER TRNAINING PROGRAMME (RTP) ON POULTRY MANAGEMENT

28-30 December, 2022

भाकृअनुप
ICAR

Edited by

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Organized by

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NATIONAL INSTITUTE OF AGRICULTURAL EXTENSION MANAGEMENT

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Refresher Training Programme (RTP) on Poultry Management

(for Establishing Agripreneurs under AC & ABC Scheme)

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Contents

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ICAR-Directorate of Poultry Research, Rajendranagr, Hyderabad

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Poultry production in India: An Overview

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INTORDUCTION

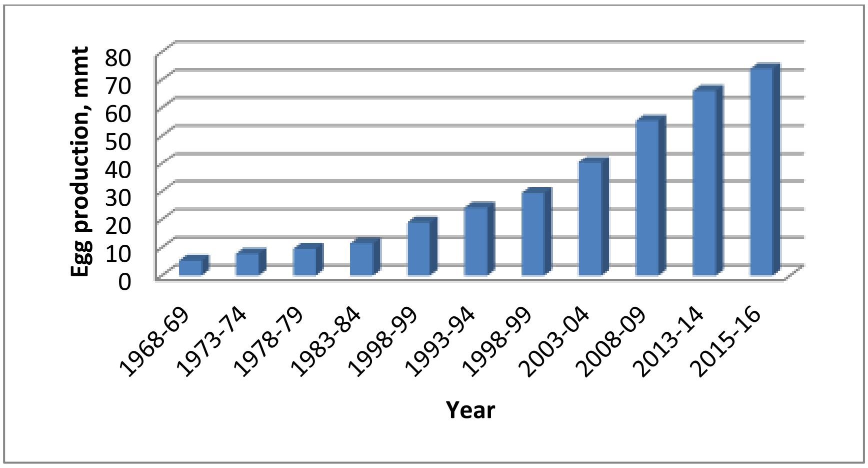
Poultry is one of the fastest growing segments of the agricultural sector in India with around eight percent growth rate per annum. The poultry sector in India has undergone a paradigm shift in structure and operation which has been its transformation from a mere backyard activity into a major commercial agri based industry over a period of four decades. The constant efforts in upgradation, modification and application of new technologies paved the way for the multifold and multifaceted growth in poultry and allied sectors. The development is not only in size but also in productivity, sophistication and quality. Development of high yielding layer (310-340 eggs) and broiler (2.4-2.6 kg at 6 wks) varieties together with standardized package of practices on nutrition, housing, management and disease control have contributed to spectacular growth rates in egg (4-6% per annum) and broiler production (8-10% per annum) in India during the last 40 years. The annual per capita availability also increased to 60 eggs and 2.5 Kg of meat, consistently with increase in productivity. However, it is far below the recommended level of consumption of 180 eggs and 10.8 kg poultry meat per person per annum by Indian Council Medical Research. This transformation has involved sizeable expansions and investments in breeding, hatching, rearing and processing. India is one of the few countries in the world that has put into place a sustained Specific Pathogen Free (SPF) egg production project.

The growth of the poultry sector in India is also marked by an increase in the size of the poultry farm. In earlier years broiler farms had produced on average a few hundred birds (200-500 chicks) per cycle. Today units with fewer than 5,000 birds are becoming rare, and units with 5,000 to 50,000 birds per week cycle are common. Similarly, in layer farms, units with a flock size of 10,000 to 50,000 birds have become common. Small units are probably finding themselves at a disadvantage because of high feed and transport costs, expensive vaccines, and veterinary care services and the non-availability of credit. Some small units are reported to be shifting from layer to broiler production because output in broiler units can be realized in six weeks.

The structure of India's poultry industry varies from region to region. While independent and relatively small-scale producers account for the bulk of production, integrated large-scale producers account for a growing share of output in some regions. Integrators include large regional firms that incorporate all aspects of production, including the raising of grandparent and parent flocks, rearing DOCs, contracting production, compounding feed, providing veterinary services, and wholesaling. The southern region account for about 57 percent of the country's egg production, the eastern and central regions of India account for about 17 percent, The northern and western regions contribute 26 percent of egg production

Current Scenario

India ranks 3rd in egg production and 7th in chicken meat production in the world (Watt Executive Guide, 2015). About 3.4 million tons (74 billion) of eggs are produced from 260 million layers and 3.8 million tons of poultry meat is produced from 3000 million broilers per annum in India. The Poultry Industry is contributing about Rs. 70,000/- crores to the national GDP and providing employment to more than 3 million people either directly or indirectly. About 2-2.5 million tons of poultry litter, a valuable organic fertilizer, is produced as a by-product every year. The poultry industry is concentrated in certain pockets of the country. The State of Andhra Pradesh and Telanagana leads the country followed by West Bengal, Maharashtra, Tamil Nadu and Punjab.



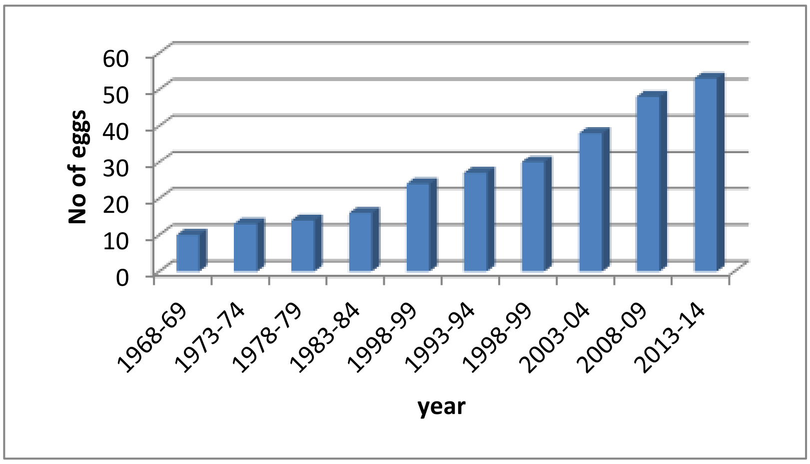
(Source: DAHD, 2014)

Fig 1 . Trends in egg production over last 6 decades

The popularity of poultry meat is on the rise during the last two decades. It is presently accounting for about 45% of the total meat consumed and is the most popular meat from any single livestock species.

Chicken dominates the poultry production in India with nearly 95% of the total egg production and the rest is contributed by ducks and others. Majority of ducks are found in certain states on the eastern and southern coast like West Bengal, Assam, Kerala, Andhra Pradesh, Tamil Nadu etc. Other species like turkeys, guinea fowls, ostriches, emus etc. are reared only in small numbers in areas having specific market demand. India is the home for many breeds of native chicken like Aseel, Kadak Nath, Miri, Nicobari, Kalahasthi etc., which are still popular among the rural and tribal areas for back yard/ free range farming. For the commercial farming, high yielding crosses developed and supplied by the private sector like Babcock, Bovans (egg type) and Cobb, Ross, Hubbard (meat type) are being used. The crosses developed under the public sector like Krishilayer, Krishibro (multicolored broiler etc.) are popular in certain areas.

Availability of eggs is highly non-uniform in different parts of the country primarily due to wide variation in the production levels. Much of the eggs produced are consumed by the urban population while the rural and tribal areas have little access to the eggs and meat produced from the industrial sources and the availability is very low. In spite of rapid growth, the poultry industry suffered many setbacks in recent times due to rising cost of feed, emergence of new or reemerging of existing diseases, fluctuating market price of egg and broilers, etc. which need to be addressed to make the poultry sector as a sustainable enterprise.



(Source: DAHD, 2014)

Fig. 2. Per capita availability of eggs in India

Poultry production systems

The rapid expansion of poultry production has been associated with technological change and increasing scale of production units. More specifically, the development has involved a switch in emphasis from traditional small-scale production using dual-purpose indigenous breeds to intensive commercial production systems using hybrid birds specially bred either for meat or for egg production. The introduction of improved, exotic, genetic material is an important first step in the growth and development of the commercial poultry sector. Generally, the new strains are less hardy and less resistant to endemic diseases than indigenous birds. The greater productive potential cannot be attained without complementary inputs of specially compounded concentrate feeds, and improved housing, management, and veterinary care. Nonetheless, the introduction of new genetic material is the foundation on which other technological improvements are added.

FAO classified poultry production systems in to four categories based on the volume of operation and level of biosecurity. The four categories are better described as "sectors" than as "systems", as increasing commercialization is associated with increased segmentation of different stages in the value chain from input supply through to retail delivery of the product (Upton, 2007). Although formal biosecurity may be higher in industrial/commercial systems, the greater bird population density may increase the probability of infection and the scale of disease outbreaks that occur in these concentrated production systems (FAO, 2007). Increasing concentration of production is also associated with problems of waste disposal and soil, air and water pollution (FAO, 2006). Within each sector there is a great deal of variation between individual types of production system and value chains, so further discussion is needed.

Village or backyard production

The most basic and simple backyard production system involving a few hens and a cockerel is essentially a closed system. Home-produced fertile eggs are hatched to provide replacements, birds feed by scavenging or are provided with household scraps and crop by-products; there are virtually no veterinary inputs and the remaining eggs and meat produced are consumed within the household. Such very simple subsistence poultry production systems are probably quite rare. Producers with even slightly larger flocks, generate cash income from the sale of eggs and birds within the local community. Transactions may take place directly between producers and consumers, but traders and other market intermediaries may be involved, selling on to other sectors of the poultry industry. Village or backyard production systems are widely distributed and exist in both rural and urban areas. In most countries, the majority of producers fall into this category, but with development of the industry a growing proportion of both meat and egg production is derived from the commercial sectors. It is estimated that today in India, only 15 percent of total poultry output is derived from "backyard" production (Landes *et al.*, 2004). In areas that are less densely populated by poultry, "backyard" systems are likely to contribute a larger proportion of total poultry production. In the village or backyard sector, production is generally based on traditional local, native breeds, producing both eggs and birds for meat. None the less, village or backyard production can make a useful contribution to dietary protein intake and incomes of resource poor households (Acamovic *et* *al.*, 2005, Rajkumar et al., 2010). Furthermore, given the lower opportunity costs5 of resources and the higher market prices offered for local poultry, backyard systems are likely to yield a positive economic return, despite increasing competition from the commercial sectors.

Commercial poultry production with low biosecurity

This sector is based on commercial production, but it retains some characteristics of the traditional, backyard systems, particularly in selling live birds in wet markets or directly to retail shops. Production units are generally intermediate in scale between backyard systems of up to 200 birds and commercial systems of over 10000 birds. Levels of biosecurity are low, in that birds are often not permanently housed, mixed flocks of chickens and waterfowl may be kept, birds are generally marketed live, and a range of different markets, un-monitored for health risks, are used for produce sales and input supplies (Upton 2007). The flocks are generally reared either for broiler meat production or for egg production. Feed is generally purchased either as premixed rations or as raw materials for home milling and mixing.

In India, the smaller independent commercial producers are of regional importance in the north and east of the country, where integrated contract production has not become established. Market limitations arise in countries, like India, where there is a marked consumer preference for live birds, rather than dressed, chilled or frozen carcasses. In India, it is suggested that relatively small-scale producers are at a disadvantage in facing high feed and transport costs, limited access to vaccines and veterinary services, and shortage of credit (Upton, 2007)

Large-scale commercial with high biosecurity

This sector consists of the generally larger-scale (over 10000 bird) commercial flocks of broilers, layers or breeding birds. Only relatively wealthy individuals or commercial joint-stock companies have the necessary investment funds or can raise sufficient credit for these larger-scale investments. Biosecurity levels are defined as high, as birds are continuously housed, strictly preventing contact with other flocks or with wildlife. Despite this, many outbreaks of HPAI appear to have started in large-scale commercial flocks. Inputs are generally supplied and products marketed through formal market agencies. The production and marketing process is clearly segmented and separate value chains for broilers and layers can be clearly identified. Production of day-old chicks, broiler growing, processing and retail distribution of the final product is the responsibility of separate commercial enterprises. They are all "stakeholders" in the value chain, adding value to the product at each stage.

The scale and intensity of production is substantially higher in the commercial and industrial sectors than in backyard systems. Advantages are derived from economies of scale, providing scope for specialization and division of labour between the different stages in the production process, leading to automation of operations and labour-cost savings. These advantages add to those derived from the use of highly productive commercial hybrid chicks and improved technologies such as the evaporative cooling or air-conditioning of poultry houses. The need for vertical coordination of all stages in the production chain, particularly in the regular supply of chicks and the transfer of birds to slaughter or markets when ready, leads to concentration of commercial poultry production in particular areas of the country. The four southern states, where poultry densities and flock sizes are high, together contribute 57 percent of the nation's egg production (FAO, 2007).

Industrial and integrated production

This sector consists of the largest and most industrialized enterprises in the poultry industry. The various stages in the value chain are vertically integrated into a single industrial company. The broiler or layer components are either fully integrated as part of the parent company, or are separate production units operating under contract to the parent company, it has been assumed that although the whole process, from chick breeding and hatching through to distribution and retailing is integrated in a single organization, feed milling remains as a separate business enterprise. In many instances, the feed and poultry production activities are integrated, together with "horizontal" links to other sectors. In other cases, vertical integration is partial – from breeder down to broiler grower, or from market distributor up to broiler producer. Vertical integration yields financial benefits by reducing the operational costs at different stages of the value chain. In non-integrated poultry systems, transaction costs are likely to be high because of: first, the frequency and regularity of transactions resulting from the cyclical nature of poultry production; second, the risks of disease and market price fluctuations; and third, the investment in very specific types of assets, or "asset specificity", involved in poultry production, processing and marketing (Williamson and Masten, 1995; Dorward *et al.*, 1998). In these circumstances, the vertical integration of the different stages of the breeding, production, processing and marketing of poultry produce is a rational economic response, which should increase efficiency and reduce unit costs. In India, substantial numbers of integrated poultry production companies have been established, particularly in the four southern states and in western India around Mumbai (Landes *et al.*, 2004).

The introduction of improved, exotic, genetic material is an important first step in the growth and development of the commercial poultry sector. Generally, the new strains are less hardy and less resistant to endemic diseases than indigenous birds. The greater productive potential cannot be attained without complementary inputs of specially compounded concentrate feeds, and improved housing, management, and veterinary care. Nonetheless, the introduction of new genetic material is the foundation on which other technological improvements are added.

Feed Resources

Success on poultry production rests primarily on the quality of the bird employed, comforting environment and provision for good feed, the last being most expensive of all other inputs, deserves befitting attention. Feed accounts for 65-70% of broiler and 75-80% of layer production cost. Maize is the popular cereal used in combination with protein meal like soybean meal which generally determines the cost of compounded feed. Production of maize increased from 9.65 million tons in 1989-90 to only 24.4 million tons in 2015. Similarly, soybean meal production increased to 11.35 million ton in 2015 from 3.52 million tons in 1999-2000. Average increase in maize availability has been 3.8% per annum which is far below the growth rate of egg or meat production. Thus, there is a need to increase the production of maize and soybean or explores the usefulness of other alternate energy and protein rich feedstuffs to maize and soybean meal, respectively, in poultry diets.

In view of the large gap between the demand and availability of feedstuffs for poultry production, a holistic approach is needed to meet the demand of ever growing poultry industry. Some of the approaches in these respects are

- **Identification of newer feed resources-** Since the production of cereals and oil seeds may not increase significantly, the availability of grain and oil seed meal to feed industry is expected to decrease. This would lead to escalation in the cost of feed ingredients and consequently the cost of eggs and meat. To some extent such a situation can be corrected by developing strains that need less feed input. However, alternate feed ingredients that are not related to human consumption and available in plenty should be identified and their suitability should be tested.

- **Utilization of structural carbohydrates and phytate phosphorus-** With the advancement of technology, the reduction in dependency of poultry on the storage plant carbohydrate, protein or other nutrient and to allow them to make greater use of structural carbohydrates and other nutrients to meet the requirement of highly genetic potential stocks. Hence the dimension from research should change from as such providing feed than technologies that utilize feed better. There are many components of feed such as B-glucans, pentosans, mannans, cellulose,lignin and phytic acid which can not be digested by poultry. These non digestible feed ingredients frequently generate digestive stress in poultry with a consequent reduction in nutrient utilization and wet litter problems. These problems could be largely alleviated by use of feed enzymes.
- **Overcoming limitations of Agro-industrial byproducts and unconventional feed stuff-** The influence of agro-industrial byproducts and unconventional feed ingredients on the performance of industrial commercial layers and broilers needs to be established before they are incorporated into feeds on regular basis. It is also essential to identify suitable easily adoptable and economically viable methodology to inactivate anti-nutritional factors and enhance the nutrient availability. The nutritive value of a variety of maize and soybean meal replacers has been examined and despite their potential, the utilization in practical formulations is negligible due to constraints imposed by several anti-nutritional, technical and socio-economic factors. These constraints need to be resolved by the feed industry utilizing the services of scientists, planners and policy makers.
- **Processing of feeds and their impact on nutritional improvement-**Commercial poultry diets normally involve the admixture of a number of different feed ingredients. Processing is related to the treatment of materials during or immediately following and mixture with the purpose of providing a balanced diet suitable for consumption of poultry. Many incriminating factors of feed are also destroyed due to processing. The loss of nutrient through excreta and the cost of production can be minimized through processing of feed. This process generally involves some degree of grindings of the material which improves uniformity of admixture provides particles of a size perceived to be suited to the target group and may make nutrients more available for digestion in the birds. Subsequently the feed may be subjected to heat treatment or pelleting. The production of crumbles and pellet feeds, especially for broilers are in increasing trend.

Steam pelleting and extrusion is much more effective to reduce microbial contamination in feedstuffs.

Disease management

Management of diseases in poultry plays an important role for the progress of the industry. Birds in the commercial farms are reared in open sided houses and maintained under optimum management conditions. Birds are reared under veterinary supervision. Vaccination is regularly practiced to protect the bird against diseases. In spite of all the measures, the poultry industry in India suffered a major setback last year due to the outbreak of Avian Influenza. The industry suffered serious trade losses following downfall in consumption of poultry meat and eggs for about 6 months.

To minimize the occurrence of disease in poultry the three most important components of disease control are Bio-security, Vaccination and Medication. Bio-security refers to all measures taken to secure prevention of all types of pathogens in poultry farms. Effective bio-security and implementation of successful hygienic procedures are increasingly dependent on Hazard Analysis Critical Control Point approach (HACCP). The principles of HACCP such as hazard analysis, critical control points, critical limits, correction, recording and verification should be strictly followed for analyzing risk assessment and risk management. Vaccination should be practiced regularly following the regulatory procedures.

Priorities for effective disease management in making the poultry industry a sustainable enterprise are

- Trans-boundary disease – Many of the diseases which are not endemic to India (Avian influenza, VVMD) may enter through germplasm and biologicals. This need strict quarantine measures.
- Establishing and strengthening surveillance and monitoring system – The surveillance and monitoring system should be carried out in established laboratories. There is need to establish a National Avian Disease Laboratory with all modern facilities for surveillance and monitoring of infectious disease in poultry.
- Diagnoses through genomic approach – Efforts may be made to develop new diagnostics and biological using genomic approaches for rapid and accurate diagnosis and effective control of poultry disease.

Food safety

There is a worldwide concern to minimize the use of antibiotics in poultry because of disease resistance and antibiotics residues in food chain. In such case suitable alternatives need to be explored, which could be beneficial and cost effective. Many products of such nature like Probiotics, Gut acidifiers, immunomodulators, etc. are available in the market, but need further research. Ensuring safe food is paramount for the protection of human health and for enhancement of the quality of life. Safe food plays an important role, whether domestically produced and consumed, imported or exported. In addition, the production of safe food represents an opportunity for income generation and market access. Over the last decades, the food chain approach has been recognized as an important step forward to ensure food safety from production up to consumption. This approach requires the commitment of all players in the food chain, involving producers, traders, processors, distributors, competent authorities as well as consumers.

The role of animal feed in the production of safe food is also recognized worldwide, and several events have underlined its impacts on public health, feed and food trade, and food security. Concerns prompted by the outbreak of bovine spongiform encephalopathy (BSE), and other more common food problems associated with Salmonella, enterohaemorrhagic Escherichia coli and other contaminants, have encouraged professionals and the feed industry to scrutinize more closely the causes of these diseases and methods for their control. Measures may require limiting the use of some ingredients or radically changing the way in which they are prepared (processed) or sourced. In some cases the locations where animals are grazed need to be restricted. FAO therefore provides current knowledge on animal feed and its impact on food safety, and orientation and advice on this matter.

Marketing

Though, commercial production of eggs and chicken meat on scientific principles has been well standardized, marketing of eggs and broiler meat are not fully organized except few in urban sectors. Eggs are still transported in open condition and in un-refrigerated vehicles. Eggs are sold as commodity in India and purchased by consumers mostly from shop next door for daily needs. Eggs are channeled through wholesale dealers, sub-dealers, retailers etc. in two to three stages, which raises the cost of eggs by 10-15% over the actual sale price at producer's place. Broilers are sold live or slaughtered at the place of sale. Sometimes the birds are dressed and displayed for sale in the open air without any concern for hygiene. Similarly eggs are sold in open without consideration for preservation of their quality. Seasonal variations in consumption and demand of eggs and meat pose greatest challenge to the stabilization of prices. The fluctuations at times go to the extent of up to 30-40% in a short period of 3-4 weeks. Thus, there is a need to strengthen the marketing system. Some of the approaches in this direction are

- Development of reliable and stable market chain round the year for marketing of poultry products.
- Facilities for hygienic slaughter and preservation of eggs should be made available at market places in both urban and rural areas.
- Formation of producer co-operatives/ Associations and Rural market yards will help in proper marketing.
- National Egg Coordination Committee, a farmers' cooperative agency has been contributing to the improvement in marketing of eggs. However, more systematized marketing strategy and the State's involvement in minimizing the channels are required for making poultry farming remunerative and cost effective in the years to come.
- Because of the location of farms in urban and peri -urban areas that too concentrated in few states, availability of eggs and chicken meat are high in these areas only, but in rural areas and rest of the country the availability is low. Thus, there is a vast scope to tap the rural markets and remote areas of the country where availability is low.

Processing and exports

Trading of chicken in India is primarily done in number and not by weight at the wholesale level. Live and fresh dressed broilers account for the bulk of sales and sale of processed meat is limited (below 5%). However, acceptance of processed chicken is on the rise, particularly in the urban markets. Due to pollution and environmental concerns, slaughtering of birds under unhygienic conditions at open places is being discouraged. Thus, the sale of slaughtered chicken is expected to increase. Hence, there is a need to develop processing facilities. Hence, there is an urgent need of many chicken processing plants in the near future and sale of processed chicken to increase both to cater domestic as well as export markets.

A few plants for processing eggs have been installed using state of the art machinery in some states with an average daily turnover capacity of 0.7-0.8 million eggs. Whole egg powder, yolk powder, egg weight powder, lysozyme etc. are being produced under high standards of operation. Egg powder from India is well accepted in EU, Japan and Far-east. However, to tap the international market there is a need to establish many more egg processing plants. It has been told that India is geographically ideally located to cater to the middle East and far eastern countries for shell eggs. Therefore vast scope exists to increase the export of shell eggs from India to these countries.

Exports of poultry produce are very low, about 700 crores per annum and the trade is very small in global market (Shukla and Nayak, 2015). At present mainly table eggs (UAE, Kuwait and Oman), hatching eggs (UAE, Oman and Kuwait) and egg powder (Japan, Poland, Belgium and UAE) are exported from India. Our major markets Middle East and Asia. Egg powder is exported to Japan and EU. India has infra structure to export eggs including all primary packaging mechanism and cold chain to deliver top quality produce to customers.

Poultry Production in rural areas

India has nearly 70% of its population living in rural areas. However, in the present scenario most of the commercial poultry production is concentrated in urban and peri - urban areas. Just 25% population living in urban areas consumes about 75-80 % of eggs and poultry meat. Non-availability of poultry products and low purchasing power of the rural people devoid them of access to the highly nutritious products like egg and meat, thereby, resulting in malnutrition. Free range and small scale semi-commercial back-yard poultry production can be advantageously promoted in rural areas, as the large commercial poultry production continues to be concentrated in urban and peri - urban locations. It can be used as a powerful tool for alleviation of rural poverty, eradication of malnutrition and creation of gainful employment in vast rural areas (Sharma and Chatterjee, 2009; Rajkumar *et al.*, 2010).

Adopting small scale poultry farming in backyards of rural households will enhance the nutritional and economic conditions of these people. A new avenue for poultry exports is also opening up as a result of the growing worldwide trend towards the consumption of eggs and meat from birds reared under free-range conditions. The enormous contributions from the public sectors resulted in development of many chicken varieties suitable for backyard/ rural poultry farming. Directorate of Poultry Research, Hyderabad under the aegis of Indian Council of Agricultural Research has developed promising crosses namely Vanaraja, Gramapriya, Srinidhi etc. Vanaraja and Srinidhi are dual purpose birds, while Gramapriya is having good egg production potential. Apart from this agricultural/veterinary universities also developed rural chicken varieties such as Giriraja, Rajasri, Gramalaxmi, Krishna J, etc. for backyard poultry. Some private firms also developed promising varieties like Kruoiler and Rainbrow roster for rural poultry and are being propagated extensively eastern parts of India The attractive multicolor feather pattern, adaptability under diversified conditions and production potential in backyards made these birds quite popular in almost all parts of this country.

Organic poultry production

Consumer awareness is growing in terms of organic food products in recent years as almost all the food ingredients are grown under intense production systems which utilize lot of chemicals and pesticides to control the pests and diseases. Organic farming can be defined as an approach to agriculture where the aim is to create integrated, humane, environmentally and economically sustainable agricultural production systems producing acceptable levels of crop, livestock and human nutrition, protection from pests and diseases, and an appropriate return to the human and other resources employed (Lampkin, 1997). Maximum reliance is placed on locally or farm-derived, renewable resources and the management of self-regulating ecological and biological processes and interactions. The usage of chemical and other external inputs are reduced as far as possible. Organic agriculture is known as ecological agriculture, reflecting this reliance on ecosystem management rather than external inputs. In India free range farming is considered to be organic if birds are reared without any medication and other feed compounds. Some of the important aspects of organic poultry are as follows

- Management of livestock as land-based systems (i.e. excluding feedlots and intensively-housed pig and poultry units) so that stock numbers are related to the carrying capacity of the land and not inflated by reliance on 'purchased' hectares from outside the farm system, thus avoiding the potential for nutrient concentration, excess manure production and pollution;
- Reliance on farm- or locally-derived renewable resources, such as biologically fixed atmospheric nitrogen and home grown livestock feeds, thereby reducing the need for non-renewable resources as direct inputs or for transport.
- Maintenance of health through preventive management and good husbandry in preference to preventive treatment, thereby reducing the potential for the development of resistance to therapeutic medicines as well as contamination of workers, food products and the environment.
- Housing systems which allow natural behaviour patterns to be used and give high priority to animal welfare considerations, with the emphasis on free-range systems for poultry.

Value addition in Poultry

Value addition in poultry plays in important role in increasing the profits. The value addition may be through nutritional manipulations, processing and transgenesis. Omega enriched eggs and meats are available in the market for premium price developed by nutritional approaches. Feeding the chicks with rich sources of omega fatty acids will aid in increasing the levels of omega 3 fatty acids in eggs and meat of the birds. The second one is through biotecnologcal approaches where in the gene responsible for specific trait will be transgressed leading to transgenesis. However, this approach is still in primitive stage where in research is being carried out. The commonly utilized method for value addition is processing of the poultry products. By value addition low valued meats and by products can processed in to a highly nutritious finished products adding to the returns.

Welfare concerns in Poultry

Welfare of poultry has become an important issue in recent days since EU banned cage rearing of birds. Animal welfare activists increasingly argue that rearing of these high producing and rapid growing birds in intensive system of rearing resulted in some of the welfare and health issues which were not apparent in slow growing extensively reared birds. Animal welfare activists allege that the welfare of birds reared particularly in conventional cages (CC) is compromised. The space provided in CC is not sufficient for birds to do normal activities such as to stand, lie down, and turn around without touching each other and sides of the enclosure (Chatterjee and Haunshi, 2015). The birds kept in CC do not have sufficient space to express their natural or highly motivated and comfort behaviours. Highly motivated or internally driven and comfort behaviours in laying hens are nesting behaviour, preening, dust bathing, wing flapping, wing stretching, foraging, pecking, etc. Wing flapping is often referred to as “comfort” (stretching) behaviour, Wing flapping requires more space than wing stretching (one wing stretched downward) and wing raising(slight elevation of both wings). All these behaviours are not seen in birds kept in CC cages.

Broilers are reared mostly on floor in open sided houses for a short period of time i.e. up to 6 weeks of age. Hence, welfare issues in broiler production are entirely different. Genetic selection for higher body weight over the last 50 years resulted in increase in growth rate by over 300% from 25 g per day to 100 g per day (Nicol 2013). This phenomenal increase in growth rate of broilers resulted in emergence of metabolic disorders such as ascites and sudden death syndrome (Bessei, 2006). Other welfare problems are leg disorders and lameness in the fast growing broilers and hunger in the broiler breeders (Weeks and Butterworth, 2004).

Extreme hunger in broiler breeders due to feed restriction to prevent accumulation of fat and in-turn affecting the egg production is considered to be one of the welfare concerns in broiler breeders. Incidence of contact dermatitis (Pododermititis) that includes hock burns, breast blisters and foot pad lesions is considered to be another welfare issue.

Policy makers should consider both positive and negative aspects of the problem before making a decision on the issue related to cages. A layer bird producing 330 eggs in a conventional cage and a broiler growing at rapid rate (2.5 kg in 42 days) is itself is very good example that the birds quite comfortable. One cannot imaging a spectacular productivity from birds if the birds are under stress or uncomfortable.

Constraints

Issues relating to animal welfare and environmental pollution by poultry units have been of increasing concern in developed countries such as the U.S. and the European Union (E.U.). Considering globalization and the international trade in poultry products, however, these issues may assume significance in a few years because of pressures from importing countries such as those in the E.U.

- A major constraint affecting the growth of the poultry industry in India is the lack of basic infrastructure such as storage and transportation, including cold chain. As a result, there are wild price fluctuations in the prices of poultry products, i.e., eggs and broilers.
- An inefficient marketing system. The presence of so many market intermediaries harms both the producer and the consumer.
- The price and availability of feed resources. Maize or corn plays a major role in broiler production, as it constitutes 50 to 55 percent of broiler feed. As the broiler industry is growing at the rate of 15 percent per annum, the demand for maize is thus likely to increase. Presently India grows only 11 million tonnes of maize and only 5 million tonnes are available for poultry, which is not sufficient if the current growth rate of the industry is to be maintained.
- Emerging and re-emerging diseases of poultry. Mutations in viral genomes leading to new variants in viruses and developing resistance to vaccines and antibiotics. Avian Influenza outbreaks occurring in parts of India is a very good example.

The policy measures that are required to improve the poultry industry must involve: (a) improving infrastructure facilities, which will help not only to stabilize the price of poultry products in the domestic market, but will also make them available in remote areas; (b) creating an efficient marketing channel that will help provide remunerative prices to producers (in other words, India's marketing set-up should also grow along professional lines); and (c) increasing maize production, which will involve using GM (genetically modified) seed varieties or, alternatively, will necessitate finding other sources of feed ingredients that can replace maize.

Conclusions

The poultry production in India continues to exhibit spectacular growth inspite of several challenges encountered over the years. With increasing demand for chicken egg and meat, the poultry production in India foresees further expansion and industrialization. Adoption of small scale poultry farming in backyards of rural households will enhance the nutritional and economic status of the rural people. With the advent of knowledge in different fields of poultry, the future challenges will not be a hindrance and thus sees a bright future for poultry production in this country.

Hatchery setup and Management

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Receiving and cleaning of hatching eggs

Eggs start deteriorating from the moment it is laid. The first change which takes place in the egg after it is laid is loss of weight due to evaporation of moisture and loss at small quantity of gases. The other change which develops during storage can be identified by candling of eggs. The egg when laid comes immediately in contact with litter, excreta, feed, water, etc., and it is usually dirty and its surface harbors bacteria and viruses.

1. **Never wash an egg with water:** Do not wash eggs unless necessary because a bacterium has a greater chance of entering through the pores. An egg's shell has a natural protective coating (cuticle) that resists the entrance of bacteria and retains moisture inside. Washing eggs with water removes this protection.
2. **Floor Eggs:** Floor eggs are a costly expense and generally not recommended for hatching purpose. Eggs laid in litter or on slats are usually dirty or cracked.
3. **Collection of eggs:** Collect the hatching eggs as frequently as possible. The fresh eggs should be cooled to temperature below the physiological zero level as quickly as possible.
4. **Cleanliness of the shel**l: Clean eggs hatch better than the soiled eggs. Dry cleaning of soiled eggs with rough cloth or sand paper may be done before setting in incubator.
5. **Precautions by the hatchery staff**: The hatchery staff should wear clean clothes and protective gloves to avoid any contamination from their side.
6. **Sanitation**: It is a very important factor while collecting eggs it is also recommended to adequately sanitize the plastic /pulp egg trays.

Selection of hatching eggs

The following points should be considered while selecting eggs for hatching purposes.

1. **Size of eggs:** The medium size (50-55 gm) should be preferred over too small or too large eggs as they create hindrance in setting in incubation trays and also do not hatch as good.
2. **Shape of eggs:** The shape of hatching eggs should be oval. Duck and turkey eggs may be less oval than chicken eggs.

3. **Shell quality:** Eggs with sound shell should be selected. Shell should be clean and thick.
4. **Interior quality of eggs:** hatching eggs should have good albumen and yolk quality and free from blood and meat spot or any other defect.

Grading of eggs

Grading is the sorting out of eggs in to different categories according to the interior quality and the individual weight of an egg. Grading for internal quality is done by candling while for noting the weight of an individual egg there are various types of automatic devices in the market. Some standards for grading of eggs are as under.

Table 1 Indian standards for quality of shell eggs

Quality factor	Grade A	Grade B
Shell	Clean, sound, unbroken and normal shape	Clean to moderately stained, sound but slightly abnormal.
Air cell	4.0 mm. or less in depth, practically regular.	8.0 mm. or loss in depth and slightly bubbly
White	Clear, reasonably firm.	Clear, may be slightly weak
Yolk	Fairly well centred practically free from defects Out line indistinct	May be slightly off centre. Outline slightly visible.

Fumigation and storage of hatching eggs before incubation

We carefully attend to the incubation process but disregard the care of the eggs before they are placed in the incubator. Even before incubation starts the embryo is developing and needs proper care. Produce quality fertile eggs from a well-managed, healthy flock which are fed properly balanced diets. Listed below are tips to maintain hatching egg quality.

1. **Fumigation:** Pre incubation fumigation of hatching eggs should not adversely affect hatchability, if the proper gas concentration is used for not more than 20 minutes. Eggs should be properly ventilated before setting.
2. **Transportation of hatching eggs**: Eggs which have been shaken or jarred in transit should be allowed to settle for24 hours or so before setting in incubator.

3. **Storage of hatching eggs**: Ideal storage conditions include a 14 -15 ^oC temperature with 75% relative humidity. Never store eggs at temperatures about 75°F and at humidity lower than 40%. These conditions can decrease hatchability dramatically in a very short period of time. Maintaining a constant environment for hatching eggs prior to incubation is critical to achieve optimum hatchability. Household refrigerators are too cold for storing fertile eggs.
4. **Storing position:** Store the eggs with the small end down. Turn the eggs to a new position once daily until placing in the incubator, if not incubating within 7 days.
5. **Storing Period:** Don't store eggs more than 7 days. Hatchability holds reasonably well up to 7 days, but declines rapidly afterwards. Eggs stored more than 7 days will benefit from daily turning. Plan ahead and have a regular hatching schedule to avoid storage problems. Do not store eggs for more than 10-14 days. After 14 days of storage, hatchability begins to decline significantly. After 3 weeks of storage, hatchability drops to almost zero.

Methods of incubation:

There are two methods of incubation, natural and artificial.

1. Natural method of incubation: In this method eggs are incubated with the help of broody hens. A broody hens used for incubating eggs should be healthy, quiet, a good sitter and have good body size. The broody hens should also be treated for internal and external parasites before allowing her to sit on eggs. Depending up on the size of hen 10-15 eggs can be placed under one bird. The broody hen should be taken out at least twice a day for about 30 minutes to be fed and watered. Candling may be done on 7th day to remove the infertile eggs. This method is still popular with small poultry keepers in remote rural areas. Although this method is disappearing and being replaced by artificial method of incubation.

2. Artificial method of incubation: In this method eggs are incubated in "egg incubators". This method of incubation of eggs is known to man for more than 2000 years. Various size's hatchery are used for this purpose. The modern hatchery is an impressive example of engineering solution of biological requirements of developing embryos and production of viable and healthy chicks. There is perfect control of temperature, humidity, ventilation and turning of eggs under hygienic condition to produce over 1 million chicks a week with relative ease from incubators equipped with sophisticated controls to maintain optimum hatchability.

Sanitation and disinfections of incubators

The microbial contamination can be prevented and controlled using proper hatchery management practices and modern health care products. Thoroughly clean and disinfect the incubator before and after you use it. It is just as important that the incubation room and egg storage area are kept equally clean. The lack of sanitation will decrease hatchability. Microorganisms are everywhere! Some are relatively harmless while others are highly pathogenic. Some pose a lethal threat to one species of animal while remaining harmless to another species. Some organisms are easily destroyed while others are very difficult to eliminate.Three terms commonly used but often misunderstood are

Sterilization: The destruction of all infective and reproductive forms of all microorganisms (bacteria, fungi, virus, etc.).

Disinfection: The destruction of all vegetative forms of microorganisms. Spores are not destroyed.

Sanitation: The reduction of pathogenic organism numbers to a level at which they do not pose a disease threat to their host.

Select the right disinfectant: Proper cleaning of facilities removes the vast majority of all organisms and must be used before application of disinfectants. This applies to all areas within the hatchery including floors, walls, setters, hatchers, trays, chick processing equipment, air and personnel.

1. The type of surface being treated
2. The cleanliness of the surface
3. The type of organisms being treated
4. The durability of the equipment/surface material
5. Time limitations on treatment duration
6. Residual activity requirements

Preparing the Incubator: Before you incubate the eggs make sure that incubatoris working properly and that you know how to operate it. Check the thermometer (at least 24 hours before you set the eggs & be sure it will stay at the correct temperature and humidity).

1. Run your incubator without any eggs for 12 to 24 hours, regulating and checking the internal temperature, humidity and turning at hourly interval.
2. Check the thermometer's accuracy and calibrate properly.
3. Thermometer with a split or gapped mercury will not give an accurate reading.

4. Do not load the eggs until the temperature and humidity are correct.

5. During incubation, eggs found to be leaking, cracked, or mouldy should be removed and disposed off. Such eggs may explode because of high microbial contamination.

Fumigation of Incubators

1. Excessive and improper fumigation may result in higher mortality in developing embryos.
2. The killing of bacterial organisms by formaldehyde is based on the concentrations of the gas, exposure time, temperature, and humidity of the incubator.
3. The disinfectant potassium permanganate and formalin (40% formaldehyde gas) have proven to be the most effective method of destroying bacterial organisms in the hatchery.
4. Fumigation of loaded setters for 30 minutes with 20 grams Potassium permanganate and 40 ml of 40% of Formalin solution for 100 cubic feet of incubator area.

Warming of hatching eggs before setting

Hatching egg removed from the cold room should not be placed directly in the setters. Rather they should be warmed slowly to room temperature first before placing in the incubator.

1. Abrupt warming from 14 degrees to 36.7 degrees Celsius causes moisture condensation on the eggshell that leads to disease and reduced hatches**.**
2. When the egg cools, embryonic development stops. Embryonic development starts again when the temperature is increased.

Incubator operation

Incubators have been designed to operate in rooms that are comfortable for people. If a room is too hot or cold, an incubator may not be able to hold the proper temperature. If the incubator is in a room where temperatures are decreased to 55 ^{0}F over the weekend, hatchability will be affected. If several people are involved in the incubation process, keep a written record.

Incubating the eggs: Successful incubation depends on maintain favourable conditions for hatching of fertile eggs. Four factors of major importance are temperature, humidity, ventilation, and turning. Commercial incubators are automated to control all of these factors.

I. Temperature (during incubation)

The required level of heat in the incubator can vary from 99.5 ^{o}F (36.7 ^{o}C) to 101 ^{o}F.

1. Using two thermometers is a good idea to ensure an accurate reading
2. The acceptable range of temperature is 98° to 101°F. Mortality is seen if the temperature drops below 97°F or rises above 102°F for a number of hours.

3. Before putting eggs into an incubator, plug it and make sure the temp is holding at 99.5-101 °F.
4. Temperature is the most important single factor influencing the development of the embryo.
5. Higher temperature will advance the hatch and a lower temperature will delay hatch.
6. Incubator overheating can quickly kill the developing embryo.
7. Never cool eggs again after starting incubation.
8. Overheating the embryo is much more damaging than is under heating.
9. Once the eggs are in the incubator, do notadjust the temperature or humidity for a few hours unless the temperature exceeds 102^{o}F.
10. Do not adjust the temperature upward during the first 48 hours after eggs are set.

II. Humidity (during incubation)

The amount of moisture in the incubation air is the relative humidity. It is usually measured by a wet bulb thermometer. Function depends on the cooling caused by evaporating water. A thermometer is covered by a cloth sleeve that extends into a container of water. If the humidity is low, much evaporation occurs, resulting in a lowering of wet bulb temperature; therefore, the wet bulb temperature is much lower than the dry bulb temperature. Humidity must be regulated. Commercial incubation maintains a wet bulb temperature of about 85^{o}F for the first 18 days for chicken eggs and 91 ^{o}F for the last 3 days. Humidity should be set so that an egg loses 13 percent of its initial weight by the last 2 days before hatching. Too much or too little humidity in the incubator will cause hatching problems and the death of embryos.

1. During hatching period, the humidity in the incubator may be increased by using an atomizer to spray a small amount of water into the ventilating holes.
2. Whenever you add water to an incubator, it should be about the same temperature as the incubator so you do not stress the eggs or the incubator.
3. Water drum meant for water air cool system should be kept full at all times.
4. The wet bulb should remain wet in water at all the time.
5. Incubation maintains a wet bulb reading of about 85 ^{o}F for the first 18 days for chicken eggs and 91 ^{o}F for the last 3 days.
6. Low humidity can cause, the shell membrane becomes dry and embryo stick to the shell, which also causes embryo mortality.
7. Humidity inside the Incubators should be controlled by slightly adjusting the rotavents and manual top ventilator.

8. If more humidity is needed adjustment can also be made by increasing or decreasing ventilation.
9. During the hatching period, using an atomizer to spray a small amount of water into the ventilating holes may increase the humidity in the incubator.
10. Relative humidity should be balanced with temperature; different temperatures require different relative humidity.

III.Turning

The act of changing the position of eggs, this keeps the embryo cantered in the egg during incubation to prevent the embryos from sticking to the shell membranes.

1. Eggs must be turned hourly during the first 18 day of incubation.
2. Turning the egg prevents adhesion of the embryonic membranes and helps in the movement of the embryo into the normal hatching position.
3. Turning stimulates the growth of the membranes, and increases the heart rate.
4. The increased heart rate and membrane growth facilitate absorption of the nutrients from the yolk, albumen.
5. Turning is not requiredduring the last three days before hatching.
6. Do not open the incubator until the hatch is completed to insure that a desirable hatching humidity is maintained.

IV.Ventilation

The embryo is living tissue and as such needs to exchange oxygen and carbon dioxide throughout the growth process.

1. The best hatching results are obtained with normal atmospheric air, which usually contains 20-21 percent oxygen and produces optimum hatching results.
2. While the embryo is developing, oxygen enters the egg through the shell and carbon dioxide escapes in the same manner.
3. As embryos grow, the air vent openings are gradually opened to satisfy increased embryonic oxygen demand.
4. The air vents should be almost fully open during the latter stages of hatching.
5. Do not open the incubator unless necessary during the last 3 days of incubation.

Testing of Incubated eggs through candling

Candling should be performed in a dark room. A fresh egg appears clear with only a small air cell. Egg candling will detect infertile and early dead germs. After 10 days of incubation, an infertile egg has an enlarged air cell, and the yolk causes an obvious dark area in the egg. After

10 days of incubation, a fertile egg has visible blood vessels and a dark spot that is the embryo.Eggs with white shells are easier to candle and can be tested earlier than dark shelled eggs. Two classes of eggs can be removed on the basis of this early test, "infertile" and "dead germs." "Infertile" refers to an unfertilized egg or an egg that started developing but died before growth could be detected. "Dead germs" refers to embryos that died after growing to be seen when candled.Eggs can be out of the incubators for half an hour without any harm for candling.

Bad eggs: The egg shows a ring at 6 days. This ring is formed by concentrated bacteria which has invaded the eggs membrane.

Good Eggs: A live embryo is spider-like in appearance, with the embryo representing a spider's body and the large blood vessels spreading out much like a spider's legs. A "dead germ" can be distinguished by the presence of a blood ring around the embryo.

1. Fertility is rarely 100%.
2. When the flock is of good producing age and the right proportion of males to hens are place together, it can be assumed that a fair amount of eggs will be fertile
3. Fertility may vary from 65% to 95% with season, condition and type of birds.
4. Fertility of eggs cannot be determined before incubating them.
5. Candling chicken eggs on the 7th and 18th day of incubation is the ideal.
6. Eggs that appear clear at 18^{th} days in incubation should be removed from the incubator. They are infertile or early dead embryos.
7. Candling will not influence embryo development if you handle the eggs gently.
8. Fertile egg shows a black spot at the top of the yolk shadow along with few blood vessels.
9. Transfer the eggs quickly to avoid cooling down of the eggs.

Hatchery Hygiene

The hatchery must always be regarded as the greatest potential source from where disease can spread. There are two classes of diseases which originate from the hatchery. The 1st includes those diseases which are definitely egg transmittable. The 2nd includes diseases those are transmitted by contact with disease producing microorganism introduced from sources other than eggs after chicks are hatched.

Ways by which infection enters in the hatchery:

The surface of eggs, egg boxes & fittings can convey infection from the poultry farms.

1. Vermins can act as carrier.
2. Flies, cockroaches etc. can bring infection from the exposed debris.

3. Clothing and hands of hatchery staff, particularly of sexers.
4. Dead or ailing birds brought to hatchery for diagnosis and advice.

To avoid the spread of diseases from hatchery following precautions may be exercised:-

1. Only nest clean eggs should be collected for hatching in clean filler flats and boxes.
2. Hatchery should not be located near poultry farms, Poultry processing plants or other hatcheries.
3. Incubators should be located in a separate room with "No Admittance" sign at door.
4. Each year before the season starts the hatchery building and all the equipments should be thoroughly cleaned and fumigated.
5. All eggs entering in incubators must be fumigated.
6. The ventilating system in the hatchery should be designed to bring fresh and filtered air in all areas. Ideally no air should be re-circulated in the hatchery.
7. The wall, ceilings and floors should be constructed of water repellent material so that they can be washed easily.
8. Keep fans, air conditioner, ventilator etc. free from chick down and dust.
9. Hatcher, chick tray etc. should be kept clean.

Using protecting

1. The hatching process releases much fluffy debris inside the incubator.
2. Care should be taken not to open the incubator.
3. Wearing gloves and a facemask may help to provide better hygiene while doing this cleanup.

Common disinfectants and uses

a) **Phenol derivatives**. One part of phenols with 4 parts of water, 1 gallon used a spray in 400 sq floor area is very effective for routine purpose.

b) **Iodine Preparations**: - Iodine preparations were containing 1.75 % iodine as is used @ 30 ml/2 gallon of water for cleaning the floor and equipment.

c) **Chlorine Preparation**: - Chlorinated lime or bleaching powder is a well-known disinfectant. It is prepared by saturating lime with chlorine gas & should contain 30-35 % of available chlorine used as disinfectant of hatchery floor.

d) **Quaternary Ammonium Compounds**: - These compounds are cleaning agent and used to scrub and disinfectant premises.

e) **Coal Tar**: - These are cresol products which form milky emulsions when mixed with water. 5% is effective for disinfecting purpose of floor space.

f) **Dettol:** - Dettol & similar products are expensive but quite effective antiseptics and disinfectants.

g) **Caustic Soda**:- It generally used as cleaning agent but 2 % solution is used as disinfectant for most microorganism

h) **Lime**:- It is used as white wash

i) **Ultraviolet Rays**:-Ultraviolet ray kill bacteria and are used for incubators and other hatchery equipments.

j) **Dry heat and steam cleaning**:- Few instruments particularly Incubator trays & metal parts are subjected to pressure steam at boiling point

k) **Formaldehydes**: - Under ideal condition formaldehyde is very effective for killing bacteria, fungus and viruses. Formaldehyde is notorious for being a poor penetrator and only works on the surface of the material.

l) **Ethylene oxide**: -It has many advantages over formaldehyde as it is effective against many poultry pathogens. Its penetrating properties are excellent so it is valuable for sterilizing the hatchery equipment. Precaution should be taken while using as it is highly inflammable and dangerous.

Rural Poultry Production

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Impressive growth has been achieved in commercial poultry farming but the rural poultry sector remained unchanged. Chicken population in rural areas increased marginally from 63 million to 73 million in past 35 years. Back yard poultry contributes around 20% (including ducks) to total egg production of the country. Majority of the population still lives in villages and they are getting access only to 25% of total poultry products. The incidence of protein deficiency among the susceptible groups like children, women, pregnant mothers and aged people can be alleviated by adopting small scale poultry farming in back yards of rural households. In rural areas it is observed that the poultry products are sold at 10-40% higher price than the prices at urban and semi urban areas. The back yard poultry production relies on minimal cost inputs in the form of kitchen waste, cheap locally available grains, tender leaves, worms, insects and other material available for scavenging. In every village it is essential to establish backyard poultry to provide high quality protein to vulnerable groups and supplemental income using minimum inputs. Commercial poultry farming will not be affected by growth of rural poultry farming as observed in most of South East Asian countries. It has been reported that 75% of eggs and meat produced in Africa and 50% in south Asian countries is derived from traditional backyard poultry production. About 70% of the total eggs in China comes from rural poultry production (Sharma and Hazary,2002). Local poultry breeds with production potential of 120 eggs/ year/ bird constitute china's poultry population although China is the largest producer of eggs and second largest producer of meat in the world. Therefore, there is need to improve / augment rural/ backyard poultry production under free range and scavenging conditions. To achieve this we should have stocks which need to in between *desi* and exotic birds with regard to plumage colour, growth rate, egg production and better Immuno competance under harsh climate and low input feeding system.

Present scenario in India

At present, India sands at 3rd and 5th position, respectively in the worlds' egg and chicken meat production.(DAHHDF& CII, 2006). Poultry industry contributes around Rs. 352 billion to the GDP and providing direct employment to about 1.5 million people and indirect employment to about 2 million people in our country. Annually about 2 million tons of valuable organic poultry manure is produced.

Rural Poultry

Chicken rearing is an age old practice since ancient years and it became a part of routine life in rural areas. Generally desi birds are used for rearing in backyards in rural and tribal areas of the country. Though the native chicken reared in the backyard contribute about 20% of the total egg production in India, their productivity is far below (55-65 eggs/year) than those reared under intensive farm conditions (310 eggs/year). About 317 millions of native birds of different genetic potential and adopted for several centuries are available in India, which accounts for 38% of the total chicken population.The chicken varieties available are not suitable for this purpose as the production potential is very low. The exotic bird were tried for rearing in backyard / rural poultry production But they are not successful because of high mortality and poor performance due to low input management and harsh climatic conditions. Therefore, it is necessary to develop chicken varieties which can produce significantly better than native chickens and survive and sustain under adverse climatic conditions utilizing minimum inputs in terms of feed, health care and management. The crosses of mediocre performing birds proved to be useful for backyard rearing. The need of the hour is to develop suitable germplasm with mediocre growth rate (1.5-2.0 kg at 12weeks of age) and egg production (120-140 eggs per year) with coloured plumage as the choice of the rural/Tribal populations.

Prospects of Backyard Poultry Farming

1. Family poultry plays a significant role in the cultural life of rural people in the following ways:
    a) as a gift to visitors and relatives,
    b) as starting capital to youths and newly married maidens,
    c) as sacrificial offerings in traditional worship,
    d) as a potential source of employment and easy source of income for small scale farmers.
2. Family poultry requires little intervention in rearing, the major intervention is in the areas of feed and water supplementation, over night housing and to a much lesser degree, health management.
3. Family poultry can easily integrate with other agriculture, aquaculture and livestock farming practices.

4. Poultry products from family poultry have social and spiritual benefits and play an important role in rural economy.
5. Free-range poultry helps in pest control and weed clearance etc.
6. Better export value for eggs and meat from free-range poultry farming in developed countries.
7. Low investment, maintenance cost and risk
8. Good demand and higher price for eggs and birds of native fowl
9. Easy to manage and handle
10. Traditional liking
11. Serve as an efficient waste disposal system by converting every leftover feed materials.
12. About 15 chicken produces 1-1.2 kg of manure per day.
13. Contribute to the village economy.
14. Women in rural areas can operate family poultry farming and women involvement is easy

Chicken varieties suitable for rural poultry farming.

Having realized the importance of RPF in India, several research institutes developed different varieties (Table 1)These are the varieties that are being now effectively being raised in different parts of the country by the rural farmers. These birds were selected based on growth rate, egg production, Immunocompetance and plumage colour. These birds are able to thrive in harsh climatic conditions of free range/ semi-intensive farming in India. Going by the present international consumer market trends, eggs and meat from free range farming will have a great demand in the days to come. In view of its varied agro-climatic conditions and vast flora in most parts, India has a great potential for poultry production in the free-range conditions and capturing a great share of the International market. The good experience of other South East Asian and African countries, where commercial poultry farming and the village poultry farming are working simultaneously for improving local poultry production will aid as guiding forces for the Indian poultry industry to march ahead in this direction.

Table 1 Rural poultry varieties

Variety	**Type**	**Developing agency**
Vanaraja	Dual	DPR, Hyderabad
Gramapriya	Egg	DPR, Hyderabad
Srinidhi	Dual	DPR, Hyderabad

Vanasree	layer	DPR, Hyderabad
KrishiBro	Meat	DPR, Hyderabad
Giriraja	Dual	KVAFSU, Bangalore
Girirani	Egg	KVAFSU, Bangalore
Krishna J	Egg	JNKVV, Jabalpur
Nandanam 99	Egg	TANUVAS, Chennai
Gramalakshmi	Egg	KAU, Kerala
Kalinga Brown	Egg	CPDO, Bhubaneswar
CARI Nirbeek	Egg	CARI, Izatnagar
CARI Shama	Egg	CARI, Izatnagar
Upcari	Dual	CARI, Izatnagar
Hitcari	Dual	CARI, Izatnagar

The germplasm developed for backyard farming has the following features

1. The colour pattern of the germplasm is more attractive than *Desi* hen. Because of coloured plumage these birds have camouflagic characters to protect themselves from predators.
2. They can thrive well under adverse environmental conditions like poor housing, poor management and poor feeding.
3. Broodiness is rarely seen in the hens.
4. Nutritional value, aroma and taste of eggs and meat from these birds are similar to Desi hen.
5. Less fat content in meat of these birds makes it acceptable to even aged peoples.
6. These birds can thrive well and perform better even in adverse environmental conditions.
7. These birds are sturdy compared to commercial birds because of their better immune competence.
8. These birds can perform well with diets high in crude fibre. It has better feed efficiency even with diets containing low energy and protein diets based on common feed ingredients available in rural / tribal areas like rice bran, broken rice, small millets (like foxtain millet, finger millet, pearl millet etc.).
9. At eight weeks of age males of these germplasm weighs about 1250 g with a feed conversion ratio of 2.2 under intensive rearing practice.
10. Mortality is less than 2.0 % up to eight weeks of age.
11. The eggs are heavier (55 to 63 g) and colour of the eggs is brown or tinted, attractive and resembles that of Desi hen.
12. Fertility and hatchability of their eggs are 87 and 80 %, respectively, and the farmer can get more number of chicks from a these birds compared to a Desi hen by using broody hen.

13. It can perform better in backyard conditions by eating green grass and insects available in the fields.
14. The performance of Desi hens can also be improved by crossing them with males of germplasm developed for backyard farming.

Improved varieties developed at PDP

The Directorate of Poultry Research, Hyderabad has developed several promising crosses namely Vanaraja, Gramapriya, Srinidhi and Vanasree and. Vanaraja is a dual-purpose bird, while Gramapriya is having good egg production potential.

Performance of varieties developed at ICAR-DPR, Hyderabad

(g)Name	Type	Colour	Body wt. 6 week(g)	Egg production		Egg weight (g)
				Farm	Field	
Vanaraja	Dual	Brown	800-900	150-160	110-120	53-58
Gramapriya	Egg	Reddish Brown	400-450	235-240	160-180	52-56
Srinidhi	Dual	Multi colour	700-800	230-235	140-160	53-56
Vanasree	layer	Light brown	350-400	150-160	130-140	48*50

Performance of varieties developed at AICRP

Name	Developed	Type	Colour	Body wt. 6 week(g)	Egg Production	Egg weight(g)
Pratap Dhan	Mpuat,Udaipur	Dual	Brown	400-450	160-165	53-58
Narmadanidhi	NDVSU, Labalpur	Egg	Blackish	350-400	180-190	49-50
Kamarupa	AAU, Guwahati	Dual	Multi colour	400-450	130-140	52-53
Jharsim	RJU, ranchi	Dual	Multi colour	350-400	160-165	52-54
Himsamrudhi	CSHPKVV, Palampur	Egg	Reddish Brown	300-350	160-180	52-54

Performance of varieties developed at ICAR-CARI,Izatnagar

(g)Name	Type	Colour	Egg Production	Body weight(g)		Egg weight (g)
				Male	Female	
CARI-Nirbhik	Egg	Brown	190-200	1847	1350	52-54
CARI-Shyama	Egg	Blackish	200-210	1460	1120	52-53
UPCARI	Dual	Multi colour	210-220	1685	1285	55-58
HITCARI	Dual	brown	190-200	1756	1320	55-58

Poultry Farm Practices and Management

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Poultry production in India from 1960 to till to-day is a great affair. From scratch it has come to a viable Industry representing our country in the global level of 3rd. place in egg production and 5th in chicken meat production. The enormous efforts put, in managing this Industry by the Scientists, Managers and other workmen involved in the field are countless. The management of the chicken from day-old to the production level in terms of egg and meat are manifold. Effective and strict management techniques are required for the birds to exhibit their production potential. So to start with, we will go-through the different management procedures involved in raising poultry.

Overall Farm Operations include

A. Chick Management/Brooding Management
B. Grower Management
C. Breeder Management

A. Brooding Management: It is the management of chicks or nursery rearing

Isolation of the brooder House

Chicks should be brooded in a house that is not located near other poultry due to danger of disease transmission. At least 300 ft. should be allowed between such houses. But a greater distance is preferable. Air moment must be from brooder areas to other poultry area and should be enclosed with a fence at least 100 ft. from the house.

Preparation on of brooder House

a) Removal of old litter
b) Cleaning and scrubbing the house
c) Cleaning of the equipment
d) Fumigation of the House using 3xconcentration.
   (1x Concentration =20g of $KMNO_4$ + 40ml of Formalin)
e) Cleaning and fumigation of bulk feed bins
f) Treatment of dirty floors with disinfectant solutions.
g) Cleaning of the grounds

Removal of all weeds and debris from the area outside the farm, burning of feathers, mowing of the grass and making necessary road repairs are essential. If a track dip-vat is involved, then it should be made empty, thoroughly cleaned and fresh disinfectants added.

Equipments of brooding

a) Brooders/ Hovers (Electricity/ Gas/ coal brooders)
b) Brooder guards
c) Chick feeder
d) Chick waterers
e) Curtains
f) De-beaker

Requirements of brooding

a) Litter
b) Brooder Guards
c) Temperature
d) Ventilation
e) Floor Space
f) Feed and feeder space
g) Water

Litter: There are many types of litter material and most likely to be used is the most economical. But litters do differ. So to choice a good litter material certain qualities to be looked into

a) Be light in weight
b) Has a medium particle size
c) Be highly absorbent
d) Should dry rapidly
e) Be soft and compressible
f) Should show low thermal conductivity
g) Should absorb a minimum of atmospheric moisture
h) Be in-expensive
i) Be comfortable when sold as a fertilizer

In some cases it may be practicable to use reused litter, but the procedure is often plagued with problems

a. One should not use reused litter if the last brood of broilers was diseased
b. Always depopulate the building when reusing the litter.
c. Disinfection of the building and equipment thoroughly maintaining a low litter pH Very little ammonia will be released when the litter is kept below pH of 7 but is rapid at a pH of 8 or above.

Recommendations for litter treatment

Phosphoric acid - 1.9 litres per 1 m^2 of space

Super Phosphate - 1 kg per 1 m2 of space

Litter material to be covered on the floor to a thickness of 2” (5cm)

Litter Management: During the first 3 weeks of the chick’s life the litter should be only slightly moist. After that it should contain about 25% moisture. The brooders should not be started until the day before the chicks are to arrive as this tends to dry the litter too much. When the chicks are placed on exceptionally dry litter, there is a tendency to increase their dehydration. There must be some humidity in the poultry house. Chicks don’t grow or feather well in a dry atmosphere.

Brooder Guards: Brooder guards should enclose the heated area. Height of the guard should be 16”. The type of the brooder will determine the distance the guards should be from the edge of the hover. But normally the distance should be about 30 inches in winter and 36 inches in summer. Begin increasing the area on 3rd day. Guards should be used for 6-9 days (we can also go up to 18 days, but inner area to be increased frequently) after which they may be removed.

Temperature: It is difficult to recommend any brooding temperature applicable to all types of brooders and all conditions. Usually however a temperature of 90 to 95^{o}F at a point of 6” (15 cm.) outside the canopy and 2” (5cm) above the top of the litter is satisfactory for chicks at 1 day of age.

As the chicks grow older the temperature may be reduced at a rate of 5 ^{o}F per week till it reaches 70$^{.F}$ or room temperature. Thermometer is a poor tool for measuring chick comfort. The chicks themselves should be the indicator. At night they should be down just outside the edge of the hover and completely circle the brooder. If they are too far-out, the temperature is too high, if too far-in, the temperature is too low. Thermometer should be used before the chicks are placed under the hovers, but after 1st two days the same may be removed and stored. Chicks should be fully feathered before supplementary heat is removed. Brooding is done up to 4 Weeks to 5weeks in cold weather a 2nd to 3rd weeks in warm weather.

Ideal brooder should be 5ft. diameter on 2.5 ft. radius. Number of Chicks to be brooded under the hover depends on the brooder size. 10 sq. inch of heating space is normally required for each chick. Two types of brooding area one is brooding or heating area (1/3rd of total area) and the other one is non-brooding or non-heating area (2/3rd of total area). Required floor space should be coordinated with the heating area.

Total number of chicks to be brooded in an area can be calculated using below mentioned formula

$$\frac{\text{Total area } (\pi r^2)}{\text{10 sq. inch}} = \text{Total no. of chicks.}$$

Brooding defects: Brooding defects happen either due to increase or decrease in temperature. If there is low brooding temperature then chicks will pile up and results in respiratory problems. 62 ^{o}F is the lower lethal temperature of day old chicks. Chicks withstand more cold than more heat. 117 ^{o}F is the high lethal temperature, chicks become dehydrated and results in more mortality.

Ventilation: Inflow of air (for O_2 requirement)—2cu. ft. of air/ 100 chicks/ min. is required for effective ventilation. It can be achieved by the 2-3 air changes. Air changes depend on the no. of birds housed, no. of openings kept and dimensions of poultry house.

Floor Space: It is one of the most important attribute to be looked in to for achieving final performance of the chicks whether it is layer or broiler. More chicks in a specified area lead to cannibalism.

1st week 10 sq. inches/chick

2nd week 25sq. inches /chick

4th week 45 – 65 sq. inches/ chick

A minimum of 700 sq. cm. should be maintained per chick up to 6th week of age.

Feeder space: Optimum feeder space to be given to chicks is 3.5 to 4cm /chick. Mainly we use linear feeder. So it is always wise to hove half of the feeder inside the brooding area and other half in the non-brooding area. Never allow the chicks to go beyond 10' to take food so we do frequent feeding. When circular pans are used allow about 20% less feeder space /bird. With 15" diameter pans provide one pan for every 33 broilers. Feed requirement depends on the age of the chicks. We use two types of feed i.e. broiler starter and finisher diet.

Water: Chicks must learn quickly to eat and drink. Although they can get along without water and feed up to 3 days after hatching but such a delay will be detrimental. Any postponement will weaken and dehydrate the chicks. Water is very much important as it serves many functions in the body. Water space to be provided is 25 to 100cm for every 100 chicks. Placement of waterer should be in between two feeders and exactly under the hover. Provide two fount type chick waterers for every 100 pullet chicks for 1st and 2nd week. After two days the founts should be placed on stands about 1" (2.5cm) high to keep litter from getting in them. Fill the waterers about 4hours before the chicks arrive. This allows time for the brooder heat to warm the water. The water temperature should be 65 ^{o}F (18 ^{o}C) and over. Use always fresh and potable water. Water consumption is two times than the food consumption.

B. Grower Management

The growing period follows the brooding period and concludes with sexual maturity. Perhaps in this age the chickens command the respect of management. How well a bird is grown will greatly determine how well it does in the laying or breeding house.

There are different methods of growing as mentioned below

a. The Grower House------------------- very good
b. The Brood – Grow House------------ Compatible
c. Grow- Lay house ---------------------- also compatible
d. Brood – Grow –Lay house---------- not compatible

Floor: The type of floor in the growing house will vary the management recommendations. Litter, part slats, part wire, all wire and cages are used for growing pullets and cockerels and alter certain procedures. Floor space needed by different stains and ages of birds is highly variable. However, the requirement of floor space is 0.8 sq. ft. at initial stage and 1.5 sq. ft at last stage of growing. For meat type breeder pullets the requirement is 2.5 to 3.0 sq. ft/bird. Slat or cage rearing is excellent also, we can opt for completely wire floor rearing.

Feeder space allocated is 2” at the beginning and to be increased to 3” by 20th week period, similarly the waterer space allocated is 0.6” (1.5cm) of linear length at the beginning and to be increased to 0.85” (2.2cm) by 20th week. Litter to be very well managed during the growing period very effectively for control of coccidiosis.

Debeaking: One must do debeaking at this grower stage otherwise cannibalism will be a problem. To properly trim the beak of a bird, a part of the upper and lower mandible is removed with an electrically controlled cauterizing blade having a temperature of 1500^{o}F (815^{o}C). Precautions during debeaking are

a) Don’t trim beaks when birds under stress
b) Sulfa drugs causes profuse bleeding
c) Trimming machines are sources of infection
d) Watering device may not be satisfactory (problem in nipple or drip type waterers, so better founts type waterers)
e) Increase the depth of feed in troughs
f) Add vitamin-k during the period of stress due to debeaking.

Lighting: Growers do not need artificial light. Duration of light should be 9 hours. Growing birds are susceptible to cannibalism but the vice may be partially eliminated by using light intensities of less than 0.5 fc (5 lx) at bird level. Light not only makes easy for the birds to eat and drink but also it affects the pituitary gland at the base of the brain and the stimulation causes mature pullets to begin the production of eggs.

Pullets tend to come in to the egg production at a younger than normal age if they are grown under natural day light during the time when day light hours are lengthening (**out-of-season** birds). When the days get shorter and those grown during the period have decreasing light are known as (**in-season** birds).

C. Breeder Management: 16-18 weeks is the more ideal for shifting growers to the cage house or layer house – 20 weeks too late and 14 weeks too early. It is of two types

1. Floor management
2. Cage management

1. Layer Management in floor

When the birds are to be moved from a growing house to a laying house just prior to sexual maturity, the usual routine of cleaning the house and equipment are fallowed as usual in brooder house preparation. Add about 3 inches (8 cm) thickness of litter material during summer months and 4 inches (10 cm) during winter months. Crippled, emaciated and blind birds are to be removed before moving to layer houses. If a coccidiostat has been used in the growing period, then continue to feed the same on the slat or wire floor 2 or 3 weeks, and then gradually withdraw it. Nests should be put in the laying house and open about a week before the first eggs are laid. This allows time for the pullets to get accustomed to them prior to the egg production. (Floor eggs can be prevented). Nests to be kept always in darken areas and bedding material to be changed frequently.

Floor space requirement: 2 sq. ft. space for layers in deep litter system. In slat it is 75% of 2 sq. ft. In cage house it is 60% allocation of the deep litter houses.

Feeder space: Allocation is 3” per bird. If pan type then 16 birds / pan. If it is a tubular feeder then 14 birds / feeder. If meat type birds then 3.5” feeder space. Pan type – 14 birds and tubular feeder – 12 bids.

Waterer space: 1” waterer space in linear feeder per bird is required. If the pan (round) type water is used then – 25 birds each.

Grit: Requirement of grit for shell and to build up body reserve. Shall grit is a part of feed only (source of ca.)

House temperature and laying performance

As the ambient temperature rises the laying pullet undergoes many changes. Rising temperature increases water consumption, respiration rate, body temperature and stress where as rising temperature decreases oxygen consumption, blood pressure, interior egg quality, egg shall quality and all. The optimum house temperature should be 80 ^{o}F (27^{o}C)). Both hot and cold weather makes problem to the birds.

Cold weather: Moisture built up and house temperature below freezing needs to be taken care, whereas moisture build up can be solved by the managers ability to regulate the movement of air to remove most of the moisture from the house while conserving the heat as much as possible, but for a house temperature below freezing, only a better house construction is the only positive answer to the difficultly.

Hot weather: At temperatures above 80 ^{o}F (27^{o}C) laying pullets begin to suffer and performance begins to diminish. At 100 ^{o}F (38 ^{o}C) things become serious. Egg production drops drastically and many birds die from heat stress.

Handling the summer stress

1. Insulation of the roof of the ceiling
2. Increase of ventilation
3. Providing fans
4. Lowering the humidity
5. Use of foggers
6. Provision of sprinklers on roof
7. Wet areas outside and around the house
8. Provide cool nests
9. Give cool and fresh water
10. Feeding during morning and evening (cool hours)
11. Keep activity in the house to a minimum

Light management: 17 hours of light duration is required for the birds for optimum production and the intensity is 1 fc (10 lux) at bird's body level. Generally, red coloured lights are useful for broilers. In layers florescent light is enough.

(2) Cage Management: It is otherwise known as wire floor management. At least 70 to 75% of the laying flocks now a days are housed in cages.

Advantages

1. Easier to care for the pullets
2. Floor eggs are eliminated
3. Culling is expedited
4. Less feed required to produce a dozen of eggs
5. Broodiness is eliminated
6. More number of pullets housed in a given house floor space
7. Labour requirements are reduced.

Disadvantages

1. Handling of manure is a problem
2. Flies become a great nuisance

3. Heavy capital investment

Lighting programme is same as in floor management

Production standards

Definition: production standards are not the averages of what the birds will accomplish under field conditions but are somewhat higher.

Importance is to provide the poultry man a guide like material to know the capacity of his own flock whether it is producing at standard, above standards or below from which the poultry men knows whether he is doing a good or a poor job of management.

Production indices: Production indices are a good rule of thumbs

a) **Hen day egg production for one day**: the formula is a measure of the egg productivity of the live hens on any given day -

   No. of egg production
   ------------------------------x 100 = % hen day production for 1 day
   No. of live hens

Example: There are 1000 hens alive on a certain day and they produce 750 eggs that day. Their hen day egg production is 75%.

b) **Hen housed egg production for one day:** The formula is the measure of the egg productivity in relation to the number of hen (housed) at the beginning of the laying period.

   No. of egg produced
   -----------------------------x 100 = % hen housed production for 1 day
   No. of hens housed

Example: 1200 hens were housed at the beginning of the laying year. To-day they laid 750 eggs. Their hen-housed egg production is 62.5%.

c) **Hen -day egg production for a log period-** This may be calculated by first computing the number of hen days in the period by totalling the number of hens alive on each day of the period. Then calculate the number of eggs laid during the same period.

   No. of egg produced
   ------------------------------------x 100 = % hen day egg production for the period
   No. of hen days in the period

d) **Hen housed egg production for a long period**: First compute average number of eggs laid per day during the period - the formula is

   Average daily No. of eggs produced
   ---x 100 = % hen housed egg production for the period
   No. of hens housed

Measures of performance efficiency in broilers

1) **Feed Conversion Ratio**

$$= \frac{\text{Total feed Consumed}}{\text{Total Body weight}}$$

F.C.R. should be always ≤ 2.

***2*) Performance Index**

$$= \frac{\text{Live weight in pounds}}{\text{Feed efficiency}} \times 100$$

3) Benefit Cost Ratio

$$= \frac{\text{Gross Receipts}}{\text{Total cost of Input}}$$

When we get 1 and above is profitable and less than 1 is loss

Artificial Insemination

Definition: It is one of the processes of fertilization. When the insemination is done artificially or with the assistance of human being without the physical involvement of both male and female birds together is called as artificial insemination.

It involves two processes such as Milking/ semen collection and insemination.

1. **Milking:** During the process of milking the male bird is kept and controlled gently under the left shoulder joint of the person who is catching the bird and then the other man / technician helps in massaging the sub-lumber region of the male birds gently by his left hand which helps to protrude the papillae and the semen is ejaculated which is collected in a clean and sterilized funnel (glass/plastic) by the right hand of the technician. Generally the first ejaculation by a single male bird contains 1(one) ml of semen but subsequently it reduces in volume say 0.5ml on even less. So it is better to milk the birds once only. Then immediately the semen is sucked in to a tuberculin syringe.
2. **Insemination:** In this process also there is involvement of two individuals; one person will catch the female bird in his left hand little tightly to both the legs of the birds. Then with the right hand thumb a little pressure is applied in the inguinal region of the female birds gently, so that the female genital tract protrudes outside. While protrusion of the female genital tract it is not to be confused with the cloaca as it remains to right side

and left side is the vagina. About 0.01 to 0.02ml of the total semen quantity already taken into the tuberculin syringe are deposited in to the oviduct of the hen to a depth of 1 to 2’’ (2.5to5.0cm) through the vagina depending in the size of the female birds and their reproductive tract. After that the pressure in the inguinal region is relaxed and the bird is left. This completes the process of insemination. The semen must be fresh and insemination must be repeated at every 5-6 days interval to maintain optimum fertility.

Advantages of Artificial Insemination: It is many folds such as

- Requirement of less no. of males: In natural mating one male is allocated for 7-8 females. But one male can produce enough semen to fertilize 50-70 females on a week basis through artificial insemination.
- Less cost on rearing of male birds.
- Best male birds can be utilized for many females to have good progeny performance.
- Fertility is never a problem & within the control of the persons who are executing the A.I. programme.

Disadvantages of A.I

- Labour consuming
- Time consuming

Precaution

- To be executed late in the evening.
- Fresh semen to be used immediately to avoid spoilage & less fertility.
- While milking the excreta not to be mixed with the semen.

Poultry nutrition and feeding management

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The commercial broilers, layers and breeders are reared under intensive production system. On the contrary, free range system or extensive method is the oldest of all and has been used for centuries. Semi-intensive system is adopted where the area under scavenging is limited. Improved native chickens, guinea fowls and ducks are reared in extensive or semi-intensive system (ICAR, 2013). The number of birds reared under extensive system mainly depends upon the available feed resources, area under scavenging, type of birds, etc.

Nutrients in feed

Energy and protein (amino acids) are two major nutrient components of poultry feed. Energy is required to maintain all biological activities (movement, walking, heartbeat, respiration, panting, etc.), vital processes (consumption, digestion, absorption, transportation, etc.) and chemical reactions occurring in the body for synthesis of proteins, fats, glycogen, eggs, organic molecules, etc (Mandal *et al.,* 2004). It is also deposited in the body in the form of protein as structural component, and fat and glycogen as readymade available source of energy whenever required for vital activities and processes, and chemical reactions. Energy concentration in the diet or its requirement is expressed either as calorie (cal) or joule. One kilocalorie (kcal) is equivalent to 4.184 kilojoules (kj), alternatively one kj is equivalent to 0.239 kcal. Energy requirements are expressed in terms of Metabolizable Energy.

The other important nutrient is protein, which plays an important role in body structural functions, muscle contraction, transportation of nutrients and oxygen, regulating acid-base balance, catalyst in chemical reactions (enzymes), immuno-competence (antibodies), chemical regulation (hormones), blood clotting, dim light vision, growth and production. Growth is a function of protein and energy deposition. Poultry birds require all the 20 amino acids for protein synthesis and other biological functions. Essential amino acids are those that are not synthesized in the animal body at a rate required for normal growth and other production functions, hence must be supplied through diet. These are histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tyrosine and valine. In addition, glycine and proline are also essential for broilers. The limiting amino acids are those essential amino acids which are usually deficient in diet. Methionine (Met) is the first limiting AA in broilers on conventional corn-soya-based diets. Threonine (Thr) is the third limiting AA for broilers and first limiting AA in starting egg-type pullets. The ideal protein concept (Kaur *et al*., 2006, 2007, 2008) may play an integral role in precision protein nutrition to minimize the loss of N and dietary P indirectly by improving growth and production. Formulating diets based on digestible amino acid values is also used, which permits higher dietary inclusion of cheaper, alternative protein sources and decrease nitrogen excretion by the bird.

Feed ingredients

The available feed resources, natural or synthetic, are classified as energy supplements, protein supplements, mineral supplements and vitamin supplements. Energy feedstuffs, constituting about 60-70% of the poultry feed, play an important role in cost effective feed formulation and providing bulk. They are divided into high energy and low energy supplements. Maize, wheat, broken rice, sorghum, fats and oils are high energy supplements. Pearl millet, finger millet and other small millets, rice polish or bran, de-oiled rice bran, wheat bran, molasses, tapioca flour, etc. are low energy supplements. Maize is the commonly used energy feedstuff in poultry feed but other ingredients, if available at cheaper rate, can be used to replace it partially or even completely.

Protein supplements are divided into vegetable and animal protein supplements. The former group includes cakes and meals of different seeds like groundnut, soybean, rapeseed, mustard, cottonseed, sunflower, safflower, sesame and cluster bean. Roasted full-fat soybean meal is also very good source of protein and fat, especially for broilers. Maize gluten, rice gluten, dried distillery grains with soluble (DDGS) etc. are also very good sources of protein. Animal protein supplements include fish meal, meat-cum-bone meal, meat meal, blood meal and poultry byproduct meal. These supplements, especially meat-cum-bone meal, meat meal and fish meal provide better quality protein than the blood meal. But caution is needed to procure good quality protein meals and utilizing them following their safe inclusion level. Synthetic amino acid supplements (L-lysine hydrochloride, DL-methionine, L-threonine, L-tryptophan) are also available in the market.

Minerals are supplemented either through a ready-made mineral mixture or through specific mineral supplements. Mineral mixture is available commercially or can be compounded. Specific mineral supplements are also added. In this case, calcium carbonate/oyster shell/ cheap marble are used as sources of calcium, and dicalcium phosphate or monocalcium phosphate as source of calcium and available phosphorus. Common salt is added as source of sodium and chlorine. Trace minerals (Cu, Zn, Fe, Mn, Se, I and sometimes

Cr) are added in the form of premix (trace mineral premix). Organic sources of trace minerals are available commercially, which may have better bioavailability.

Vitamins are supplemented either through premixes or through individual vitamins. Two types of vitamin premixes are available in the market. One premix supplies vitamins A, D_3, and K and riboflavin (B_2). The inclusion rate is 5.0 to 15 g /q depending upon concentration. The other premix supplies water-soluble vitamins including members of B-complex, vitamin E and sometimes vitamin C. The rate of inclusion is 7.5-25 g/q of feed depending upon concentration of different vitamins. In addition, choline chloride (100, 60 or 50% premix) is also available in the market.

Feed Additives

Besides nutrients, present day's poultry are also fed several other compounds aimed at preventing/minimizing the infectious agents' loads, preventing mycotoxins, augmenting nutrient digestibility etc. Antibiotic compounds have been employed as feed additive in low concentrations throughout the world for nearly 50 years to promote growth and feed conversion efficiency in broilers, and to increase egg production in layers. Probiotics (live bacterial and yeast strains), certain non-digestive feed components (prebiotics) like galacto-oligo-saccharides, fructo-oligo-saccharides, mannan-oligo-saccharides and lactose derivatives have all been tried in chickens, rabbits and other monogastric animals to combat colonization of pathogens (*Salmonella* spp., *Escherichia coli, Vibrio cholera*, *S. typhimurium, S. enteridis* etc.).

Enzymes for improving nutrient utilization have become very popular in the nutrition of monogastrics like chickens. Non-starch polysaccharidases such as cellulases, pectinases, hemicellulases, arabinoxylanases and beta glucanases are used for releasing nutrients trapped in high fibrous diets. Supplementation of diet with microbial phytase increases availability of phytate-bound phosphorus, calcium, zinc, copper, crude protein and amino acids.

Addition of suitable coccidiostat in diets protects growing poultry birds (below 12 weeks of age) from coccidiosis. Similarly, use of different toxin binders or adsorbents (activated charcoal, bentonites, zeolites, diatomaceous earth, mannanoligo-saccharides, live yeast, etc.) reduce the adverse effects of mycotoxins. Oflate other compounds viz., antioxidants, liver tonics, immunostimulants etc. have also become a regular component of poultry feed.

Nutrient Requirements

The requirements of chickens have been optimized and published (NRC, 1994, BIS 1992 etc.). Use of NRC standards under Indian conditions may not be appropriate as the requirements differ due to several factors such as management practices, genetic makeup, environmental temperature, metabolic and behavioral characteristics, feedstuff qualities and dietary variables. The available requirements are very old and present day's poultry are fed mostly based on company's recommendations. Very recently ICAR has come out with the latest nutrient requirements for poultry (ICAR, 2013).

Daily requirements for different nutrients during starter (0-3 weeks) and finisher (4- 6 or 7 weeks) periods of broiler as a function of metabolic body size and daily body weight gain are given in different equations. The requirement of other amino acids can be calculated as proportion of Lys requirement, i.e. for Arg 110-114, Ile 73, Leu 109, Val 82, Phe 65, His 32 and Trp 18%. Requirement of digestible amino acid is calculated based on the digestibility coefficients, i.e. for Lys 0.90, Met 0.90, Thr 0.84, Arg 00.92, Ile 0.88 Leu 0.93, Val 0.87, Phe 0.89, His 0.88 and Trp 0.91%. The regression values and practical experiences in commercial practice are the basis for prescribing the nutrient requirements during pre-starter phase.

Layer type replacement pullets are generally reared in three phases viz. starter (0-8 weeks of age), grower (8-20 weeks of age) and layer (20 weeks or above). For meeting the nutrient requirement, particularly that of calcium at onset of lay, pre-lay phase (17/18 – 20 weeks) is recommended. Similarly, the laying phase is often divided into phase I (20-30 weeks) and phase II (>30 weeks).

On an average one laying hen showing 90% egg production requires 16-18 g of protein and 285 to 290 kcal ME per day. Meeting calcium requirement is important during overall growth (0.9 to 0.7%), but most crucial during laying phase. Just prior to initiation of egg production, huge amount of calcium is stored in bones, which is sufficient for 6 to 30 eggs. Therefore, calcium concentration is increased to about 2% of diet a week before onset of egg production. White Leghorn hens producing 90% eggs require daily about 3.8 to 4.2 g of calcium.

Feed Formulation

Feed formulation is a mathematical calculation to prepare a balanced ration. Though it is an art, but use of skill and scientific knowledge on nutrition principles, dietary variables, nutrient and dietary interactions, etc. make the formulation effective to exploit maximum performance. Birds are maintained at a low cost without exerting much stress. The important points considered during feed formulation are requirement of nutrients for poultry or composition of a formula in terms of nutrients, analytical nutrient composition of various feed ingredients, maximum effective/ safe levels of inclusion of feed ingredients, availability, wholesomeness and cost of feed ingredients.

Requirement of nutrients: Based on the nutritional research studies, the essential nutrients (energy, protein, amino acids, minerals and vitamins) required for different classes of birds have been given. Though a big list of nutrients is available, the attributes that need consideration are metabolizable energy, protein and amino acids (lysine, methionine, methionine + cysteine, threonine, arginine, phenylalanine), calcium, available P, electrolyte balance (sodium, potassium, chlorine), zinc, manganese, iron, copper, selenium, vitamin A, vitamin D3, vitamin E, riboflavin and other water soluble vitamins.

Feed composition values: The most efficient way to furnish nutrients to the birds is to analyze the feed ingredients for various nutrients. However, under practical conditions it becomes difficult to analyze all the ingredients for desirable nutrients, though it is a must to ensure feed quality. The average nutrient content of the feed ingredients based on the analyses done previously is available in the form of published feed composition tables. These can be used very cautiously using knowledge on nutrition.

Maximum level of inclusion of feed ingredients: There is a need to utilize locally available feed ingredients in the least cost efficient feed mix. However, most of the feedstuffs in their native state harbour one or more of the anti-nutritive substance(s). Inclusion of an ingredient beyond its maximum level may induce imbalance of nutrients, and reduce the palatability of the diet and performance of the birds. Birds are rendered ill due to the presence of anti-nutritional factors beyond tolerance level.

Availability and cost of feed ingredients: The knowledge on the availability and cost of feed ingredients in the local market is a prerequisite for formulating feed. The quality and cost of feed ingredients vary widely, and need consideration. The cost of ingredients based on nutrient density (energy and protein) should get priority over mere cost of ingredients when choosing the ingredients for formulation.

Ideas for hot climate feed formulation

The most important aspects in feed formulation under hot climate conditions are:

- To support daily feed intake
- To limit the heat increment using fat and oil
- To use special supplements

An important aspect in the composition of feed for poultry in heat stress conditions is to limit the heat increment of feeding. This is the increased heat production following consumption and digestion of feed. The different major nutrients cause different quantities of metabolic heat production. The highest increment is caused by the digestion of crude protein, especially if it is used as a source of energy. Crude protein should be adjusted as low as possible, based on the usage of synthetic amino acids and a formulation procedure which is known as the generic term Ideal amino acid nutrition. This tool makes it possible to reduce crude protein in the diet without harming production and in addition, it helps to reduce feeding costs. The digestion of carbohydrates, which is mainly starch, causes a relatively high heat increment as well. It can be limited to some extent by using fat and oil as a source of energy in poultry diets. On an average, fat and oil have three times energy content as in cereals and cause much lesser metabolic heat increment.

The benefits of adding extra fat and oil to the diet can be summarized as follows:

- Increased content of metabolizable energy
- Due to the fatty acid profile (linoleic acid), adjustment of egg weight
- Improved liver health
- Improved palatability of (dusty) mash feed

Vitamin C is considered as one of the most important supplements under heat stress conditions. Normally, birds synthesize sufficient vitamin C, but due to heat stress and severe panting, the balance of electrolytes is affected. Negative effects can be reduced with higher levels of vitamin C. In addition, it will support egg shell quality. The recommended dosage is 100 – 200 mg/kg. With the same target in mind, the use of sodium bicarbonates should be kept as a standard. Sodium bicarbonate or sodium carbonate, should be applied as a standard supplement to achieve a ration of sodium to chloride by 1:1. This is highly beneficial not only for a good egg shell, but also when a higher level of sodium has to be achieved as a result of low daily feed intake.

Vitamin E, which also serves as a natural antioxidant in addition to its nutritional value, should be increased to at least 50 mg/ kg. For breeders, a level of 100 mg/kg has been proven to support hatchability and chick quality. Supplements which will increase the nutritional value of all raw materials are the Non-Starch-Polysaccharide – Enzymes and Phytase. They increase the biological nutritional value of the raw materials which will support nutrient intake under heat stress and/or make it possible to decrease nutrient density of the diet without harming the production.

Feed is the major input (65 to 80%) and feed-cost is the major constraint but is a major mean for manipulating production cost and making enterprise profitable. A sizable quantity of cereals and edible oilseed meals are used in livestock and poultry ration, and thus both livestock and poultry compete with the human beings directly. India's population is also growing (1.58%). Globalization and economic integration are perceived in terms of opening up of economics, liberal movement of goods and services and factors of production. Impact of globalization on livestock and poultry industry has increased the competitiveness for marketing the products in world as well as domestic market. Availability of feed resources could be one of the major constraints in livestock and poultry production in future as the opportunity for the area expansion for cultivation has almost exhausted. Therefore, the more careful approaches to sustain the poultry sector in the competitive market should be the reduction of cost of production, production of safe and quality products to meet the consumers' demands and also to ensure the animal welfare to satisfy consumers. Again production of foodstuffs and thus feedstuffs fluctuates greatly due to frequent monsoon failure, low productivity, insects, weeds, environmental concerns, cost efficiency, sustainability, declining area under cultivation, etc. The farmers are also being encouraged for diversion towards production of cash and commodity crops. The trend for production of food grains is decreasing in recent years. Therefore, the search for newer feeds is urgent need to meet the challenges. However, some of the identified alternate feeds are prone to be a promising for supplementing in the poultry diets, but they also contain some inherent incriminating factors limits their use in poultry diet.

Factors limiting the use of alternative feed ingredients in poultry feed formulations

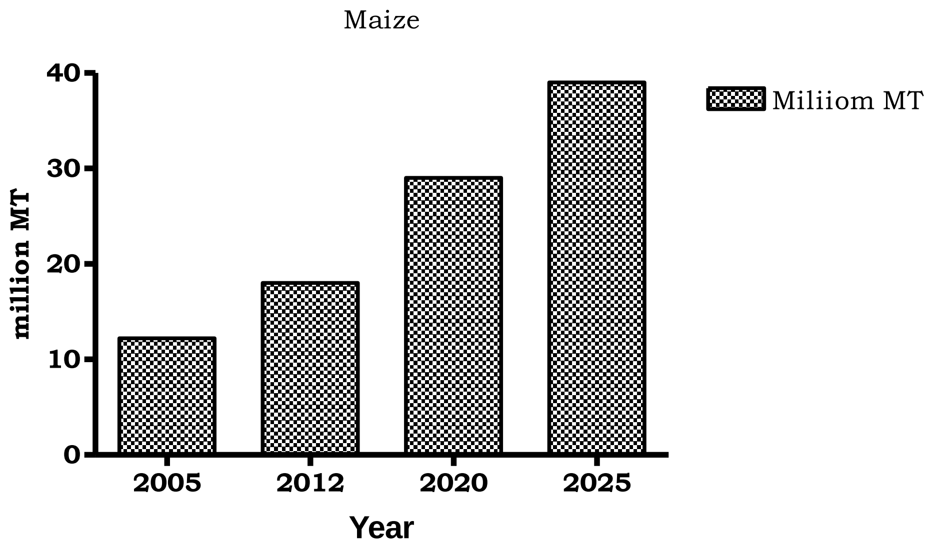
Nutritional aspects	• Lack of consistency in nutrient quality • Limited information on the availability of nutrients • High fibre content • Presence of anti-nutritional factor • Need for nutrient supplementation (added cost)
Technical aspects	• Seasonal and unreliable supply • Bulkiness, physical characteristics • Need for de-hulling and/or processing (drying, detoxification) • Limited research and development facilities for determining nutrient composition and inclusion levels in poultry diets.

Socio-economic aspects	• Competition with use as human food • Poor prices relative to other arable crops (farmer) • Cost per unit of energy or limiting amino acids, relative to traditional feedstuffs (feed manufacturer) • Cost of processing

Poultry Development Review; Poultry feed availability and nutrition in developing countries, FAO Publication.

In India, the growth rate of agriculture has declined from 3.37% per annum in 1980s to 1.74% per annum since 1990 and food grains production has been lower than population growth for the last four decades. (Basu and Das, 2012). The annual growth in agriculture in the country was hardly 1% against the growth in human population 1.5% apart from increased demand of feed ingredients 8 to 12% for poultry sector.

Projected requirement of Maize at 6% average growth in broilers and layers



The average increase in commodity availability has been 4.33% per annum during 2001-2012, which is far below the growth rate of egg, meat or milk production. Moreover, there is diversion of maize for starch and distilleries. Therefore, only two options are left with either to increase maize production drastically by increasing yield or area under production or to utilize other cereals and cereal by-products as alternate to maize.

Alternative energy sources that can replace maize in poultry diets

Feeds	**Comments**
Cereals	
Wheat	Can be used when cost-competitive Limitation: high non-starch polysaccharide contents result in intestinal digesta viscosity problems; can be used without restriction when xogenous carbohydrases are added
Sorghum	Limitation: tannins lower protein and energy digestibility; low-tannin sorghum can completely replace maize
Millets	Can replace 50–65% of maize, depending on millet type Limitations: high fibre contents, presence of tannins
Cereal milling co-products	
Rice bran/polishing/ Wheat bran	Limitations: high fibre, phytic acid, rancidity; good-quality material can be used at levels of 5–10% in broiler diets and up to 40% in layer diets
Roots and tubers	
Cassava root meal	High in starch, excellent energy source Limitations: low protein, powdery texture, needs detoxification to remove the cyanogenic glucosides; can be used at levels of 30–40% in nutritionally balanced, pelleted diets
Cassava peel meal	Limitations: high fibre, very high levels of cyanogenic glucosides, needs processing; carefully prepared meal may be used at 5% level
Sweet potato tuber meal	High in starch, good energy source Limitation: powdery texture; can be used at levels up to 50% in nutritionally balanced, pelleted diets
Fruits and fruit co-products	
Banana and plantain meal	Limitation: low palatability due to tannins in the peel; removal of peels improves nutritive value; inclusion must be limited to 10–20%
Breadfruit meal	Good energy source; can be included at up to 30%
Jack seed meal	Limitations: lectins in raw seeds, needs processing; processed meal can be included at up to 30%
Mango seed kernel meal	Limitation: high levels of tannins; processed meal can be used at levels of 5–10%

Poultry Development Review; Poultry feed availability and nutrition in developing countries, FAO Publication.

Methods of feed formulation

Algebric equation : is used commonly when two mixtures are to be combined for arriving at required nutrient concentration. Popular example is with the cereal and protein concentrates.

Pearson square : A simple procedure originally devised to blend milk products to a known fat percentage, and can be used for diet formulation too.

Hit and trial method: This has been the traditional way of feed formulation and still widely used by professionals. The amount of feed ingredients is changed so as to arrive at required nutrient levels in the feed. For this, the ingredients are arbitrarily altered and the nutrient concentration is calculated, which is continued till the desired nutrient level is achieved. The computer applications like MS Excel can be effectively used for quickly formulating the feeds using this method.

Least cost formulation: Is a feed formula that is both nutritionally-complete (within limits) and with a minimum ingredient cost (within limits). It is now-a-days developed and completed through the use of computers using linear-programming software. There are numerous computer software developed on the linear programming for formulating least cost rations, which are widely used by most feed mills/manufacturers. Some of the popular software include Ecomix, Winfeed, Myfeed, FeedMu, Feedsoft, Autofeed, Optimix etc.

Least cost Poultry feed formulation

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The basic purpose of feed formulation is to prepare a balanced feed which support optimum performance in terms of either meat or egg production. A balanced ration is one which supplies all the nutrients in proper quantity and proportion that are needed support optimum growth, egg production and health. Poultry feed is primarily a mixture of several feedstuffs such as cereals, vegetable and animal protein supplements, vitamins, mineral mixtures and feed additives. These feedstuffs together with water provide the energy and nutrients that are essential for the birds growth, reproduction and health namely protein and amino acids, carbohydrates, fats, minerals and vitamins. The commercial broilers, layers and breeders are reared under intensive production system. On the other hand, the oldest of all and longest in use is the free range system, often known as the extensive approach. Where there is little space available for scavenging, a semi-intensive method of rearing is adopted. Improved native poultry is raised in an extensive or semi-intensive system, including chickens, guinea hens, and ducks (ICAR, 2013). The amount of birds raised in an extensive system mostly depends on the feed resources that are accessible, the area used for scavenging, the species of birds, etc.

FEED FORMULATION

Feed formulation requires scientific knowledge and skill in implementing nutrition principles, dietary variables, nutrient and dietary interactions, etc to get maximum performance. It involves mathematical calculations. Birds are maintained at a low cost without exerting much stress. The important points considered during feed formulation are requirement of nutrients for poultry or composition of a formula in terms of nutrients, analytical nutrient composition of various feed ingredients, maximum effective/ safe levels of inclusion of feed ingredients, availability, wholesomeness and cost of feed ingredients. Nature and type of feed prepared, physical condition of ingredients , average daily feed consumption , interaction of different nutrients, environmental temperature and cost of final product 1i.e also should taken into account for formulation of feed.

A. Nutrient requirements:

Based on the nutritional research studies, the essential nutrients (energy, protein, amino acids, minerals and vitamins) required for different classes of birds have been given. Though a big list of nutrients is available, the attributes that need consideration are metabolizable energy, protein and amino acids (lysine, methionine, methionine + cysteine, threonine, arginine, phenylalanine), calcium, available P, electrolyte balance (sodium, potassium, chlorine), zinc, manganese, iron, copper, selenium, vitamin A, vitamin D3, vitamin E, riboflavin and other water soluble vitamins. The requirements of chickens have been optimized and published (NRC, 1994, BIS 1992 etc.). Use of NRC standards under Indian conditions may not be appropriate as the requirements differ due to several factors such as management practices, genetic makeup, environmental temperature, metabolic and behavioral characteristics, feedstuff qualities and dietary variables. The available requirements are very old and present day's poultry are fed mostly based on company's recommendations. Very recently ICAR has come out with the latest nutrient requirements for poultry (ICAR, 2013).

Broilers: Daily requirements for different nutrients during starter (0-3 weeks) and finisher (4- 6 or 7 weeks) periods of broiler as a function of metabolic body size and daily body weight gain are given in different equations. The requirement of other amino acids can be calculated as proportion of Lys requirement, i.e. for Arg 110-114, Ile 73, Leu 109, Val 82, Phe 65, His 32 and Trp 18%. Requirement of digestible amino acid is calculated based on the digestibility coefficients, i.e. for Lys 0.90, Met 0.90, Thr 0.84, Arg 00.92, Ile 0.88 Leu 0.93, Val 0.87, Phe 0.89, His 0.88 and Trp 0.91%. The regression values and practical experiences in commercial practice are the basis for prescribing the nutrient requirements during pre-starter phase.

Layers: Layer type replacement pullets are generally reared in three phases viz. starter (0-8 weeks of age), grower (8-20 weeks of age) and layer (20 weeks or above). For meeting the nutrient requirement, particularly that of calcium at onset of lay, pre-lay phase (17/18 – 20 weeks) is recommended. Similarly, the laying phase is often divided into phase I (20-30 weeks) and phase II (>30 weeks). On an average one laying hen showing 90% egg production requires 16-18 g of protein and 285 to 290 kcal ME per day. Meeting calcium requirement is important during overall growth (0.9 to 0.7%), but most crucial during laying phase. Just prior to initiation of egg production, huge amount of calcium is stored in bones, which is sufficient for 6 to 30 eggs. Therefore, calcium concentration is increased to about 2% of diet a week before onset of egg production. White Leghorn hens producing 90% eggs require daily about 3.8 to 4.2 g of calcium.

B. Feed composition values:

The most efficient way to furnish nutrients to the birds is to analyze the feed ingredients for various nutrients. However, under practical conditions it becomes difficult to analyze all the ingredients for desirable nutrients, though it is a must to ensure feed quality. The average nutrient content of the feed ingredients based on the analyses done previously is available in the form of published feed composition tables. These can be used very cautiously using knowledge on nutrition.

The available feed resources, natural or synthetic, are classified as energy supplements, protein supplements, mineral supplements and vitamin supplements. Energy feedstuffs, constituting about 60-70% of the poultry feed, play an important role in cost effective feed formulation and providing bulk. They are divided into high energy and low energy supplements. Maize, wheat, broken rice, sorghum, fats and oils are high energy supplements. Pearl millet, finger millet and other small millets, rice polish or bran, de-oiled rice bran, wheat bran, molasses, tapioca flour, etc. are low energy supplements. Maize is the commonly used energy feedstuff in poultry feed but other ingredients, if available at cheaper rate, can be used to replace it partially or even completely.

Protein supplements are divided into vegetable and animal protein supplements. The former group includes cakes and meals of different seeds like groundnut, soybean, rapeseed, mustard, cottonseed, sunflower, safflower, sesame and cluster bean. Roasted full-fat soybean meal is also very good source of protein and fat, especially for broilers. Maize gluten, rice gluten, dried distillery grains with soluble (DDGS) etc. are also very good sources of protein. Animal protein supplements include fish meal, meat-cum-bone meal, meat meal, blood meal and poultry byproduct meal. These supplements, especially meat-cum-bone meal, meat meal and fish meal provide better quality protein than the blood meal. But caution is needed to procure good quality protein meals and utilizing them following their safe inclusion level. Synthetic amino acid supplements (L-lysine hydrochloride, DL-methionine, L-threonine, L-tryptophan) are also available in the market.

Minerals are supplemented either through a ready-made mineral mixture or through specific mineral supplements. Mineral mixture is available commercially or can be compounded. Specific mineral supplements are also added. In this case, calcium carbonate/oyster shell/ cheap marble are used as sources of calcium, and dicalcium phosphate or monocalcium phosphate as source of calcium and available phosphorus. Common salt is added as source of sodium and chlorine. Trace minerals (Cu, Zn, Fe, Mn, Se, I and sometimes

Cr) are added in the form of premix (trace mineral premix). Organic sources of trace minerals are available commercially, which may have better bioavailability.

Vitamins are supplemented either through premixes or through individual vitamins. Two types of vitamin premixes are available in the market. One premix supplies vitamins A, D_3, and K and riboflavin (B_2). The inclusion rate is 5.0 to 15 g /q depending upon concentration. The other premix supplies water-soluble vitamins including members of B-complex, vitamin E and sometimes vitamin C. The rate of inclusion is 7.5-25 g/q of feed depending upon concentration of different vitamins. In addition, choline chloride (100, 60 or 50% premix) is also available in the market.

Besides nutrients, present day's poultry are also fed several other compounds aimed at preventing/minimizing the infectious agents' loads, preventing mycotoxins, augmenting nutrient digestibility etc. Antibiotic compounds have been employed as feed additive in low concentrations throughout the world for nearly 50 years to promote growth and feed conversion efficiency in broilers, and to increase egg production in layers. Probiotics (live bacterial and yeast strains), certain non-digestive feed components (prebiotics) like galacto-oligo-saccharides, fructo-oligo-saccharides, mannan-oligo-saccharides and lactose derivatives have all been tried in chickens, rabbits and other monogastric animals to combat colonization of pathogens (*Salmonella* spp., *Escherichia coli, Vibrio cholera*, *S. typhimurium, S. enteridis* etc.).

Enzymes for improving nutrient utilization have become very popular in the nutrition of monogastrics like chickens. Non-starch polysaccharidases such as cellulases, pectinases, hemicellulases, arabinoxylanases and beta glucanases are used for releasing nutrients trapped in high fibrous diets. Supplementation of diet with microbial phytase increases availability of phytate-bound phosphorus, calcium, zinc, copper, crude protein and amino acids.

Addition of suitable coccidiostat in diets protects growing poultry birds (below 12 weeks of age) from coccidiosis. Similarly, use of different toxin binders or adsorbents (activated charcoal, bentonites, zeolites, diatomaceous earth, mannanoligo-saccharides, live yeast, etc.) reduce the adverse effects of mycotoxins. Oflate other compounds viz., antioxidants, liver tonics, immunostimulants etc. have also become a regular component of poultry feed.

C. Maximum level of inclusion of feed ingredients: There is a need to utilize locally available feed ingredients in the least cost efficient feed mix. However, most of the feedstuffs in their native state harbour one or more of the anti-nutritive substance(s). Inclusion of an ingredient beyond its maximum level may induce imbalance of nutrients, and reduce the palatability of the diet and performance of the birds. Birds are rendered ill due to the presence of anti-nutritional factors beyond tolerance level.

D. Availability and cost of feed ingredients:

The knowledge on the availability and cost of feed ingredients in the local market is a prerequisite for formulating feed. The quality and cost of feed ingredients vary widely, and need consideration. The cost of ingredients based on nutrient density (energy and protein) should get priority over mere cost of ingredients when choosing the ingredients for formulation.

METHODS OF FEED FORMULATION

Several methods are available for formulating feed. These are

By hand calculation: It is possible to prepare simple diet by hand. The fewer nutrients such as metabolisable energy, crude protein, calcium phosphorus and amino acids are taken into consideration. Only limited feedstuffs can be used and it is a long and tedious process. For a commercial diet with more than ten feed ingredients and more than ten nutrient to take into consideration , the possible number of combination is difficult to manage by hand calculation.

Algebric equation: is used commonly when two mixtures are to be combined for arriving at required nutrient concentration. Popular example is with the cereal and protein concentrates.

Pearson square : A simple procedure originally devised to blend milk products to a known fat percentage, and can be used for diet formulation too. It is a simple, direct and easy method. It permits quick substitution of ingredients without disturbing one nutrient. It is a method of balancing protein requirement without consideration given to mineral, vitamin and other nutrient requirement. This m,ethod cannot be used for least cost feed formulation.

Hit and trial method : This has been the traditional way of feed formulation and still widely used by professionals. The amount of feed ingredients is changed so as to arrive at required nutrient levels in the feed. For this, the ingredients are arbitrarily altered and the nutrient concentration is calculated, which is continued till the desired nutrient level is achieved. The computer applications like MS Excel can be effectively used for quickly formulating the feeds using this method.

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Feed for poultry may be given in the form of mash, pellets or crumbles.

Mash feeding is more popular for feeding commercial chicken. On small farms wet mash feeding is practiced in summer to increase intake, palatability and reduce dustiness. However wet mash feeding requires cleaning of feeders every day otherwise prone to mold growth .

Pellet feeds are prepared when mash feed is subjected to temperature and steam and forced to pass through a die made up of holes. Nowadays pellets have become popular for feeding commercial chicken. Higher palatability, increased feed intake, destruction of harmful microbes, increased digestibility, uniformity reduce wastage of feed make this pellet feed popular among poultry farmers.

Crumbs or crumbles are given to chicks upto 3 weeks of age or for layers. Pellet feeds are crushed and crumbled into smaller particles to make crumble feed.

Common poultry diseases and their diagnosis and control

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Newcastle Disease (ND)

Newcastle disease is a highly contagious disease caused by avian paramyxovirus of serotype 1 (APMV-1) belonging to the family of Paramyxoviridae. It affects wild birds and domestic poultry and usually presents as a respiratory disease. Depression, nervous manifestations, or diarrhea may also be the predominant clinical symptoms and mortality.

Newcastle Disease symptoms can be respiratory, nervous, intestinal symptoms for both clinical and subclinical infections. ND can be classified into five different categories:

1. Viscerotropic velogenic, a highly pathogenic form in which hemorrhagic intestinal lesions are frequently seen.
2. Neurotropic velogenic, a form that presents with high mortality, usually following respiratory and nervous signs.
3. Mesogenic, a form that presents with respiratory signs, occasional nervous signs, but low mortality.
4. Lentogenic or respiratory, a form that presents with mild or subclinical respiratory infection.
5. Asymptomatic: a form that usually consists of a subclinical enteric infection.

With velogenic viruses, the disease may appear suddenly, with high mortality occurring in the absence of any other clinical signs. In other cases, clinical signs often begin with listlessness, increased respiration and weakness, diarrhea, ending with prostration and death. In cases involving the neurotropic velogenic isolates, neurological signs such as torticollis or colonic movements of the head or the legs, are commonly observed a few days after infection has started. A dramatic drop in egg production can be seen in layers and breeders. Morbidity rate may reach 100%. The clinical signs induced by isolates classified as mesogenic are usually limited to respiratory signs and drop in egg production in laying hens. Nervous signs may occur but are not common. Mortality rate is generally low. Finally, lentogenic strains do not usually cause disease in adults, but in young, fully susceptible birds, respiratory problems can be observed. Such reactions can be complicated by infections with other pathogens. Apathogenic strains induce no clinical sign (asymptomatic form). Likewise, for clinical signs, the extent and location of the gross lesions depend on the virus strain, the host conditions and all those aforementioned factors affecting the severity of the disease. Additionally, there are no pathognomonic lesions associated to ND.

In the respiratory tract, mucosal hemorrhages, marked congestion of the trachea and airsacculitis may be observed. Hemorrhagic lesions in the digestive tract particularly in the mucosa of the proventriculus, caeca, small intestine and lymphoid tissues such as caecal tonsils and Peyer's patches are commonly seen. In laying hens, egg yolk in the abdominal cavity and flaccid and degenerative ovarian follicles are often found. Finally, even with chickens showing nervous signs, gross lesions are not observed in the central nervous system.

Infectious bursal disease (IBD)

Infectious bursal disease is a highly contagious disease of young chickens caused by a Birnavirus of serotype 1. Virus strains can be divided in classical and variant strains. The virus is very stable and is difficult to eradicate from an infected farm. IBD virus is very infectious and spreads easily from bird to bird by way of droppings. Infected clothing and equipment are means of transmission between farms. Chickens and turkeys appear to be natural hosts.

Clinical IBD occurs usually between 3 and 8 weeks of age depending on maternal antibody levels. Affected birds are listless and depressed, pale, huddling producing watery white diarrhea. Mortality varies. Usually new cases of IBD have a mortality rate of about 5 to10% but can be as high as 60% depending on the pathogenicity of the strain involved. Highly pathogenic strains are called "very virulent" IBD (vvIBD) resulting in high mortality. Subclinical IBD occurs with infections before 3 weeks of age. Early IBD infection result in permanent immunosuppression without mortality. Immunosuppression is economically important due to increased susceptibility to secondary infections especially in the respiratory tract. Gumboro disease related diseases such as inclusion body hepatitis are also more frequent in these birds. In broilers this form of the disease results in bad performance with lower weight gains and higher feed conversion ratios.

Typical clinical signs and post mortem lesions are found after IBD infection. Post mortem lesions; in acute cases the bursa of Fabricius is enlarged and gelatinous, sometimes even bloody. Muscle haemorrhages and pale kidneys can be seen. Infection by variant strains is usually accompanied by a fast bursal atrophy (in 24-48 hours) without the typical signs of Gumboro disease. Also in chronic cases the bursa is smaller than normal (atrophy). The bursa destruction is apparent on histologic examination. The lack of white blood cells (lymphocytes) results in a reduction in the development of immunity and decreased resistance of the birds to other infections. Histopathological examination, serology, virus isolation and PCR are confirming tools. IBD can be confused with sulfonamide poisoning, aflatoxicosis, and pale bird syndrome (Vitamin E deficiency).

No treatment is available for IBD. Vaccination of breeders and young chicks is the best means of control. The induction of a high maternal immunity in the progeny of vaccinated breeders, together with the vaccination of the offspring is the most effective approach to successful IBD control. A variety of live and inactivated vaccines have been developed to enhance the control of classical, variant and vvIBD challenges. Recently, immunocomplex vaccines and a new generation of recombinant vector vaccines based on HVT-vector carrying an insert of the VP2 part of the IBD-virus are available for the control of IBD.

Infectious bronchitis (IB)

IB is probably one of the most widespread poultry diseases around the world, due to its highly contagious nature. It is caused by a gamma coronavirus that affects the respiratory, urinary and reproductive systems of the chickens, causing different disorders depending on the tissue tropism characteristics of the invading viral strain. An additional issue is the high mutation rate and recombination ability of the IB virus. Diseased chickens are the source of infection, spreading IB virus (IBV) by the aerogenous route, as well as some spread via feed and water.

The incubation period of IBV is short and dose-dependent; it may be less than 18 hours when the virus is inoculated intratracheally or 36 hours after ocular application. In chickens up to the age of 4 weeks, IB manifests itself in the form of severe respiratory signs (sneezing, coughing, and rales). Rhinitis and conjunctivitis, depression and crowding around heat sources are observed. The morbidity rate may reach 100%. The mortality in young chickens is usually insignificant unless a secondary infection with a different agent occurs. In such cases, there is a moderate to severe inflammatory cell infiltration of upper respiratory tract mucosa, resulting in thickened and more compact mucosa.

In one-day old chickens, IB infection can permanently damage the oviduct, influencing egg production and egg quality during the production period. In layer hens infected with the IB virus, oophoritis and dystrophic necrobiotic lesions affecting primarily the middle and the final third of oviduct’s mucosa lining are observed. The oviduct is atrophied, cystic, with deposits of yolks or completely formed eggs in the abdominal cavity (the so-called internal layer). The consequences are drop in egg production, appearance and increase in the number of deformed and pigmentless eggs or eggs with soft shells and watery albumens.

The nephropathogenic effect of IBV infection is usually manifested in young chicks and reproductive tract lesions after egg laying begins. The severity of IB-related respiratory infection is complicated by secondary bacterial or viral pathogens, i.e. E. coli, Mycoplasma gallisepticum, Newcastle disease virus etc. resulting in chronic airsacculitis and pneumonia.

The vaccination used at poultry farms will develop the active immunisation against IBV. Live vaccines are generally attenuated, prepared from vaccinal strains selected according to the antigenic spectrum of regional isolates. It is also important to determine the potential for cross protection, mainly applicable for live vaccines. Inactivated oil-adjuvant vaccines against IB are applied as booster vaccines to protect layers and breeder flocks; usually these are available as polyvalent vaccines that also include ND, IBD and/or other vaccinal strains.

Marek's Disease (MD)

Marek's disease is caused by a alphaherpesvirus. The disease is highly contagious. Main transmission is by infected premises, where day-old chicks will become infected by the oral and respiratory routes. Dander from feather follicles of MD-infected chickens can remain infectious for more than a year. Young chicks are particularly susceptible to horizontal transmission. Susceptibility decreases rapidly after the first few days of age. Species affected include chickens, also quail, turkeys and pheasants are susceptible.

Clinically, infected birds show weight loss, or may exhibit some form of paralysis. The classical form: neurolymphomatosis (paralysis) with leg nerve involvement causes a bird to lie on its side with one leg stretched forward and the other backward. When the gizzard nerve is involved, the birds will have a very small gizzard and intestines and will waste away. Acute Marek's disease is an epidemic in susceptible or unvaccinated flocks causing depression paralysis, mortality and lymphomatous infiltrations/tumors in multiple organs. Subclinical infections result in impaired immune responses as MDV causes a lytic infection in lymphocytes. Mortality usually occurs between 10 and 20 weeks of age and can reach up to 50% in unvaccinated flocks

The presence of tumors in liver, spleen, kidneys, lungs, ovary, muscles, or other tissues is indicative of MD, but they can also be indicative of lymphoid leucosis. However, nerve involvement, either grossly (swelling of leg, wing or other nerves) or microscopically, is typical of MD. Eye involvement can be visible as an irregular constriction of the iris (ocular lymphomatosis). Skin involvement often consists of tumors of feather follicles or in between follicles it is a reason for broiler condemnation in certain parts of the world. A proper diagnosis to differentiate MD from LL requires histological examination. Microscopically, the lymphomas are characterized by a mixture of pleomorphic lymphocytes. The paralysis is caused by lesions and enlargements of the affected nerves. Virus isolation or PCR from buffy coat (fresh blood samples) and/or affected organs can confirm the infection

There is no effective treatment for affected flocks. Vaccination is an effective means of control. It has been demonstrated that MD vaccine only prevents the appearance of Marek's disease tumors and paralysis. It does not prevent the birds from becoming infected with MD-virus. It is therefore of major importance to maintain high hygienic and sanitary measures by good management to avoid early exposure of young chickens. Multiple age farms are big risk to Marek's disease. Vaccination against Marek's disease is performed in the hatchery; there are two routes of application; In-ovo injection into the18 days embryonated eggs or injection in day-old chickens. Most used vaccines are the Rispens (serotype-1), SB1 (serotype-2) and HVT vaccine strains (serotype-3). The choice on the strains for MD vaccination will depend on the virulence of the strains present in the field. In India, serotype 1 vaccines are not permitted, only Serotype 2 and Serotype 3 vaccines are allowed to control MD.

Chicken Infectious Anemia

Chicken infectious anemia (CIA) is a disease of young chickens characterized by aplastic anemia, generalized lymphoid atrophy, subcutaneous and intramuscular hemorrhage, and immunodepression. CIA is caused by Chicken Anemia Virus (CAV) classified into genus Gyrovirus of the family Circoviridae. CAV is non-enveloped and are environmentally very resistant. All ages are susceptible to infection but clinical disease is typically seen only during the first 2 to 8 weeks. The virus is spread both vertically and horizontally. The most important method of transmission is vertical from infected hens. Antibody-negative chicks are most susceptible to clinical disease. CAV also easily spreads via feces among birds in a population.

The only specific sign of CAV infection is anemia characterized by hematocrit values ranging from 6 to 27% (normal hematocrit values are generally 29-35%). Nonspecific clinical signs include depression, pale tissues, depressed weight gain, and secondary bacterial, mycotic, and viral infections. Morbidity and mortality rates depend on various viral, host and environmental factors and concurrent infection with other agents. Uncomplicated CIA may only cause low mortality and poor performance. When complicated with other factors mortality can be 30% or even higher. Early infections with CIAV can interfere with vaccination against Marek's disease or infectious bursal disease.

Marked thymic atrophy is the most consistent lesion. Fatty yellowish bone marrow, particularly in the femur, is characteristic. Bursal atrophy can also be seen in a small number of birds. Hemorrhages in the mucosa of the proventriculus, subcutis, and muscles may also be observed Secondary bacterial infections may occur and include gangrenous dermatitis or blue wing disease if the wings are affected.

A presumptive diagnosis is based upon clinical signs and gross lesions. PCR is the test of choice for identification of CAV in chicken tissues.

Best prevention is by immunization of breeder flocks prior to the onset of egg production (between 13-15 weeks of age but no closer to egg production than 4 weeks). No treatment is available.

Infectious Laryngotracheitis (ILT)

ILT is caused by a Herpesvirus, only one serotype is known. The natural entry of ILT is via the upper respiratory tract and ocular route. Field spread occurs via direct contact from bird to bird and/or transmission by contaminated people or equipment (visitors, shoes, clothing, egg boxes, transport crates). Incubation period varies from 4-12 days. Chickens are the primary natural host but other species (pheasants) can also be affected.

An acute respiratory disease with nasal discharge and moist rales followed by gasping, marked respiratory distress and expectoration of blood-stained mucus in laying birds. Egg production can drop 10-50% but will return to normal after 3-4 weeks. Mortality can vary from 5-70%. Spread through a chicken house is slower compared to IB and ND. Post mortem lesions are found throughout the respiratory tract but most pronounced in the larynx and trachea. Depending on the severity of the infection tracheitis with haemorrhagic and/or diphteric changes are noticed.

Clinical picture with birds showing respiratory distress and expectoration of bloody mucus are indicative for ILT. Laboratory confirmation with: histopathology showing intranuclear inclusion bodies in tracheal epithelial cells, virus isolation from tracheal swabs on embryonated chicken eggs, virus detection with PCR or IFT on tracheal samples. Detecting antibodies from blood samples after infection.

There is no treatment for ILT. Vaccination is the preferred control method. Vaccination in the early stage of an infected flock may reduce the spread and limit the outbreak. The existing live conventional CEO ILT vaccines are effective in controlling clinical problems but have the risk of spreading and reversion to virulence after multiple passage through chickens. Recombinant vaccines based on HVT-vector carrying inserts of important immunogenic ILT proteins show good efficacy and do not spread and cannot revert to virulence because there is not a full ILT virus involved.

High pathogenicity avian influenza (HPAI)

High pathogenicity avian influenza (HPAI) viruses have an IVPI in six-week-old chicken greater than 1.2 or, as an alternative, cause at least 75% mortality in four-to eightweek-old chickens infected intravenously. H5 and H7 viruses which do not have an IVPI of greater than 1.2 or cause less than 75% mortality in an intravenous lethality test should be sequenced to determine whether multiple basic amino acids are present at the cleavage site of the hemagglutinin in molecule (HA0); if the amino acid motif is similar to that observed for other high pathogenicity avian influenza isolates, the isolate being tested should be considered as high pathogenicity avian influenza virus. India notified the first outbreak of H5N1 HPAI virus on 18th February, 2006. Since then, several outbreaks of HPAI have been reported from different parts of the country.

HPAI is a severe form of influenza usually seen in chickens. Viruses of high pathogenicity may cause fatal infections preceded by few signs. Onset is sudden, the course is short, affected birds are quite ill, and mortality may approach 100%. Signs may relate to the respiratory, enteric, or nervous systems. There may be diarrhea, edema of the head and face, or nervous disorders. Classical lesions of HPAI in chickens include cyanosis and edema of the head, vesicles and ulceration on the combs, edema of the feet, blotchy red discoloration of the shanks, petechiae in the abdominal fat and various mucosal and serosal surfaces, and necrosis or hemorrhage in the mucosa of the gizzard and proventriculus.

Clinical history, signs, and lesions may be suggestive of AI, but are similar to other diseases. Confirmation of suspect AI cases requires laboratory tests such as serology (AGID and/or ELISA) and virus detection (real-time RT-PCR and/or virus isolation). Positive samples are then subjected to H5 and H7 subtype specific real-time RT-PCR tests, sequencing and/or inoculating susceptible chickens with the virus. Influenza must be differentiated from other poultry diseases including Newcastle disease, mycoplasmosis, chlamydial infections, and fowl cholera.

Stamping out is policy adopted in India for Prevention, Control and Containment of HPAI. All outbreaks of influenza should be reported immediately to the state veterinarian or other appropriate health authorities so that appropriate measures can be taken. Voluntary isolation of infected flocks is the responsibility of the owner and is necessary to prevent transmission to other flocks. Rigorous measures to prevent the contamination of and control the movement of people and equipment are required in order to stop this disease.

Low pathogenic avian influenza (LPAI)

Low pathogenic avian influenza (LPAI) H9N2 viruses have been isolated from various species of wild birds and domestic poultry in the world. It is the most prevalent influenza subtype circulating endemically in chickens worldwide. Since they got established in poultry about 25 years ago, LPAI H9N2 viruses have continuously evolved antigenically and have spread to new geographic areas, causing huge economic losses to the poultry industry. Despite their classification as LPAI, poultry outbreaks of H9N2 are associated with significant economic losses, largely due to reduced egg production, reduced feed conversion efficiencies, and highly lethal bacterial or viral co-infections. Secondary infections lead to mortality as high as 50% in broilers as well as layers. LPAI H9N2 infections are frequently associated with moderate-to-high mortality in broilers and long lasting drops in egg production in layers and breeders. The primary target of the H9N2 LPAIV is the epithelium and the lymphoid tissue of the respiratory tract. Replication causes lesions and a local immune suppression. The virus spreads to the epithelium of the reproductive tract causing significant drop in egg production in layers and breeders. With no complications AIV H9N2 infected birds may recover without clinical signs. Although H9N2 infections commonly result in low mortality, they make chickens more susceptible to secondary infections, especially Escherichia coli infections. In addition, H9N2 infections can be complicated with other pathogens (MG, IBV, Metapneumo, Avibacterium paragallinarum) and contributing environmental factors (e.g., poor ventilation, high environmental temperature) leading to severe respiratory disease that can cause mortality up to 50-60% in broilers. Summer is the most vulnerable period for broilers and layers as heat stress levels are immensely high (day time temperature touches 47°C in northern parts of India).

The keys to control LPAI are good biosecurity, bird management and vaccination and surveillance. Vaccination is authorized in most infected countries but not authorized in India. Only killed vaccines are available globally. These vaccines used in broiler, layers and breeders are expected to reduce the clinical disease, performance losses (final weight, feed conversion rate, egg production) and virus replication in the respiratory system. The amount of antigenic content, the matching between field and vaccine strains, the ability of the adjuvant to stimulate an immune response, the proper inactivation of live virus are key requirements to ensure sufficient vaccine efficacy.

Avian Encephalomyelitis (AE) (Epidemic Tremor)

Avian encephalomyelitis (AE) is a viral infection of chickens, turkeys, pheasants, and coturnix quail characterized in young birds by ataxia progressing to paralysis and, usually, by tremors of the head and neck. Infected adults usually show no signs.

AE is caused by a hepatovirus belonging to the Picornaviridae family. There appear to be no serologic differences among isolates. All field strains are enterotropic but some strains are more neurotropic than others. Virus is present in the feces of infected birds and will survive there for at least 4 weeks. The virus survives treatment with ether and chloroform and is fairly resistant to various environmental conditions.

During the acute phase of infection in laying chickens, a period up to 1 month, some layers shed virus in some of the eggs they lay. Although vertically transmitted AE may affect hatchability, many of the chicks will hatch and can show clinical signs of the disease as early as the 1st day of age. The infected chicks will shed virus in their feces resulting in horizontal spread to other chicks. Younger chicks tend to shed virus for a longer period of time than older chicks.

Clinical outbreaks are usually observed in chickens and most outbreaks are in 1-3-week-old chicks. In chicks, signs may be present at the time of hatch but usually occur between the 1st and 2nd week of age. Age resistance is marked if exposure is after 2-3 weeks of age. In chicks, signs include dull expression, ataxia progressing to paralysis and prostration and tremors of the head and neck. Tremor may be inapparent but often can be accentuated if the bird is frightened or held inverted in the hand. The morbidity in chicks is quite variable but may go as high as 60%. If most chicks in the flock come from immune dams, morbidity is usually low. Mortality averages 25%. Few birds with signs recover completely. Those that survive often fail to grow or produce eggs normally. Many survivors later develop a bluish opacity to the lens of the eye and have impaired vision.. Layers seldom show signs when infection is going through the flock. However, good production records often reveal a significant decline in egg production generally lasting no more than 2 weeks.

Generally, there are no gross lesions. In chicks, whitish areas in musculature of the gizzard can sometimes be observed. No gross lesions are seen in adult birds. Microscopically there is a disseminated, nonpurulent encephalomyelitis with widespread and marked perivascular cuffing Swelling and chromatolysis of neurons in nuclei in the midbrain and cerebellum, and dense lymphoid aggregates in the muscle of the proventriculus and/or gizzard as well as the myocardium and pancreas.

In chicks, the history, age of the birds, and typical signs of central nervous system (CNS) lesions permit a strong presumptive diagnosis. The diagnosis can often be strengthened by histopathologic examination. Alternatively, the direct fluorescent antibody technique can be used to demonstrate AE viral antigen in infected chicks.

Chicks from immune hens are usually protected by parental immunity during the critical first few weeks after hatching. Breeding flocks can be vaccinated to provide maximum protection to their chicks. Although vaccination is usually conducted prior to the onset of lay, some killed vaccines can be used during production. Both killed and live vaccines are used for vaccination and are effective. Live vaccine is given by the wing web stick method in combination with pox, via the drinking water, or by spray. Chicks from flocks that have been naturally infected will probably receive enough parental immunity so that they will not develop the disease.

Fowl Pox

Fowl pox is caused by a Poxvirus. Introduction of infected or "carrier" birds in a susceptible flock will cause an outbreak by direct contact and water or feed transmission. Mosquitoes and other flying insects can also transmit the virus from bird to bird and also transmit the disease to near-by flocks. The incubation period varies from 4 to 20 days. Chickens, turkeys, pheasants and pigeons can be affected by different Fowl Poxvirus strains.

The lesions of fowl pox can be external (mainly on the head) or internal ("wet pox") in the oral cavity, oesophagus and/or trachea; they can also be found on other parts of the body (skin of legs, cloaca etc.). The lesions on the head, combs, and wattles are usually wart-like in appearance, yellow to dark brown in color. The internal lesions (diptherie) in the mouth, oesophagus and/or trachea are yellow-white and cheesy in appearance. Affected birds will be depressed, lack appetite and when "wet pox" is present they breathe laboriously. Mortality is variable, from a low 1 to 2%, when slight head lesions are present, to over 40% when the diphtheritic form ("wet pox") is more prevalent. Reduced egg production can be observed in laying birds, this will return to normal in a few weeks.

Wart-like lesions of the head particularly of the comb and around the eyes or yellow cheesy lesions of the mucous membranes of the nasal and oral cavities are suggestive of fowl pox. A definitive diagnosis can be made in a laboratory by histological examination (inclusion bodies) or virus isolation in embryonated chicken eggs.

There is no effective treatment. Preventive vaccination using a live vaccine is by far the most successful control method. Even when an outbreak of Fowl Pox has been diagnosed, it is advisable to vaccinate the flock immediately (emergency vaccination) to stop further spreading of the infection.

Inclusion Body Hepatitis (IBH)

Inclusion body hepatitis is a disease of young chickens characterized by sudden onset, increased mortality and hepatitis accompanied with intranuclear inclusion bodies. Most commonly IBH cases involve FAdV8 and FAdV11, but sporadic cases associated with FAdV2 have been documented. 2. HHS has been associated with FAdV4. Outbreaks of IBH are sometimes associated with immunosuppression or exacerbated if affected flocks are immunosuppressed

IBH is characterized by sudden onset of mortality peaking after 3–4 days and usually stopping on day 5 but occasionally continuing for 2–3 weeks. Morbidity is low; sick birds adopt a crouching position with ruffled feathers and die within 48 hours or recover. Mortality might be only slightly elevated but occasionally it might reach values as high as 30%. Higher mortality appears in younger birds less than three weeks of age. IBH is predominantly seen in meat-producing birds and it may start in the first week of life. Disease in young birds is most likely caused by vertical transmission, although no clear differentiation between vertical and horizontal introduction can be made. Immunosuppression induced by IBDV and CAV infection appears to facilitate adenoviruses in producing IBH. In India IBH was often associated with the presence of aflatoxins in the feed). Growth retardation, reduced uniformity, and a higher selection rate are observed.

The liver is swollen, enlarged, yellow to tan, and there may be mottling with focal soft areas with petechial and ecchymotic hemorrhages under the capsule and in the parenchyma. Petechial and ecchymotic hemorrhages may be present in the skeletal muscles of the legs. The skin is pale and may be discolored yellow. The kidneys frequently are swollen and pale or mottled. In addition, there is an accumulation of clear, straw-colored fluid in the pericardial sac and pulmonary edema. Multifocal necrosis in the pancreas is reported in severe outbreaks. Microscopically, there is multifocal to locally extensive. degeneration and necrosis of hepatocytes often with the characteristic large basophilic intranuclear inclusions in the hepatocytes

Duck Plague (Duck Virus Enteritis)- Duck Plague (DP) (Duck Virus Enteritis).

Duck Plague is an acute herpesvirus disease of ducks, geese, and swans characterized by weakness, thirst, diarrhea, short duration, high mortality, and by lesions of the vascular, digestive, and lymphoid systems. All age groups and many varieties are susceptible; however, mostly adults are affected. The virus can be transmitted horizontally from infected to susceptible bird by direct contact or through contact with the contaminated environment (particularly water). Natural infection is limited to ducks, geese, and swans. A carrier state for as long as 1 year has been demonstrated in wild ducks. Vertical transmission has been reported experimentally.

In young commercial ducklings, signs appear 3-7 days after exposure. Ducklings have diarrhea, a blood stained vent, dehydration, and a cyanotic bill. Death usually occurs in 1-5 days. In domestic breeder ducks there is a marked drop in egg production (25-40%) a sudden, high persistent mortality. Sick birds show inappetence, weakness, ataxia, photophobia, adhered eyelids, nasal discharge, extreme thirst, prolapsed penis, and watery diarrhea. They soon become exhausted and unable to stand. They then maintain a position with their head down and drooping outstretched wings. Tremors may be apparent. Morbidity and mortality are usually high but vary from 5 to 100%. Most birds that develop clinical signs die. Wild waterfowl are said to have similar signs. They often conceal themselves and die in vegetation near the water.

Grossly, hemorrhages are present at many sites and there may be free blood in body cavities, gizzard, or intestine. Hemorrhages often occur on the liver, in the mucosa of the gastrointestinal tract (including the esophageal proventricular junction), throughout the heart, in the pericardium and ovary. There may be edema in the cervical region. There is severe enteritis. There may be elevated, crusty plaques in the esophagus, ceca, rectum, cloaca, or bursa of Fabricius. In young ducklings the esophageal mucosa may slough. There is hemorrhage and/or necrosis in the annular bands or discs of lymphoid tissue along the intestine. The spleen is usually of normal or reduced size. Initially the liver may be discolored and contain petechial hemorrhages. Later it may be bile-stained and contain scattered small, white foci as well as many hemorrhages. Microscopically there may be intranuclear inclusion bodies in degenerating hepatocytes, epithelial cells of the digestive tract, and in reticuloendothelial cells.

Typical signs and lesions, along with epizootic losses, are highly suggestive of duck plague. The diagnosis can be strengthened if intranuclear inclusion bodies can be demonstrated or if the virus can be demonstrated in the tissues through fluorescent antibody tests and PCR.

Duck farmers should prevent cohabitation or contact of their ducks with wild waterfowl. All appropriate quarantine and sanitary practices should be followed to prevent disease. Inactivated vaccines are available for prevention. Regular immunization of breeder ducks provides adequate protection. There is no effective treatment.

Duck Hepatitis (DH)

Duck hepatitis (DH) is a peracute, rapidly spreading viral infection of young ducklings characterized by a short duration, high mortality, and by punctate or ecchymotic hemorrhages in the liver. DHV type 1 is a highly contagious disease. The virus is excreted by recovered ducklings for up to 8 weeks after onset of infection. Susceptible ducklings can be infected by direct contact with infected ducklings or their contaminated environment. The virus can survive for 10 weeks in contaminated brooders and for 37 days in feces. The viruses do not appear to be transmitted through the egg and there are no known vectors of the disease.

The incubation period is very short, often around 24 hours in experimental infections, and morbidity is close to 100%. Onset of disease and spread within a flock are very rapid and most mortality occurs within 1 week of onset. Affected ducklings at first are slow and lag behind the flock. Within a short time, they squat with their eyes partially closed, fall on their side, kick spasmodically, and soon die. They often die in the opisthotonos position. Death often occurs within 1 hour of the appearance of signs. Mortality is age related and occurs as follows: ducklings less than 1 week old—up to 95% mortality; ducklings 1-3 weeks old—up to 50% mortality; ducklings over 4 weeks and older ducks—negligible mortality. In older or partially immune ducklings, signs and losses may be so limited that the disease may go unrecognized.

The cadaver may be in opisthotonos, the position in which many of the ducklings die. The liver is swollen and contains punctate or diffuse hemorrhages. The kidneys may be swollen and the spleen enlarged. Microscopically, there may be areas of hepatic necrosis, bile duct proliferation, and some degree of inflammatory response. The sudden onset, rapid spread, short course, and focal, hemorrhagic hepatitis in young ducklings suggest a diagnosis of DHV. There is no treatment for the disease. To prevent this disease, keep age groups isolated and vaccinate breeder ducks with an attenuated live virus duck hepatitis vaccine (to produce maternally immune ducklings).

Chronic Respiratory Disease (CRD)

The underlying cause of CRD is Mycoplasma gallisepticum (MG). The condition is frequently triggered by respiratory viruses such as ND and IB and subsequently complicated by bacterial invasion. The main agents involved in the infection are Mycoplasma gallisepticum and E. coli. Stress caused by moving the birds, by debeaking, other operations/ handlings or other unfavorable conditions e.g. cold or bad ventilation, make the birds more susceptible.

The main problem is that parent birds infected with Mycoplasma gallisepticum can transmit the organism through the egg to their offspring (vertical transmission). In addition, infection can occur by contact or by airborne dust or droplets (horizontal transmission). The incubation period varies from 4 days to 3 weeks. Species affected are Chickens and Turkey

Young chickens (broilers or layer pullets) show respiratory distress. The birds frequently show lack of appetite, decreased weight gain and increased feed conversion ratios. In adult birds the most common signs are sneezing and general respiratory distress. In laying birds a drop in egg production between 20-30 % can occur. In breeders hatchability can be affected and day-old chick quality produced from hatching eggs coming from infected flocks will be reduced. CRD does not normally cause an alarming number of deaths. The effect is more of a chronic nature causing reduced weight gain and higher feed conversion ratios in broilers and lower egg production in breeders and layers. In this way the overall economic losses can be very high.

Grossly a reddish inflamed trachea and/or frothy, cheesy exudate in the airsacs, especially in complicated cases (e.g. with secondary E. coli infections) are observed. In mild MG infections the only lesion might be slight mucus in the trachea and a cloudy or light froth in the airsacs.

Diagnosis of MG infection can be made based on clinical signs and post mortem lesions followed by confirmation in the laboratory using blood (serum) samples for serology or organs swabs for identification by PCR or mycoplasma isolation.

Treatment of MG-infected chickens or turkeys with suitable antibiotics or chemotherapeutics has been found to be of economic value, but will not eliminate MG from the flock. Prevention by monitoring and vaccination has become a more effective method of combating the disease especially in layers.

Mycoplasma Synoviae Infection

Mycoplasma synoviae (MS) infection most frequently occurs as subclinical upper respiratory tract infection inducing airsac lesions. After MS becomes systemic it can induce acute to chronic infection of synovial membranes of joints and tendons resulting in synovitis, tendovaginitis or bursitis. Recently MS was isolated from laying flocks with drop in egg production and/or misshapen eggs (so called “glass window eggs” or “apex Egg abnormalities”). Mycoplasma synoviae is spread horizontally via direct contact and vertically from parent to progeny. Species affected Chickens and turkeys are the natural hosts for Mycoplasma synoviae.

First recognized signs are pale comb, lameness, retarded growth and, as the disease progresses, ruffled feathers, swelling of joints and breast blisters. Respiratory involvement is generally asymptomatic but is possible; usually 90-100% of the birds will be infected. Clinical synovitis varies around 5-15% in an infected flock. Mortality is low around 1% (exceptional up to 10%). More recent strains induced drop in egg production and/or misshapen eggs (so called “glass window eggs”).

In general no lesions are found in the respiratory tract. At post mortem from the early stage of synovitis, a viscous creamy to gray exudate involving synovial membranes of tendon sheaths, joints and keel bursa can be found; other findings are liver and kidney swelling.

Organism confirmatory diagnosis based on isolation and identification of Mycoplasma synoviae can be done by culturing or PCR. Serological monitoring can be done with serum plate agglutination (RPA), Elisa and HI tests.

Treatment Mycoplasma synoviae is susceptible to several antibiotics. Antibiotic treatment will diminish clinical signs but not eliminate MS from a flock. Prevention by monitoring and vaccination has become a more effective method of combating the disease especially in layers. Economic losses in commercial layers can be reduced by proper use of MS vaccines.

Colibacillosis (Escherichia Coli Infections)

Avian colibacillosis is an infectious disease of birds in which Escherichia coli is the primary or secondary pathogen. Infections include airsacculitis, cellulitis, omphalitis, peritonitis, salpingitis, synovitis, septicemia and coligranuloma. Colibacillosis occurs in all types and age groups of poultry as well as in other birds. Most reported outbreaks in poultry have been in chickens, turkeys, and ducks. Many outbreaks occur in poultry raised under a low standard of sanitation, poor environmental conditions, or after a respiratory or immunosuppressive disease. Infection is more frequent in young than mature birds. Colibacillosis is common throughout the world.

The etiologic agent is Escherichia coli (E. coli). The O (somatic) antigen serotypes most commonly associated with disease outbreaks are O1, O2, O35, O36, and O78. The K (capsular) antigens most commonly associated with virulence are K1 and K80. In the intestinal tract of normal poultry, nonpathogenic serotypes far outnumber pathogenic serotypes, with 10% to 15% of intestinal coliforms being potential pathogens. E. coli is present in the intestine of birds and mammals and is disseminated widely in feces. Birds are continuously exposed through contaminated feces, water, dust, and environment. Any time a bird's resistance to disease is impaired, pathogenic or facultative pathogenic strains may infect the bird. Sequestered E. coli in such sites as the intestine, nasal passages, air sacs, or reproductive tract may be a latent source of infection. E. coli has been isolated from the eggs of normal hens. Its presence has been attributed to ovarian infection, oviduct infection, and to eggshell contamination followed by penetration. Chicks may hatch with a latent infection; however, active infection will typically only occur if some environmental stress or lesions initiates the disease process.

A variety of lesions from which E. coli has been isolated include:

1. Airsacculitis: Respiratory signs occur and vary in severity. This pathology may be associated with poor environmental conditions such as dusty litter, poor ventilation, high ammonia levels, sudden variation in the barn temperatures, but also with concomitant respiratory (infectious bronchitis virus, Newcastle disease virus, laryngotracheitis virus, mycoplasmas) or immunosuppressive (infectious bursal disease, chicken anemia virus) diseases. In these cases, E. coli is a secondary pathogen and will cause the airsacculitis lesions. Air sacs are normally thin, glistening and transparent but bacterial infection will cause the air sacs to become thickened, number of blood vessels within the air sac walls increases and exudate will accumulate within the cavity of the air sac. An acute inflammation will be characterized by the presence of mucous exudate which will eventually become fibrinous. Thickened air sacs and caseous exudate in the air sac will be present in more severe and chronic cases. There often is an accompanying adhesive pericarditis, fibrinous perihepatitis and peritonitis (hence a polyserositis). Airsacculitis occurs chiefly in 3-7-week-old broilers, probably peaking at 5-6 weeks.

2. Pericarditis: Most serotypes of E. coli, after a septicemia, cause a pericarditis. Opaqueness and thickening of the pericardial sac, an edematous epicardium along with myocarditis typically occurs. Pericarditis can also be caused by other bacteria including Chlamydophila sp.

3. Omphalitis and yolk sac infection: E. coli is often isolated in pure culture from organs or the yolk sac of recently hatched birds having depression, septicemia, and variable mortality. With omphalitis the navel is swollen and inflamed and the bird feels wet. Abnormal yolk material and peritonitis is typically seen on necropsy of birds with an E. coli infection of the yolk sac. A great variety of other organisms such as species of Aerobacter, Proteus, Klebsiella, Pseudomonas, Salmonella, Bacillus, Staphylococcus, enteric Streptococcus, and Clostridia are frequently isolated from yolk sacs of embryos and navels of chicks, most likely as mixed infections.

4. Coliform septicemia of ducks (duck septicemia): E. coli, Salmonella, and Riemerella (Pasteurella) anatipestifer produce respiratory signs, airsacculitis, pericarditis, perihepatitis, and peritonitis. In outbreaks of R. anatipestifer, involvement of the air sacs and a dry, thin transparent covering over visceral organs are present. In coliform septicemia (E. coli) usually a moist, granular to coagulative exudate of varying thickness is present on abdominal and thoracic viscera and surfaces of air sacs. The spleen and liver are swollen and dark with bile staining of the liver.

5. Acute septicemia: An acute septicemic disease caused by E. coli resembles fowl typhoid and fowl cholera. Birds are in good flesh and have full crops suggesting acuteness of the disease. This can occur in young or mature birds. There are sudden deaths, and variable morbidity and mortality. Parenchymatous organs are swollen with congested pectoral muscles. Livers are green in color and may have small necrotic foci. There may be petechial hemorrhages, pericarditis, or peritonitis. Acute systemic disease may also be caused by various Pasteurella, Salmonella, Streptococci, and other organisms.

6. Enteritis: Enteritis caused by E. coli is considered rare but pathogenic attaching effacing E. coli have been reported. Diarrhea and dehydration are noted on clinical examination. At necropsy there is enteritis, often with excessive fluid in the intestines. E. coli may be isolated from parenchymatous organs.

7. Salpingitis: This lesion may occur following entry of coliform bacteria from the vagina in laying hens. It is also likely to develop when the left greater abdominal air sac becomes infected by E. coli, causing a chronic salpingitis. Affected birds usually die during first 6 months postinfection and never lay. The oviduct is distended with exudate that may be caseous and has a foul odor. No specific signs are noted but there may be an upright (penguin) posture.

8. Coligranuloma (Hjärre's disease): Signs vary in this uncommon disease of chickens and turkeys. Nodules (granulomas) occur along the intestinal tract, and mesentery, and in the liver. The spleen is not involved. The lesions resemble those of tuberculosis. The agent is a mucoid coliform, possibly not E. coli. Granulomas of the liver have many causes, some of which would include the anaerobic genera Eubacterium and Bacteroides.

9. Synovitis and osteoarthritis: Affected birds are lame or recumbent. There is swelling of one or more tendon sheaths or joints. Synovitis and/or osteoarthritis are frequently a sequel to a systemic infection. With synovitis many birds will recover in about 1 week. Osteoarthritis is a more severe and chronic condition where the joint is inflamed and the associated bone has osteomyelitis. These severe chronic infections make birds unwilling or unable to walk and necropsy findings often include dehydration and emaciation. Synovitis-arthritis may also be caused by reovirus, or species of Mycoplasma, Staphylococci, and Salmonella.

10. Panophthalmitis and meningitis: Occasional birds have a hypopyon and/or hyphema, usually in one eye, which is blind. Likewise, meningitis is a rare sequelae to E. coli septicemia.

11. Cellulitis : This is one of the most common causes of condemnation at slaughter in broiler chickens. It is recognized primarily at post-mortem inspection, with no abnormality having been noted in live birds. Gross lesions include variable yellowing and thickening of the skin lateral to the vent and extending in severe cases over the ventrocaudal aspect of the breast. On incising the skin a yellow caseous plaque of variable size is noted in the subcutis. Histologically there is cellulitis involving both dermis and subcutis. The inflammatory reaction includes edema and heterophil infiltration in active areas, whereas there is accumulation of a walled-off causative sheet of exudate surrounded by a zone of giant cells in more chronic areas of involvement. Coccobacillary bacteria can be seen in microcolonies within the exudate and E. coli is recovered quite consistently on culture. This condition may affect up to 8% of entire flocks at slaughter resulting in extensive trim-out, downgrading, or whole-carcass condemnation. Cellulitis is caused by the secondary infection of skin wounds. Risk factors such as certain broiler breeds, poor feathering, sex (males more susceptible), skin scratches, increased stocking density and litter type have been associated with this condition.

Diagnosis of primary colibacillosis is based on the isolation and typing of a coliform into one of the serotypes recognized as pathogens. When E. coli is isolated secondary to some other primary disease, it should be diagnosed as secondary colibacillosis.

Measures should be taken to minimize eggshell contamination of newly laid hatching eggs. Eggs should be disinfected on the farm prior to storage and should be stored under ideal conditions. Scrupulous hatchery sanitation, disinfection, and/or fumigation procedures should be practiced. A vigorous sanitation program should be followed in raising poultry. Diseases, parasitism, and other stresses on a flock should be minimized as much as possible. Dust should be controlled. Only feeds free of fecal contaminations should be fed to poultry. Pelleted feeds are more likely to be free of contamination. Treatment of water with halogens and related compounds as well as conversion to nipple drinkers has greatly decreased the incidence of septicemic forms of colibacillosis.

Numerous antimicrobials have been utilized for treatment. These have included tetracyclines, neomycin, sulfa drugs and others but E. coli has developed resistance to many of these commonly used antimicrobials. Antibiotic sensitivity testing is therefore strongly suggested as well as record keeping of treatment history by farm.

Pullorum Disease

Pullorum disease is an infectious, egg-transmitted disease of poultry, often characterized by white diarrhea and high mortality in young birds and by asymptomatic adult carriers. Pullorum disease occurs in all age groups of chickens and turkeys but causes greatest loss in those less than 4 weeks old.

The etiologic agent is S. Pullorum, a nonmotile, Gram negative bacillus adapted to poultry. This organism, like many other Salmonella spp., tends to infect young birds more frequently than older individuals and to establish a bacteremia. S. Pullorum is primarily spread vertically through occasional infected eggs laid by infected carrier hens. Many of the infected chicks hatch and then transmit the organism horizontally to other birds in the hatch through the digestive and respiratory systems. Adult carriers also shed the organism in their feces. Slow horizontal spread to other adults is possible through contamination of feed, water, and the environment. Also, contamination of nests and eggs therein can result in eggshell penetration and infection of chicks that hatch from those eggs. Cannibalism of infected bacteremic birds can result in transmission.

In adults usually there are no signs. The infected adult may or may not appear unthrifty. An infected hen may or may not be a productive layer. A few of the newly hatched birds appear weak or soon die. In others that develop bacteremia sudden death may occur. Mortality may be low during the first few days if only a few of the eggs contained the organism. Morbidity and mortality begin to increase around the 4th or 5th day. Sick birds appear sleepy and weak. There is anorexia, white adherent diarrhea with pasting of the vent area, huddling near heat sources and shrill chirping. A few days later there may be respiratory signs in birds that inhaled the organism in the hatcher. Losses usually peak during the 2nd or 3rd week and then diminish. Survivors often are irregular in size and some are unthrifty, stunted, or poorly feathered. Many remain carriers and disseminators of the etiologic agent. Mortality varies greatly but often is very high and can approach 100%. Mortality is increased by shipping, chilling, or poor husbandry.

Grossly, in adults often there are no lesions. Occasionally there is a nodular myocarditis, pericarditis, or abnormal gonads. An abnormal ovary may have hemorrhagic, atrophic, or discolored follicles, Less frequently there is oviduct impaction, peritonitis, or ascites. Affected testes may have white foci or nodules. In young chicks, there may be few or no lesions in very young birds that die after a short septicemic course. Occasional dead birds feel wet. Many birds have pasted white feces in the vent area. Classically there are nodules in one or more of the following sites: lungs, liver, gizzard wall, heart, intestinal or cecal wall, spleen, and peritoneum. Frequently there are petechial hemorrhages or foci of necrosis in the liver. Later there may be swollen joints in occasional birds. When the intestine is opened, white plaques may be found in the intestinal mucosa and cheesy cores of debris may be found in the intestine or ceca. Plaques and cecal cores occur more frequently in birds that die later in the course of the outbreak.

In young chicks, typical history, signs, and lesions may suggest pullorum disease. Positive agglutination tests, either plate or tube, using sera from convalescent surviving birds may strengthen the diagnosis. Chicks hatched by small, noncommercial operators are more likely to be positive for S. Pullorum. For a definitive diagnosis, S. Pullorum must be isolated and identified.

Prevention is based on establishment and maintenance of pullorum-free breeder and multiplier flocks by serologic testing and other measures. Insofar as chemotherapy perpetuates the carrier state, treatment of pullorum-infected birds is indefensible and should not be recommended under any circumstance.

Fowl Typhoid

Fowl typhoid, caused by Salmonella gallinarum, is an infectious disease, primarily of chickens, with many of the clinical and epidemiologic features and lesions that occur with pullorum disease. S gallinarum shares many antigens with Salmonella Pullorum and the two organisms usually cross-agglutinate. As a consequence, birds exposed to or infected with either disease can be identified by the same agglutination test. Transmission of infection through eggshell contamination may be of somewhat greater importance than with pullorum disease. Also, S. gallinarum is more frequently transmitted among growing or mature flocks and the incidence and mortality in older birds is usually higher.

Clinical signs of fowl typhoid and pullorum disease are similar in birds less than approximately 1 month old. Semimature and mature birds with fowl typhoid often have pale head parts (comb, wattles, face), shrunken combs and wattles, and diarrhea. Mortality can be substantial.

Lesions of acute fowl typhoid in older birds include: bile-stained ("bronzed") enlarged liver with or without small necrotic foci, enlargement of the spleen and kidneys, Pallor throughout the cadaver and thin watery blood, enteritis in the anterior small intestine, often with ulceration. In older birds, chronic fowl typhoid lesions resemble those seen in pullorum disease. S. Gallinarum should be isolated and identified for diagnosis. Preventive vaccination with SG9R strain is commonly practiced in the poultry industry.

Infectious Coryza

Infectious coryza is an upper respiratory disease caused by *Avibacterium paragallinarum* affecting chickens characterized by decreased activity, nasal discharge, sneezing, and facial swelling. The disease apparently affects only chickens.

Chronically ill or healthy carrier birds are the reservoir of infection for *A paragallinarum*. Chickens of all ages are susceptible; however, susceptibility increases with age. The incubation period is 1–3 days with a typical disease duration of 2–3 weeks. Duration of illness may be longer in the presence of concurrent diseases such as mycoplasmosis. Infected flocks are a constant threat to uninfected flocks. Transmission is by direct contact, airborne droplets, and contamination of drinking water. Transmission does not occur via eggs. "

In the mildest form of infectious coryza, the only signs may be listlessness, a serous nasal discharge and occasionally slight facial swelling. With increased severity extreme swelling of one or both infraorbital sinuses with edema of the surrounding tissues may prevent the eyes from fully opening. In adult birds, especially males, the edema may extend to the intermandibular space and wattles. The swelling usually abates in 10–14 days; however, if secondary infection occurs it can persist for months. There may be varying degrees of rales depending on the extent of infection. In acute cases, only the infraorbital sinuses may be involved and contain copious, grayish, semifluid exudate evident on gross inspection and during histopathologic examination. With chronicity this exudate may become consolidated. Histopathologic features include edema, hyperplasia and erosion of respiratory mucosal and glandular epithelia and edema with infiltration of heterophils, macrophages, and mast cells. Other lesions may include conjunctivitis, tracheitis, bronchitis, and air-sacculitis, particularly if other pathogens are involved.

Isolation of a gram-negative, satellitic, catalase-negative organism from chickens in a flock with a history of a rapidly spreading disease is diagnostic for infectious coryza. Polymerase chain reaction testing has been reported to provide more accurate results versus to bacterial culture.

Sound management practices and vaccination can help prevent infection. Prompt antimicrobial treatment with supportive care of infected birds to aid recovery

Prevention is the only sound method of control for infectious coryza. All-in/all-out flow of animals as part of sound farm management and biosecurity practices are important disease prevention measures.

Vaccination on individual farms should be completed ~4 weeks before infectious coryza outbreaks typically occur.

Because early treatment is important, immediate administration of medication via drinking water is recommended. Erythromycin and oxytetracycline are usually effective. Additionally, several newer-generation antimicrobials (eg, fluoroquinolones, macrolides) are active against infectious coryza. Various sulfonamides, including trimethoprim-sulfamethoxazole, and other drug combinations have been successful for treatment.

Riemerella anatipestifer Infection

Riemerella anatipestifer infection, also known as infectious serositis, duck septicemia, new duck disease, or anatipestifer syndrome is a septicemic disease of ducks, geese, turkeys, and various other birds caused by R. anatipestifer. The disease is prevalent worldwide and causes significant economic loss due to high mortality, weight loss, and condemnations. The acute form of the disease can cause mortality as high as 75% in ducks, especially at farms where infection persists because hatches are frequently moved from one pen to another to create space for the next hatch.

Adverse environmental conditions and concomitant disease often predispose flocks to epomitics of R. anatipestifer infection. The disease is not of public health importance. In the United States,

federal or state notification is not required.

The acute form of the disease usually occurs in ducklings 1-8 wk of age. Chronic infections may occur in older birds. Riemerella anatipestifer infections have also been reported in turkeys swans, pheasants, guinea fowl, partridges, quail, and chickens. Clinical signs of the disease include ocular and nasal discharge, sneezing, greenish diarrhea, tremors of the head, neck and legs, ataxia, and coma. The common gross lesions are fibrinous pericarditis, perihepatitis, airsacculitis, and meningitis. In females, the oviduct is filled with caseous yellowish white exudate. Chronic and localized infections result in synovitis/arthritis and dermatitis. Infections originate from exposure via the respiratory tract or through abrasions or cuts in the skin.

Strict biosecurity should be maintained, with regular cleaning and disinfection of facilities. Appropriate vaccines or bacterins (guided by serotyping or whole genomic sequencing) should be administered in naive ducklings and breeder birds on most commercial duck and goose farms. All-in/all-out management systems should be used when applicable and down time should be allotted between flocks.

Sulfaquinoxaline or a combination of penicillin and streptomycin can be used for initial treatment; however, antimicrobial susceptibility testing should be performed because multidrug-resistant strains are becoming more prevalent due to antimicrobial use and development of antimicrobial gene resistance. Enrofloxacin is highly effective in preventing death in ducklings when administered in the drinking water

Aspergillosis

Aspergillosis is an acute or chronic disease, primarily affecting the respiratory system. Peritoneal, visceral and systemic infections especially involving brain and eyes can also occur. The most common etiology is Aspergillus fumigatus but A. flavus can be involved. Aspergillosis occurs frequently in turkeys, chickens, and game birds. This condition has also been reported in penguins, raptors, migratory waterfowl, psittacines and zoologic specimens, such as flamingos. All species of birds probably are susceptible.

Aspergillus fumigatus can penetrate egg shells under ideal growth conditions and thus infect the embryos. Such eggs will often appear green when candled (the embryo will be dead). Infected embryos may hatch with well developed lesions. If infected eggs break in the hatchery, large numbers of spores are released which contaminate the hatchery environment and air systems can lead to severe outbreaks in very young birds (less than 3 weeks of age). Navel infections can also occur. In Adults, infection usually follows inhalation of large numbers of spores from heavily contaminated feed, litter or environment. Conjunctival infections may occur from heavy exposure to airborne spores following traumatic injuries. Infections in the brain, posterior chamber of the eye or other visceral tissues result from systemic invasion from the respiratory tract.

Dyspnea, gasping, cyanosis and accelerated, labored breathing frequently are observed. Other signs include diarrhea, anorexia, somnolence, progressive emaciation, dehydration and increased thirst. Mortality is high in clinically affected birds. Signs of central nervous system disturbance may occur in a small percentage of the birds if there has been spread to the brain. Signs often include ataxia, falling, pushing over backwards, opisthotonos, paralysis, etc. A gray-white opacity may develop in one or both eyes when there is eye infection. Ocular discharge occurs when the conjunctiva is infected and there can be corneal ulceration. A large mass of exudate typically accumulates in the medial canthus under the third eyelid.

Mycelial growth with sporulation may be apparent as fuzzy gray, blue, green or black material (sporulating fungus) or pale yellow plaques on air sac, pleura, pericardium, peritoneum or in the syrinx and main bronchi of the lungs. Pale yellow or gray circumscribed nodules or plaques in the lungs, air sacs bronchi or trachea (usually the syrinx); less often in the brain, eyes, heart, kidneys, liver, or at other sites. In mature birds two patterns of air sac infection are found: disc-like plaques in the recurrent bronchi of the caudal thoracic and/or abdominal air sacs or markedly distended air sacs containing copious fluid and soft fibrinopurulent exudate.

The signs and gross lesions of aspergillosis are very suggestive of the diagnosis which can be confirmed by microscopic demonstration of fungus in fresh preparations made from the lesions or in histologic sections. Microscopic examination reveals septate, branching hyphae within lesions. Hyphae can be seen in fresh preparations cleared with 10% KOH or stained with lactophenol cotton blue. If fungus is grossly visible in the lesions, the typical fruiting bodies and spores can be easily found. In histologic sections, special stains (methenamine-silver, PAS, Gridley) are useful for demonstrating fungi in tissues. Nodules in the lungs usually appear as granulomas containing fungal hyphae. Using sterile technique, the fungus can be cultured by tearing a nodule or plaque open and putting it on fungus media. Aspergillus will usually grow on blood agar in 24-48 hours. Sabouraud's dextrose agar is a more selective medium.

Collect clean eggs, fumigate immediately after collection and store. Do not set cracked eggs or eggs with poor shell quality. Thoroughly clean, disinfect and fumigate incubators and hatchers. Inspect air systems and change air filters regularly in hatcheries. Monitor hatchery environment for mold contamination. Use only dry, clean litter and freshly-ground, mold-free feeds. Store feeds and litters properly so as to inhibit growth of mold. Make sure feed bins and feed lines are kept clean, dry and free of mold growth. Do not permit feed to cake in feeders. Avoid wet litter under or around the waterers or feeders. Mold inhibitors may be added to feed to control fungus growth and prevent infection. Optimize the ventilation and humidity in the poultry house to reduce air-borne spores. Humidity should be kept in the mid-range, neither too low nor too high. The fungus multiplies during the wet period producing abundant spores which then become aerosolized when conditions become dry.

If aspergillosis is diagnosed in a flock, cull clinically affected birds and remove any contaminated feed and litter. Clean and disinfect the house and then spray it with 1:2000 copper sulfate solutions or other fungicide and allow it to dry. Often antibiotics are given simultaneously to prevent secondary bacterial infection.

Coccidiosis

Avian coccidiosis is a common protozoal disease of poultry and many other birds characterized by diarrhea and enteritis. Coccidiosis in poultry affects the intestinal tract, except for renal coccidiosis in geese. Coccidiosis is found in all segments of the poultry industry and has a world-wide distribution. The development of intensive confinement production systems has increased the economic significance of this disease. Subclinical disease has been recognized as having important impact on performance in commercial meat-bird production and negative impacts on flock uniformity of layer and breeder pullets. Coccidiosis can be one of the predisposing factor for necrotic enteritis caused by Clostridia perfringens.

Coccidiosis in chickens is caused by the protozoal species of Eimeria. There are nine described species of Eimeria in chickens Coccidia have a direct but complex life cycle. Infection is by the fecal-oral route. Ingestion of infected feed, water, litter and soil results in infection. Sporulated (infective) coccidial oocyst is ingested, sporozoites are released to initiate a series of asexual replications followed by a sexual cycle that lead to development of thousands of new oocysts in the intestine or ceca. Unsporulated oocysts are shed in the feces. These oocysts sporulate within 24 hr and then are infectious for other chickens. A single oocyst may give rise to more than 100,000 progeny. Coccidia produce lesions in the gut by destruction of the epithelial cells in which they develop and multiply, and by trauma to the intestinal mucosa and submucosa.

Nine species of Eimeria have been described in chickens: E. acervulina, E. necatrix, E. maxima, E. brunetti, E. tenella. E. mitis, E. mivati, E. praecox and E. hagani. The more pathogenic species often cause diarrhea which may be mucoid or bloody. Dehydration often accompanies the diarrhea. Diarrhea and dehydration are soon followed by ruffled feathers, anemia, listlessness, weakness, retraction of the head and neck and somnolence. Growth rate is often adversely affected. In laying hens coccidiosis is usually manifested by a drop in egg production. Depigmentation of the skin may be apparent in well established cases. Morbidity and mortality within a flock may vary greatly, but both can be very high.

E. acervulina is a moderately severe pathogen causing enteritis in the anterior one third of the intestinal tract The enteritis can be mild to severe and cause thickening of the mucosa. **Eimeria necatrix** causes severe enteritis characterized by congestion, hemorrhage, necrosis and blood in the middle small intestine with bloody feces. The lesions with E. necatrix have the appearance of salt and pepper (dark red). Eimeria maxima is moderately pathogenic and may cause moderately high mortality. It causes mild to severe enteritis sometimes with thickening of the intestinal wall and marked dilatation of the middle small intestine, these resemble E. necatrix, but the lesions of E. maxima are bright red. **E. brunetti** causes enteritis in the lower small intestine, rectum and proximal cecum. In severe cases, a fibrinous or fibrinonecrotic mass of debris may cover the affected mucosa or produce caseous cores in the ileum and rectum. **E tenella** is highly pathogenic, causes a marked typhlitis with occasional involvement of the adjacent areas of the intestine. Blood is often apparent in the ceca and feces in the early stages of the infections. **E. mitis** causes no clinical lesions, the lower small intestine which may appear pale and flaccid. **E. mivati** causes reduced weight gain and mortality. **E. praecox** causes watery intestinal contents with mucus and mucoid casts in the duodenum. There may be reduced weight gain, loss of pigmentation, dehydration and poor feed conversion. **E. hagani** causes watery intestinal contents and catarrhal inflammation.

Anticoccidial compounds in feeds are the most common method of control. However, coccidia may become resistant to the anticoccidials, therefore rotation of types of products may be used to prolong efficacy. Several anticoccidials are approved for prevention of coccidiosis, such as Amprolium, Monensin, Clopidol, Nicarbazin, Robenidine, Decoquinate, Lasalocid, Halofuginone, Narasin, Diclazuril and Semduramycin. Care should be taken in choosing the product to be used. Commercial coccidiosis vaccines are available. Planned exposures of young chicks or poults to small numbers of oocysts by coarse spray at the hatchery or in feed, water or gel blocks or in ovo at 18 to 19 days incubation have been used successfully. Chemical agents widely used for treatment include amprolium, sulfadimethoxine, sulfaquinoxaline, sulfamethazine. Sulfas should not be used in layers. Required withdrawal times are usually required prior to marketing. Increasing vitamins A and K in feed or water may reduce mortality and hasten recovery, respectively.

Internal Parasites

The most important internal parasites of poultry belong to the taxonomic group Nematodes (roundworms) and Cestodes (tapeworms).

1. **Ascarids** (Large Intestinal Roundworms): One of the most common parasitic roundworms of poultry (Ascaridia galli) occurs in chickens and turkeys. Heavily parasitized birds may be droopy, emaciated and show signs of diarrhea. Feed efficiency is usually impaired in severe cases. Normal cleaning and disinfecting agents do not kill the eggs.

2. **Cecal Worms:** These worms (Heterakis gallinae) are found in the ceca of chickens, turkeys and other birds. The worms themselves are not considered a major threat, but they are highly considered a major carrier/vector for the agent that causes blackhead (Histomonas meleagridis). 3. **Capillaria** (Capillary or Thread Worms): There are many Capillaria species that affect birds; but in commercial poultry the commonly encountered are Capillaria annulata and Capillaria contorta. These occur in the crop and esophagus of the hosts. These may cause thickening and inflammation of the mucosa. Severe infestation may lead to mortality.

4. **Tapeworms**: Tapeworms or cestodes are flattened, ribbon-shaped worms composed of numerous segments or division. Tapeworms vary in size from very small to several inches in length. Several species of tapeworms affect birds but the most commonly found in poultry are Raillietina cesticillus and Choanotenia infundibulum. Occlusion of the intestines is a fairly common finding.

Birds in modern commercial poultry systems have a lower incidence and worm burden by the less access to many parasites and intermediate hosts; however, the incidence in backyard and free range flocks can be higher with a significant worm burden. Also, clinical disease in all-in-all-out production systems for commercial broilers and turkeys is rare.

Control measures that interrupt the life-cycle are effective for most nematodes with direct cycles of infection. For parasites with indirect life-cycles (some nematodes, cestodes and trematodes), control is often aimed at elimination of the intermediate host such as beetles or other insects, snails or slugs, or preventing access of poultry to the intermediate host. Piperazine is commonly used for treatment for internal parasites in meat and egg producing fowl. Fenbendazole has been used as a feed or water additive has been successfully used against Capillaria, and Heterakis infections. Thiabendazole, mebendazole, cambendazole, levamisole and tetramisole have been used against Syngamus and other nematodes such as

Trichostrongylus. Pyrantel tartrate and citarin have also been effective against some nematode infections. Butynorate is approved for treatment of some cestodes of chickens.

External Parasites

The most common external parasites seen in poultry are lice and mites. Typically, these feed on the bird's blood, skin, or dermal structures.

Lice: Poultry lice are tiny, wingless, 6-legged, flat-bodied, insects with broad, round heads. They lay their eggs on the host bird's feathers, especially near the base of the feather shaft. A female louse will lay 50 to 300 eggs at a time, which she cements to the feather shaft. There are several species of lice that affect poultry, and multiple species can affect a bird at any given time. In domestic fowl, more than 40 species of lice have been reported. Some of the most important chicken lice include the Body Louse (Menacanthus stramineus), Head Louse (Culclotogaster heterographa), Shaft Louse (Menopon gallinae), Wing Louse (Lipeurus caponis), Fluff Louse (Gonicocotes gallinae) and the Brown Chicken Louse (Goniodes dissimilis). Birds may be parasitized simultaneously by more than one species. The lice found on poultry do not suck blood, rather they feed on dry skin scales, feathers, and scabs. However, they will ingest blood extruding from irritated skin. The entire life cycle of the lice occurs on the host bird, primarily in the feathers. Eggs are white and commonly appear in bunches on the lower feather shaft. Feathers of infested birds may have a moth-eaten appearance. Due to the feather damage, the bird may have a dull or roughened appearance

Poultry Mites There are two major types of mites found on the body of poultry. They are the Northern Fowl Mite and the Chicken Mite (or Red Roost Mite). The Northern Fowl Mite is the most common external parasite in poultry, especially in cool weather climates. It sucks blood from all different types of fowl. As compared to the Chicken Mite, the Northern Fowl Mite primarily remains on the host for its entire life cycle. These mites are small and black or brown in color, have 8 legs, and are commonly spread through bird-to-bird contact. The Chicken Mite is a nocturnal mite that is primarily a warm weather pest. These mites suck the blood from the birds at night and then hide in the cracks and crevices of the houses during the day. Chicken Mites are dark brown or black, much like the Northern Fowl Mite. The life cycle of mites can be as little as 10 days, which allows for a quick turnover and heavy infestations. Mites can be transferred between flocks by crates, clothing, and wild birds.

Flocks infested with lice or mites show similar general symptoms. Birds will have decreased egg production; decreased weight gain; decreased carcass-grading quality; increased disease susceptibility; and decreased food intake. If any of these generalized symptoms are observed, a visual evaluation is recommended. Inspect birds around the ventral region for signs of lice or mites since infestations usually start in this area of the bird.

Sanitation and cleanliness are the keys to lice and mite control. Sanitation includes cleaning and disinfecting housing facilities and equipment between flocks. Chemical control can include the use of carbaryl. Treat the walls, floors, roosts, nest boxes, and the birds simultaneously. Tetrachlorvinphos and permethrin compounds are commonly used as spray/dip for control of mites and lice

Mycotoxicosis

Mycotoxicosis is a disease caused by a toxic fungal metabolite. Poultry mycotoxicoses are usually caused by fungi that colonize and invade grains and feeds, but other environmental aspects may be involved. Grains used as foodstuffs support the growth of certain fungi when environmental conditions of temperature and humidity are suitable. Some of these fungi produce metabolites that are toxic to humans and animals and cause disease (mycotoxicosis) by either ingestion or cutaneous exposure.

1. Aflatoxicosis: Mycotoxins of the aflatoxin group (B1, B2, G1, G2) are the cause of aflatoxicosis. Aflatoxin B1 is the most common in grains and is highly toxic. Aflatoxin forms in peanuts, corn, and cottonseed, and their products, in other grains, and in poultry litter. A. flavus is the primary producer of aflatoxin in grains. Grains damaged by insects and drought stress, and broken pieces of grain (screenings) are more likely to support fungal growth and toxin formation. Aflatoxin B1 is a potent, naturally occurring carcinogen and thus has special public health considerations. Aflatoxicosis in poultry is primarily a disease of the liver with important ramifications for other body systems, which may ultimately cause production problems and mortality. Affected birds have reductions in growth, carcass pigmentation, egg production, and immune function, and have increased nutrient requirements for protein, trace elements (selenium), and vitamins. The disease may be fatal. At necropsy, lesions are minimal with either transient exposure or exposure to a low concentration of toxin. Jaundice, generalized edema and hemorrhages, tan or yellow discoloration of the liver, and swelling of the kidneys are seen with more severe intoxication.

2. Ochratoxicosis: Ochratoxins A, B, and C are usually produced by toxigenic strains of P. viridicatum but may be produced by other species of Penicillium and by Aspergillus ochraceus.

Ochratoxin A is the most toxic and is the greatest threat to poultry production. Clinically, reductions in feed intake and increases in mortality, weight loss, drops in egg production have been reported from Ochratoxin A. Gross and microscopic lesions occur in the kidneys and liver. Visceral gout and reductions in plasma carotenoids, immune function, and certain blood coagulation factors also occur.

3. **Trichothecene**: (Fusariotoxicosis): More than 40 trichothecene mycotoxins are known to exist. T-2 toxin is one of the most toxic to poultry. Chickens with fusariotoxicosis (trichothecene mycotoxicosis) have had reduced growth, abnormal feathering, severe depression, and bloody diarrhea. In chickens, pigeons, ducks, and geese, the caustic properties of the trichothecenes have been manifested as feed refusal, extensive necrosis of the oral mucosa and areas of the skin in contact with the mold, and symptoms of acute gastrointestinal disease. Trichothecene mycotoxicosis may cause necrosis of the oral mucosa, reddening of the mucosa of the remainder of the gastrointestinal tract, mottling of the liver, distention of the gallbladder, atrophy of the spleen, and visceral hemorrhages.

4. Citrinin Mycotoxicosis: Citrinin is a mycotoxin that was first isolated from Penicillium citrinum but is also produced by other species of Penicillium and by a few species of Aspergillus. Citrinin mycotoxicosis in the chicken, turkey, and duckling can cause clinical illness of marked watery fecal droppings related to increases in water consumption and urine output. Metabolic alterations of electrolytes and acid-base balance occur. Young birds have reduced weight gain. Citrinin produces marked functional changes in kidneys, however, gross lesions may be slight or overlooked. Swelling of kidneys and microscopic lesions of nephrosis may occur following severe exposure. In these circumstances, lymphoid tissues may be depleted and necrosis occurs in the liver.

Control: Prevention of mycotoxicoses requires the detection and control of mycotoxin contamination in feed ingredients and the application of feed manufacturing and management practices that prevent mold growth and mycotoxin formation. Mycotoxins can form in decayed, crusted, built-up feed in feeders, feed mills, and storage bins. This can be prevented by inspection of bins between flocks to certify absence of feed residue and by cleaning bins and feeders when necessary. Antifungal agents added to feeds to prevent fungal growth have no effect on toxin already formed, but may be cost-effective management in conjunction with other feed management practices. Several commercial products, most of which contain proprionic acid, should be applied according to manufacturers' instructions. Zeolytes, a class of silica-containing compounds used as anticaking agents in feed formulation, and as aids in the improvement of eggshell quality, show promise as a practical and economical method of reducing the effects of certain mycotoxins. Hydrated sodium calcium aluminosilicate has been shown to bind aflatoxin B1, possibly by sequestration in the digestive tract, and reduce its toxicity to chickens.

Treatment: Remove the toxic feed and replace it with unadulterated feed. Treat concurrent diseases (parasitic, bacterial) identified in the diagnostic evaluation. Substandard management practices should be immediately corrected as they have increased detrimental effects in a flock stressed by mycotoxins. Vitamins, trace minerals (selenium), and protein requirements are increased by some mycotoxins and can be compensated for by feed formulation and water-based treatment.

Vaccination Schedule for Backyard Poultry

Age	**Vaccine**	**Route**
1 day	Marek's disease	S/C injection
5-7 day	Newcastle disease (Lasota)	Intraocular or drinking water
14^{th} day	Infectious Bursal disease (Intermediate Strain)	Oral drop or Drinking water
24^{th} day	Infectious Bursal disease (Intermediate Strain)	Oral drop or Drinking water
30^{th} day	Newcastle disease (Lasota)	Eye drop or drinking water
6^{th} week	Fowl Pox	IM or SC injection
9^{th} week	Newcastle disease (R2B)	S/C injection
Repeat ND Lasota and Fowl pox every six months preferably before summer (Feb/March) and before winter (Sep/October)		

Vaccination Schedule – Commercial broiler

Age	Vaccine	Route
In hatchery	IB (H120)	Intraocular or spray
5-7 day	Newcastle disease (Lasota)	Intraocular or drinking water
14^{th} day	Infectious Bursal disease (Intermediate Strain)	Oral drop or Drinking water
21^{th} day	Infectious Bursal disease (Intermediate Strain)	Oral drop or Drinking water
28^{th} day	Newcastle Disease (Lasota)	Intraocular or Drinking water

Vaccination Schedule for Commercial Layer

Age	Vaccine	Route
1 day	Marek's disease	S/C injection
5-7 day	Newcastle disease (Lasota) Infectious bronchitis (H120/Ma5)	Intraocular or drinking water
14th day	Infectious Bursal disease (Intermediate Strain)	Oral drop or Drinking water
24th day	Infectious Bursal disease (Intermediate Strain)	Oral drop or Drinking water
28th day	Newcastle disease (Lasota) Infectious bronchitis (H120/MA5)	Intraocular or drinking water
6th week	Infectious Coryza Fowl Pox	IM or SC injection
9th week	Newcastle disease (R2B)	S/C injection
12th week	Infectious Coryza	IM or SC Injection
16 weeks	ND+IB (Inactivated)	IM or SC injection
From 35 weeks onwards repeat ND Lasota & IB (H120/MA5) at every 6-8 weeks interval through drinking water		

Vaccination Schedule for Ducks

Age	Vaccine	Route
3-4 weeks	Duck Cholera (Inactivated)	SC injection
8-12 weeks	Duck Plague (Inactivated)*	SC injection

***Annual Vaccination is recommended**

Chicken Drug List

Active Ingredients	Route	Withdrawal Time (days)	Dose
Amprolium	Water	0	0.006-0.024%
Amprolium	Feed	0	0.0004-0.25%
Arsanilic acid	Feed	5	90 g/ton
Bacitracin methylene disalicyclate	Water	0	100-400 mg/gal
Bacitracin methylene disalicyclate	Feed	0	4-200 g/ton
Bacitracin zinc	Water	0	100-400 mg/gal
Bacitracin zinc	Feed	0	4-50 g/ton
Bambermycins	Feed	0	1-2 g/ton
Ceftiofur sodium[A]	Inject	0	0.08-0.20 mg/bird
Chlortetracycline	Water	1	100-1,000 mg/gal
Chlortetracycline	Feed	2	10-500 g/ton
Clopidol	Feed	5	0.0125-0.0250%

Cyromazine[B]	Feed	3	1 lb/ton
Decoquinate	Feed	0	27.2 g/ton
Diclazucil	Feed	0	1 ppm
Enrofloxacin	Water	2	25-50 ppm
Erythromycin phosphate	Water	1	0.5 g/gal
Erythromycin[C]	Feed	1-2	92.5-185 g/ton
Gentamicin sulfate	Inject	35	0.2 mg
Halofuginone hydrobromide	Feed	4	2.72 g/ton
HygromycinB	Feed	3	8-12 g/ton
Lasalocid	Feed	0	68-113 g/ton
Lincomycin	Feed	0	2-4 g/ton
Lincomycin Het[D]	Water	0	64 mg/gal
Lincomycin/spectinomycin	Water	0	2 g antibacterial action/gal
Maduramicin ammonium	Feed	5	4.54-5.45 g/ton
Monensin	Feed	0	90-110 g/ton
Narasin	Feed	0	54-72 g/ton
Narasin/nicarbazine	Feed	5	54-90 g/ton of combination
Nicarbazine	Feed	4	0.0125%
Nitarsone	Feed	5	0.01875%
Novobiocin	Feed	4	6-14 mg/lb BW/day
Nystatin	Feed	0	50-100 g/ton
Oxytetracycline hydrochloride	Water	5	200-800 mg/gal
Oxytetracycline[E]	Feed	0-3	5-500 g/ton
Oxytetracycline	Inject	5	5-25 mg/bird/day
Penicillin (from procaine penicillin)	Feed	0	2.4-100 g/ton
Piperazine	Water	0	51 mg/bird
Robenidine hydrochloride	Feed	5	30 g/ton
Roxarsone	Water	5	0.002% (21.7g/oz)
Roxarsone	Feed	5	22.7-45.4 g/ton
Salinomycin	Feed	0	40-60 g/ton
Sarafloxacin hydrochloride	Water	0	20-40 ppm
Semduramicin	Feed	0	22.7 g/ton
Spectinomycin dihydrochloride	Water	5	0.5-2 g/gal
Spectinomycin dihydrochloride[A]	Inject	0	2.5-5 mg/bird
Stephmycin sulfate	Water	4	10-15 mg/llb
Sulfachloropyrazine sodium	Water	4	0.03%
Sulfadimethoxine	Water	5	1.875 g/gal
Sulfadimethoxine/ormetoprim	Feed	5	113.5 g/ 68.1 g/ton
Sulfamethazine sodium	Water	10	61-89 mg/lb BW/day
Sulfaquinoxaline	Water	10	0.025-0.04%

Tetracycline hydrochloride	Water	4	200-800 mg/gal
Tylosin tartrate	Water	1	50 mg/lb BW/day
Tylosin[F]	Feed	0-5	4-1,000 g/ton
Tylosin tartrate	Inject	3	25 mg/2 lb BW
Virginiamycin	Feed	0	5-20 g/ton
Zoalene	Feed	0	36.3-113.5 g/ton

[A] For use in 1-3 day-old chicks only.
[B] For use in layers or breeders only.
[C] Do not use high dose level (185 g/ton) in layers.
[D] Use only up to 7 days of age.
[E] Three-day withdrawal only required with 200 g/ton dose.
[F] For layers use 20-50 g/ton dose. Highest dose level (1,000 g/ton) requires 5-day withdrawal.

Sustainable Poultry Waste Management through Composting

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The poultry industry is one of the largest and fastest growing agro-based industries in the world. There is an increasing demand for poultry meat mainly due to its acceptance by most societies and its relatively low cholesterol content. Eggs and chicken are accepted by all communities and are available at the most reasonable prices. One of the major issues the poultry industry is currently facing is the accumulation of large amount of wastes, especially manure and litter, generated by intensive production, which is causing major environmental problem. To overcome environmental issues related to pollution, environmentally and economically sustainable management technologies are to be evolved to mitigate the adverse effect of poultry waste and evolve the means to utilize those for producing the meaningful by products, which can be used by other stakeholders.

There is no conscious effort made to clearly understand the utilization and management technique of poultry waste for agriculture, problems associated with its acquisition, handling, seasonal variations, organization and farmer's perception as well as their implications on yield. This concern has brought the need to focus attention on the techniques used for managing and utilizing poultry waste in agriculture and how it influences yields and well-being of farmers. Large-scale accumulation of the poultry wastes may pose disposal and pollution problems unless environmentally and economically sustainable management technologies are evolved. Large-scale accumulation of these wastes may pose disposal and pollution problems unless environmentally and economically sustainable management technologies are evolved. Most of the manure and litter produced by the poultry industry is currently applied to agricultural land. When managed correctly, land application is a viable way to recycle the nutrients such as nitrogen (N), phosphorus (P) and potassium (K) in manure. However, pollution and nuisance problems can occur when manure is applied under environmental conditions that do not favour agronomic utilization of the manure-borne nutrients. The continued productivity, profitability and sustainability of the poultry industry will likely be dependent on the formulation of best management practices to mitigate environmental consequences associated with air and water quality parameters that are impacted by land application, and the development of cost-effective innovative technologies that provide alternative to land application of poultry wastes.

Development of management programs should meet the increasing demand for poultry products, while minimizing the environmental effects of poultry wastes on soils, crops, surface waters, and ground waters. Effective environmental management of any poultry waste begins with an understanding of its composition and the physical, chemical, and microbiological reactions that control the fate of potential pollutants in the waste following land application. The three most common poultry wastes are poultry manure or poultry litter, dissolved air flotation (DAF), sludge originating from poultry processing plants and hatchery wastes and dead birds. The major poultry production operations include broiler chickens, turkeys, and eggs. Land application of animal waste is an important management practice to recycle nutrients, to improve or maintain soil fertility, and to improve soil biological and physical properties. The components of an effective waste management program for the agricultural use of organic wastes include site selection; production and collection; storage, handling, and treatment; transfer and application; and utilization. The land disposal of waste from the poultry industry and subsequent environmental implications has stimulated interest into cleaner and more useful disposal options. There are three main alternative disposal routes for poultry litter viz. composting, anaerobic digestion and direct combustion. These technologies open up increased opportunities to market the energy and nutrients in poultry litter to agricultural and non-agricultural uses. Common problems experienced by the current technologies are the existence and fate of nitrogen as ammonia, pH and temperature levels, moisture content and the economics of alternative disposal methods.

Composting is the natural process of 'rotting' or decomposition of organic matter by microorganisms under controlled conditions. Compost is a rich source of organic matter. Soil organic matter plays an important role in sustaining soil fertility, and hence in sustainable agricultural production. In addition to being a source of plant nutrient, it improves the physico-chemical and biological properties of the soil. As a result of these improvements, the soil: (i) becomes more resistant to stresses such as drought, diseases and toxicity; (ii) helps the crop in improved uptake of plant nutrients; and (iii) possesses an active nutrient cycling capacity because of vigorous microbial activity. These advantages manifest themselves in reduced cropping risks, higher yields and lower outlays on inorganic fertilizers for farmers.

Earthworms are popularly known as the “farmer’s friend” or “nature’s plowman”. Earthworm influences microbial community, physical and chemical properties of soil. They breakdown large soil particles and leaf litter and thereby increase the availability of organic matter for microbial degradation and transforms organic wastes into valuable vermicomposts by grinding and digesting them with the help of aerobic and anaerobic microbes. Earthworms’ activity is found to enhance the beneficial microflora and suppress harmful pathogenic microbes. Soil wormcasts are rich source of micro and macro-nutrients, and microbial enzymes. Vermicomposting is an efficient nutrient recycling process that involves harnessing earthworms as versatile natural bioreactors for organic matter decomposition. Due to richness in nutrient availability and microbial activity vermicomposts increase soil fertility, enhance plant growth and suppress the population of plant pathogens and pests. This review paper describes the bacterial biodiversity and nutrient status of vermicomposts and their importance in agriculture and waste management.

Poultry production is indirectly associated with the greenhouse gas nitrous oxide because of the sector's high concentrate-feed requirements and the related emissions from arable land due to the use of nitrogen fertilizer. FAO–IFA (2001) reported a 1 percent N_2O-N (nitrogen in nitrous oxide) loss rate from nitrogen mineral fertilizer applied to arable land. By applying this loss rate to the total nitrogen fertilizer attributed to the poultry sector, estimated that nitrous oxide emissions from poultry feed related fertilizer to be 0.07 million tonnes of N_2O-N per year – about 35 percent of the global nitrous oxide emissions attributed to the livestock sector from mineral fertilizer application. Overall, intensive poultry production (indirectly and directly) contributes an estimated 3 percent of the total anthropogenic greenhouse gas and is responsible for about 2 percent of the total greenhouse gas emissions from the livestock sector. This estimate, however, does not include emissions from land use and land-use change associated with feed production or emissions related to transport of feed. Poultry production in intensive systems and its impacts on the environment has shown that the issues associated with poultry production, as environmental impacts related to backyard or mixed extensive systems are marginal because of the limited concentration of wastes and reliance on locally available sources of feed, such as food residues, crop residues or feed collected by free-ranging birds. Poultry production is associated with a variety of pollutants, including oxygen-demanding substances, ammonia, solids, nutrients (specifically nitrogen and phosphorus), pathogens, trace elements, antibiotics, pesticides, hormones, and odour and other airborne emissions. These pollutants have been shown to produce impacts across multiple media.

The amount of manure produced depends on the number of animals reared plus the rate of waste production. Anaerobic decomposition depends on the type of manure storage. The majority of poultry production systems handle manure as a solid, and the manure thereby tends to decompose under aerobic conditions generating less methane than would be generated under anaerobic conditions. Appearance and aesthetics are major factors in the general public's perception. Therefore, it is very important that aesthetics and appearance be given priority for the overall benefit and viability of animal agriculture. Remove any medical consumables floating in the manure and mortalities or afterbirth that may have been dumped in the storage structure.

Manure by-products have the potential for being recycled on agricultural land. Beneficial use through land application is based on their ability to favorably alter soil properties, such as plant nutrient availability, soil reaction (pH), organic matter content, cation exchange capacity and water holding capacity. Poultry waste contains all essential nutrients including micronutrients and it has been well documented that it provides a valuable source of plant nutrients, especially for organic growers. Addition of poultry manure to soils not only helps to overcome the disposal problems but also enhances the physical, chemical and biological fertility of soils. For example, continuous cultivation of arable soils often results in the deterioration of soil structure leading to reduced crop yield. Addition of poultry manure has been shown to improve the fertility of the cultivated soil by increasing the organic matter content, water holding capacity, oxygen diffusion rate and the aggregate stability of the soils. Optimum use of manure by-products requires knowledge of their composition not only in relation to beneficial uses but also to environmental implications. Environmental concerns associated with the land application of manure by-products from intensive animal operations include leaching losses of N in sub-surface drainage and to groundwater, contamination of surface water with soluble and particulate P, reduced air quality by emission of greenhouse gases and volatile organic compounds, and increased metals input. Maintaining the quality of the environment is a major consideration when developing management practices to effectively use manure by-products as a nutrient resource and soil conditioner in agricultural and horticultural production systems. Most of the environmental problems associated with improper practices of land application of manure by-products have centred on the contamination of ground and/or surface water with two major nutrients, N and P. However, manure by-products may also contain other potentially toxic trace elements, such as arsenic (As), copper (Cu) and zinc (Zn), which, to date, have received less attention. For example, poultry manure addition is considered to be one of the major sources of As input to soils. To offset the environmental risks of manure land application to reduce the risk of offsite contamination, land application guidelines should be developed that consider the total composition of the manure by-products rather than only one component, i.e., N and/or P concentration. On the other hand, the concentration of trace elements in poultry litter and its by-products could be minimized by controlling the quality of raw feed materials and reducing mineral additives in poultry diet. Uncontrolled decomposition of manure produces odorous gases, including amines, amides, mercaptans, sulphides, and disulphides. These noxious gases can cause respiratory diseases in animals and humans. Ammonia volatilization from manure creates odour problems, and it may also contribute to atmospheric deposition and acid rain. Furthermore, greenhouse gases, such as carbon dioxide, methane and nitrous oxides are also released from manure handling and storage facilities, which are implicated in ozone depletion and global warming. Improved manure handling and storage methods are needed to reduce the emission of these gases. The composition of poultry litter in relation to nutrient content and environmental contaminants, its value as a nutrient source and soil amendment to improve soil fertility, alternative uses of poultry litter including animal feed and fuel source, and cost-effective innovative technologies for improving the beneficial value of poultry litter. Poultry litter provides a major source of N, P and trace elements for crop production and is very effective in improving the physical, chemical and biological fertility, indicating that land application remains as the main option for the utilization of this valuable resource. The best management practices to mitigate environmental consequences associated with air and water quality parameters that are impacted by land application in order to maintain the continued productivity, profitability, and sustainability of the poultry industry may be thought of.

With ever increasing population coupled with pressure on resources, people suffer intense food insecurity and poverty. Urban agriculture has increasingly become a source of livelihood to a number of people. The growing recognition of agriculture practicability and usefulness has been easing the burden of food insecurity and also improving the economy, because of the incredible utilization and management of poultry waste as alternative to synthetic fertilizer and as ingredient for improving soil and production output. Despite the perceived benefits associated with poultry waste utilization, there has been uncertainty about its quality and suitability for crop production probably due to the complexities of its nature involving the complex interactions among biophysical, social, cultural and economic factors. There is also no conscious effort made to clearly understand the utilization and management technique of poultry waste for agriculture, problems associated with its acquisition, handling, seasonal variations, organization and farmer’s perception as well as their implications on yield. This concern has brought the need to focus attention on the techniques used for managing and utilizing poultry waste in agriculture and how it influences yields and well-being of farmers. Understanding the drivers of poultry waste management and utilization techniques especially as it affects crop yield and revenue generation among farmers, could pave ways for improving poultry waste activities for agriculture and consequently increase income, food security and poverty reduction.

Note