Innovations in Lab to Land Based Production and Processing Technologies for Sustainable Poultry Production"

Dr Gautham Kolluri
Dr Jaydip Rokade
Dr Shahaji Phand
Sushirekha Das

PUBLISHED BY :-
ICAR-CENTRAL AVIAN RESEARCH INSTITUTE
IZATNAGAR- 243122 (UP) INDIA

Innovations in Lab to Land Based Production and Processing Technologies for Sustainable Poultry Production"

Dr Gautham Kolluri | Dr Jaydip Rokade |
Dr Shahaji Phand | Sushirekha Das

Innovations in Lab to Land Based Production and Processing Technologies for Sustainable Poultry Production

Editors: Gautham Kolluri, Jaydip Rokade, Shahaji Phand and Sushrirekha Das

Edition: 2023

ISBN: 978-93-91668-75-4

Citation: Gautham Kolluri, Jaydip Rokade, Shahaji Phand and Sushrirekha Das (2023). Innovations in Lab to Land Based Production and Processing Technologies for Sustainable Poultry Production [E-book] Hyderabad: ICAR-CARI, UP & National Institute of Agricultural Extension Management, Hyderabad, India

Published for Dr. P. Chandra Shekara, Director General, National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India by Dr. Srinivasacharyulu Attaluri, Program Officer, MANAGE and printed at MANAGE, Hyderabad as e-publication.

Designing & Formatting By:-
ADIL - E - OFFICE
Bareilly | +91 8395804304 | adileoffice786@gmail.com

MESSAGE

National Institute of Agricultural Extension Management (MANAGE), Hyderabad is an autonomous organization under the Ministry of Agriculture & Farmers Welfare, Government of India. The policies of liberalization and globalization of the economy and the level of agricultural technology becoming more sophisticated and complex, calls for major initiatives towards reorientation and modernization of the agricultural extension system. Effective ways of managing the extension system needed to be evolved and extension organizations enabled to transform the existing set up through professional guidance and training of critical manpower. MANAGE is the response to this imperative need. Agricultural extension to be effective, demands sound technological knowledge to the extension functionaries and therefore MANAGE has focused on training program on technological aspect in collaboration with ICAR institutions and state agriculture/veterinary universities, having expertise and facilities to organize technical training program for extension functionaries of state department.

Since the beginning of agriculture, at least, human development has been dependent on the goods and services provided by livestock, and even the most advanced post-industrial cultures continue to be incredibly dependent on animals for food and nutrition security. The continued significance of cattle must be acknowledged as our knowledge of economic growth develops. The economy of emerging nations, where food insecurity is a widespread issue, rely heavily on livestock. The emergence and spread of transboundary animal diseases can pose serious threats to public health; encouraging greater competition with higher levels of market concentration will likely prevent many small producers from participating in markets. The necessity to eliminate the incorrect use of antimicrobials in stock-raising and to reduce the detrimental impacts of livestock production on biodiversity and the environment underpins all of these problems. To support the transformation needed in the livestock sector to enhance its contribution.

This e-book covers an array of subjects, Innovations in Lab to Land Based Production and Processing Technologies for Sustainable Poultry Production. I would like to extend my appreciation to ICAR-CARI, UP & MANAGE, Hyderabad editors for the tremendous effort in compiling this eBook. I also thank the authors, editors, and designers who have contributed to this eBook creation.

Dr. P. Chandra Shekara
(Director General, MANAGE)

भाकृअनुप-केन्द्रीय पक्षी अनुसंधान संस्थान
इज्जतनगर-243 122 (उ०प्र०) भारत
ICAR-Central Avian Research Institute
Izatnagar-243 122 (U.P.) INDIA
(AN ISO 9001:2008 CERTIFIED INSTUTION)

डॉ अशोक कुमार तिवारी
निदेशक
Dr Ashok Kumar Tiwari
Director

MESSAGE

Poultry industry in India has emerged as the most dynamic and fastest growing segments amongst agricultural sector today with an annual growth rate of 6.19% in egg and 7% in broiler production. Now, India has become world's third largest egg and fifth largest chicken meat producing country. This transformation had taken place in all the areas of poultry farming such as breeding, nutrition, hatching, management as well as product processing technologies, etc. The poultry sector in India has an annual turnover of 10,000 million US $ and satisfies the hungers of 20 million people through employment. Around 4 lakh farmers are engaged in poultry farming activities with 85% of them having less than 2 hectare of land. Urban demand still accounts for 80% of domestic consumption. South India accounts for majority of the total poultry production and consumption in the country. Andhra Pradesh, Karnataka, Telangana, Tamil Nadu in south, Maharashtra in the west and Haryana, Punjab in the north, West Bengal in the east are key states in this aspect. Being, a premier poultry research and training institute in Uttar Pradesh, the ICAR-Central Avian Research Institute,Izatnagar has shared a much of burden to bridge the gap for reaching the needy farmers with technological advancements. Despite the potential developments in poultry industry, village or rural poultry production is still untapped in terms of witnessing the ongoing progressive low cost technologies for sustainable poultry production. Skill development may bridge this gap by training the field functionaries to ensure technology transfer efficiently. This manual has been prepared carefully with incorporating all the field experiences of the institute faculty as, an up-to-date ready reference to the readers.

I thank Director General, MANAGE, Hyderabad for their financial assistance and co-ordination in organizing this training programme. I specially congratulate editors for their dedicated and painstaking efforts in developing this contemporary concept and successfully implementing this off campus training programme.

(Ashok Kumar Tiwari)

EPABX: +91-0581-2303223, 2300204 Fax: +91-0581-2301321; Director: +91-0581-2301261 (O), +91-9457257425 (Mob.)
E-mail: director.cari@icar.gov.in ❖ cari_director@rediffmail.com ❖ Website: https://cari.icar.gov.in
A Premier Institute of Poultry Research, Education & Training

CONTENTS

Sustainability of Indian Poultry Sector in Context of Privatization

A.K. Tiwari and Gautham Kolluri

Background

Several decades ago, poultry was considered as backyard activity with native birds such as Aseel, Kadaknath and other non-descriptive breeds without much attention to scientific practices and no concept of commercial farming observed. With the launch of pilot project in Orissa, commercial poultry keeping was promoted and subsequently breeds like White Leghorn, Rhode Island Red, and Black Minorca were considered for improving egg size and number. The Central Poultry Breeding Farms laid the foundation for the development of poultry industry i.e., to acclimatize the genetically superior stock imported in 1956 from America under the Technical Cooperation Mission. Four multiplication farms with foreign collaboration were set up in the private sector for production of exotic chicks capable of laying 240 eggs a year.

Indian poultry sector represents various diversifications with conventional backyard poultry rearing to highly mechanized intensive poultry rearing with an advanced technology and is characterized by a mix of small (low input-low output), medium (medium input-medium output) and large (high input-high output) farms. Poultry industry in India has made a remarkable growth ever since its inception and is presently emerging as a sunrise sector with a growth rate of 8.51 and 7.52% in egg and broiler production respectively (BAHS, 2019) as against 2.5% for agricultural crops (The Economic Survey, 2019-20). Estimates from All India Poultry Breeders Association indicates that, poultry contributes for USD 17.31 billion of total India's Gross value and satisfy the hungers of 50 million people through direct and indirect employment. The organized poultry sector is contributing nearly 70% of the total output, with the rest from the unorganized sector. Within the poultry sector, broiler and layer segment constitutes about 65.3 and 34.7 % with the monthly turnover of 400 million chicks and 8400 million eggs respectively (ICRA, 2020). Around one million farmers are engaged in poultry farming activities with 85% of them having less than 2 ha of land or the landless. Urban demand still accounts for 80 % of domestic consumption. While layer farms are scattered especially in rural areas, the commercial broiler farms are mainly concentrated around urban and peri-urban areas. South India accounts for majority of total poultry production and consumption in the country. Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Maharashtra in the west and Haryana, Punjab in the north are key regions in this aspect. Currently, more than 85% of total egg production and 60% of broiler production are from improved poultry birds in the organized sector. A network of about 700 hatcheries, feed mills, veterinary pharmaceuticals and equipment manufacturing units have made poultry a dynamic agri-business in the country. In order to meet the ICMR-NIN recommendations of per capita egg and meat consumption, the volume of existing business must expand four and six fold respectively.

1.0. Eggs and layers

India is the third largest egg producing country in world, with an estimated egg (in shell) production of 129.6 billion (BAHS, 2021) from 392 million layers. Per capita availability and consumption is maintaining at 79 and 70 eggs respectively. Egg production in India is growing at a compounded annual growth rate (CAGR) of over 8%. About 80% of country's egg production comes from only eight major egg producing states, while 1.5% comes from NE states. Rest of all the states put together contributes only 5%. Andhra Pradesh accounts for the highest share of over 30% across India with 2,800 crore eggs produced, while Tamil Nadu, shares about 20%, ranks second with 2,000 crore eggs each year. Maharashtra, Haryana, Punjab and West Bengal are other leading egg producing states, but each has a less than 10% share in the total eggs produced. Karnataka, Kerala and Odisha are other significant egg producing states with over 5% share in egg production across India. In Andhra, production capacity is about 1 egg/head and 75% of its production goes for export. India's largest egg laying farm is located at Karlam village, Vishakhapatnam district, Andhra Pradesh (Radha SakkuAgro Farms) which harbours one million chickens in a single completely enclosed temperature controlled facility with fully automated systems. This might be the Asia's largest egg producer. Namakkal is the poultry hub/poultry belt of Tamil Nadu with varying farm types from basic conventional house to automated environmentally controlled house with 1 lakh bird capacity. The turnover of egg production is almost 7 crores per day with 2.5 crores of eggs produced from this region alone. Even north India is witnessing EC poultry sheds. The egg production sector continues to expand and egg prices crossed four rupees at the farm gate in 2014. Recently, large states like West Bengal, Bihar, Chhattisgarh and Uttar Pradesh showed huge expansion on egg production due to highly urban demand. Low cost of egg production, high productivity, rise in egg consumption in the north owing to growing per-capita income of a young and increasingly urban population and emerging export markets are certain key growth drivers of egg production in India.

2.0. Meat and Broilers

With an annual growth rate of 11.4%, country's broiler production is 4.5 MMT from 2,820 million broilers slaughtered each year and is the fourth largest producer of chicken in the world after US, China and Brazil (USDA, 2015) and is approaching 4.2 MMT. As per Indian estimates, it is 3.27 MMT and contributing to 46% of total meat share produced in the country. The Indian broiler industry is growing at more than 15% annually among Asian countries with an unbeatable growth. Organized sector contributes 80% of total chicken meat production and is mainly concentrated in southern parts. Andhra Pradesh contributes maximum followed by Tamil Nadu, Maharashtra, Rajasthan, West Bengal, Uttar Pradesh, Punjab, Kerala and Odisha together accounting for about 92% of the total poultry meat production in the country. Around 3% is contributed by other states to total poultry meat production.

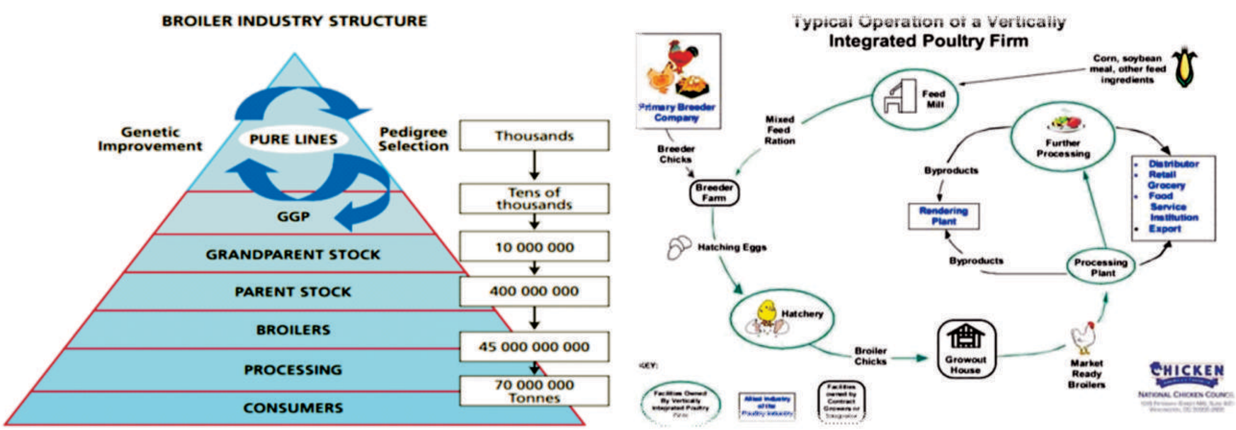
2.1. Private Integrators in broiler industry

Integration is well developed in broiler industry; vertical integrated operations are much concentrated in southern and western India. 60-70% of all broiler operations use the integrator model, on other hand smaller backyard constitutes 20%. One integrator generally has 20,000 contracted farms. The major private integrators operating in the southern and western region of the country are Venkateswara, Suguna, Pioneer, Diamond Riverdale, Star Chick, Gold Chick, Godrej Real Gold, Godrej Agro Vet, Shanthi, Peninsula, Skylark and Komarla. Contract Broiler Farming (CBF) is commonly practiced in Andhra Pradesh, Tamil Nadu, Telangana, Karnataka and Maharashtra and other adjoining states. It accounts 80 % in south, 70% in west, 45% in east and 30% in north. The meat obtained by integrator will find its way for exports as frozen dressed chicken or cut up parts. CBF has played a major role in the growth of the broiler sector, especially in structure, size and number of broiler farms in southern and western India. Earlier commercial broiler farms used to produce 200 to 500 chicks per cycle on average; now, units with fewer than 5,000 birds are becoming rare, and units with 5,000 to 50,000 birds per cycle are common. Though commercial farming can yield substantial gains, the transition from subsistence farming to market-driven broiler production is burdened with marketing risk. It is estimated that 37% of broiler production in India is under contracts, and about 78% are concentrated in southern India.

The live poultry market constitutes 90-95% of total sales because of growing middle class and preference for fresh culled chicken. At present bulk of broilers produced is either sold alive or as deskinned carcasses in retail markets. While, dressed chicken is sold as freshly dressed whole chicken or cut-up parts. Numerous of small poultry dressing plants contribute to10-15 % dressed chicken in unscientific manner. While only 7% of dressed chicken is processed and produced scientifically by mechanical mode in modern and mechanized processing plants (2,000-6,000 chickens/hr) and chilled or frozen form. There are only five modern integrated poultry processing plants producing dressed chicken, chicken cut parts and other chicken products like burger patties, nuggets, sausages, salami, breast fillet and other portions. India depicts a diverse picture of modern vertically integrated poultry processing plants on one side of the coin while with millions of small production units of live broilers for processing on the other. Over time efficiency deteriorates because the broiler has an ever-increasing body mass to maintain. Over the years, gradual decline in feed efficiency from around 4.42 -2.2 in the early 1960's to 1.75-1.47 today is achieved which is a threefold increase in feed efficiency due to Genetics, nutrition and other management changes over the last 44 years (Kotiah, 2013). Over the past two decades, feed conversion rates for poultry have improved by about 40% due to improved productivity and efficient feeding strategies. However, still only 25-35% of the nutrients consumed by poultry are utilized.

2.2. Private poultry companies and their operating environment

Suguna poultry farms, occupied a share of 40 and 25% share of the Indian market for broilers and laying hen. Currently, it is producing 7.5 million broilers per week. Broiler parents are imported from Aviagen (Great Britain) and layers are from Lohmann Tierzucht (Germany) for the supply of Ross and LSL-Lite layer grandparent stock. Ultra-modern breeding farms have been used for layers and parent stock for the first time in country. High capacity hatchery and environmental controlled houses are in operation at Sadayapalayam and Madurai. At Udumalpet (Tamil Nadu), Suguna has established its most modern and technologically advanced automatic processing plant with 3600 birds/day to produce 1500 metric tonnes per month. Venkateshwara Hatcheries has established an automatic dressing plant (from Stork) at Kamshet, right between around Pune and Mumbai regions with 4000 birds/hr with further cut-ups and automatic deboning facilities. The company has developed swiftly as the largest exporter of chicken eggs from India and it holds 70% of the market share of egg exports from India. Venky's is marketing vaccines under brand name *Ventri Biologicals*, disinfectants, sanitizers and other performance products under *BV Biocorp Ltd.* **Shanthi Poultry Farms (P) Ltd., is** one of the leading poultry groups in integrated farming in South India. It has typical processing of chicken that follows a cycle that begins from the adult birds to packing and freezing with vigorous export potentials. Venkateswara Hatcheries has opted to use tennis to promote their brand Venky's. Similarly, Godrej Agrovet (compound feed company), Mumbai, IB company, Chhattishgarh, Skylark in North are the other leading integrators. MNC such as Japfacomfeed, Indonesia, CP feeds, Thailand have Indian market business turnover of USD 3 and 12 billion respectively (Businees India, 2017).



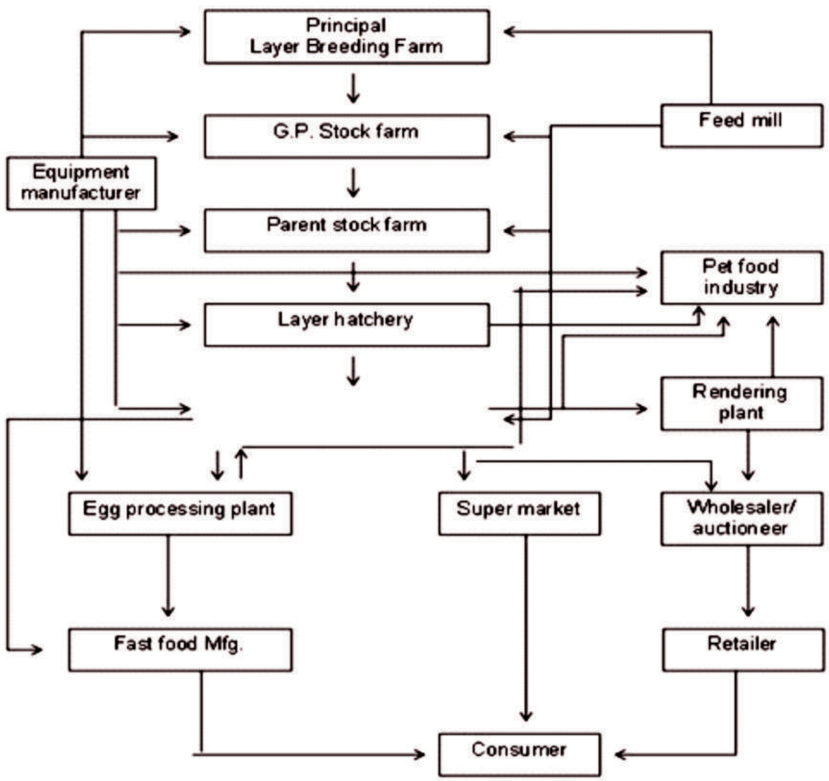
Broiler integration in poultry

Layer integration in poultry

Conclusion:

Privatization in poultry industry allows to reach maximum numbers in limited time. Further, involvement of big players results in scrapping of m*ushrooming growth of independent small farms with streamlined mechanism of inputs and outputs. Cost of production of final product will come down. Industry will grow in an organized way. Possibility of production of diversified products and fast foods. As the by-products are recycled there will be less environmental pollution. Stabilize the prices by balancing supply and demand in the market. Both the producers and consumers are benefitted likewise. Poultry contract farming is comparatively risk free venture.*

LAYER INTEGRATION ORGANISATIONAL SET UP



Integrated Rural Poultry Farming for doubling farmers income: A demonstration with CARI GIRIGRAM TAKINIKI PARK

Chandrahas Raj Narayan and V.K. Saxena

1 Dean, College of Veterinary and Animal Sciences, Kishanganj, Arrabari, Bihar-855115, India
2 Principal Scientist, ICAR-Central Avian Research Institute, Izatnagar-243122, Bareilly (UP) India
3 Director Research, Bihar Animal Sciences University, Patna, Bihar

Poultry has emerged as one of the fastest growing segment in agriculture sector. Indian poultry market was valued at Rs.1708 billion in the year 2021 with an estimated CAGR of 10.5%. Indian poultry scenario is dominated by organized commercial segment (80%) while the unorganized rural or backyard poultry segment contributes to about 20% of the market share. Share of rural poultry from 217.49 million heads in 2012 and increased to 317.07 million heads in 2019, a 40.78% increase. However, still the share of rural poultry on nation's egg production is only 17% and poultry meat production is 25%. Per capita availability of eggs has increased from 5 to 84 egg per annum and that of poultry meat from 150 g to 3600 g since 1950-51 to 2017-18 but it is still far below the ICMR recommended levels of 180 eggs and 11 Kg meat per person per annum. With this scenario, the achievement of recommendation of ICMR for per capita availability of egg and poultry meat is not possible only through expansion of commercial poultry industry with exotic birds. The need of hour is to boost improved indigenous/Desi chicken-based backyard poultry farming in integration with other technologies like vermin-farming, maggot production, Moringa and other fodders for lowering down the cost of production and producing other products like vermi-compost, earthworms, maggots, flowers etc. for extra income generation.

Hypothesis: The unorganized poultry sector of India is mainly owned by poor farmers involving meagre investment, low input varieties or Desi chicken and minimal housing facilities under semi intensive or free range system. The present scenario of shrinkage of basic resources like land, feed grains and water, associated with diseases, pollution coming out of large scale poultry operations as well as the issues like antimicrobial resistance, welfare issues and tropical stress are putting great challenges before commercial poultry sector. On the other hand, under Indian situation, the unorganized poultry sector offers to overcome most of these problems and present a viable alternative for augmenting overall poultry production. In addition, added with other technologies like moringa, vermin-culture, maggot culture, medicinal and aromatic plants or floriculture etc may further add to income generation as well may be viable occupation for the literate and unemployed youths. At present government driven schemes such as start up, stand up and Atmanirbhar Bharat are also giving ample thrust for promoting such small scale business enterprise. Besides this, such projects may be a step further in the direction of achieving the goal of "doubling the famers' income". In view of this, the present model of poultry production under free range system using one acre land, namely "GirigramTakniki Park", has been established for utilizing the backyard poultry concepts along with moringa plantation and other commodities like seasonal fodder, vermin-culture, maggot production, floriculture etc. for generation of more income under unit area.

Infrastructural development: The model project was initiated in one acre (64mx64m) land within the premises. Boundary, huts, vermi-pits, maggot incubators and other structures were constructed as per following details.

Fence/Boundary: With the objective to provide predator-free environment for birds maintained under the free range system for optimum utilization of resources and to fetch optimum productivity, a moderate low cost and durable structure was erected around the periphery of the proposed site. The dimension of fence / boundary was 64mx64mx3.1m above the ground comprising of both brick work and iron mesh. The foundation (0.91m) of all four sides of 64mx64m land and boundary wall of 0.61m was constructed. Angle iron (35mmx35mmx5mm) of 4.42m height were grouted 1.37m with strong holdfast and 3.05m above ground, was fixed at a distance of 3.5m on each side of boundary. Therefore, total 107 angle iron supports were fixed on all four sides for fencing purpose. GI mesh of 2mm thickness and 25mmx36mm (Burfi jail on lower end) & 36mmx36mm (square mash on upper end) size with 1.3m height each (2.6m) was fixed by wielding in angle using iron patti (25x3mm) as base frame. Above 3.1m, angle iron (0.6m) was bended at suitable angle for fixing 3-4 rows of barbed wire throughout the boundary of 256m for the protection of birds from jumpers and high flyer type of predators as well as for preventing the birds from flying out from inside. A gate (3.6mx3.1m) of angle iron (35mmx35mmx5mm) frame and iron sheet (14Ggauge) with cross support of iron patti (32mmx3mm) was fixed on angle iron pillars (50mmx50mmx6mm) at the entrance.

Poultry Huts: Total 06 huts(6.2mx5.5m) constructed each with a capacity to house 250-300 birds from locally available materials. The floor of hut was made with layer of bricks (brick-on-edge) filled with saw dust and paddy husk. Three types of houses using different materials were constructed i.e. Bamboo frame and thatched roof hut, Bamboo frame with roof made of gunny bag and tarpaulin (polythene) and Huts made of fiber sheet with square hollow iron pipe frame.

1. Bamboo frame and thatched roof hut: Bamboo frame on all the sides with 76X76 mm mesh size was fixed (Fig 1.).Height of hut at sides and at centre was approx. 1.33m and 2.10m, respectively. An overhang of 0.6m from roof on all sides was also provided for protection from rain showers entering in to the huts. Roof was made up of paddy thatch. Fiber sheet of approx. 1.5 mm upto 0.6m from ground was fixed to protect serpentines and other creeping predators to enter into the huts. Above the fibersheet,bamboo mesh of appropriate size was fixed in rest of sides all around except gate. Gate of 1.5x1.0m wide with single pane for closing and opening and with provision of locking was installed.

Perches (2-4, depending on size) were hanged internally by the two length wise side of huts at suitable height (approx. 0.6m) to meet the welfare of the birds (Fig. 2).

2. Bamboo frame with roof made of gunny bag and tarpaulin (polythene): The frame on sides and top was made up of bamboo strips as mentioned in above hut. Height of hut at sides and at centre was approx. 1.33m and 2.10m, respectively. An overhang of 0.6m from roof on all sides was also provided. Roof top was made of bamboo frame covered with gunny bag and tarpaulin (black polythene).

Fig. 1 Bamboo frame and thatched roof hut

Fig. 2. Perches for birds

All the four sides were covered with fiber sheet upto 0.6m from ground and above the fibersheet, bamboo mesh of appropriate size was fixed in rest of 0.9m height on all the sides (Fig. 3). Gate of 1.5x1.0 m wide with single pane for closing and opening and with provision of locking was installed. Perches (2-4, depending on size) were hanged internallyby the two-length wise side of huts at suitable height (approx. 0.6m) to meet the welfare of the birds.

3. Huts made of fiber sheet with square hollow iron pipe frame: The hollow square pipe of this hut was of 1.5″X1.5″at main frame and of 1.0″x1.0″ at other supporting frames. The fiber sheet roof was fitted over the frame (Fig.4). Height of hut at sides and at the centre was approx. 1.5m and 2.1m, respectively. An overhang of 0.3m from roof on all sides was also provided. Fiber sheet of approx. 1.5 mm upto 0.6m from ground was fixed on all sides. Wire mesh of 2 mm thickness and of approximately 32X32 mm mesh size was fixed in rest of 0.6mheight on all the sides above the fiber sheet. Above this wire mesh, a 0.22m strip of samefiber sheet was fixed up to the roof height around the hut. Gate of 1.8-1.6x0.9 m wide with single pane for closing and opening and with provision of locking was installed. Perches (2-4, depending on size) were hanged internally by the two length wise side of huts at suitable height (approx. 0.6m) to meet the welfare of the birds.

Fig. 3. Bamboo huts with roof of gunny bag and tarpaulin

Vermi-pits for vermi-culture: The indigenously designed five pits, each of 6.7mx0.9mx0.3m, internally of brick were constructed for the production of earthworms (Fig. 5). The cow dung and farm waste were utilized for growing the earthworms. Indian earthworm species *Perionyxceyelensis*popularly named as "Jai Gopal" received from IVRI, Izatnagar, was used for vermi-culture after adopting optimum management practices. Before putting the waste in vermi-pits, windrows of cowdung, plant leaves and grasses up to 2 ft height were made and allowed for its decomposition for 10 to 15 days in winters and 5 to 7 days in summer seasons. This was used as feed resources for worms in vermi-pits. The earthworms were used as a source of protein concentrate for feeding the birds. The proximate analysis of worms (Table 1) revealed that they are good alternate feed resource for replacing Soybean meal (SBM).

Fig. 4. Huts made of fiber sheet with square hollow iron pipe frame

Maggot Incubators: Incubators for production of maggots were prepared using old (discarded) over head plastic tanks (250 lit capacities) and 2" PVC pipe (Fig. 6). Incubators were filled uptothree-fourth of its capacity. Incubators were filled with wastes like rotten potato, pre-soaked maize mesh, poultry excreta, molasses to attract the flies especially Black Soldier Fly or BSF Non-usable plastic egg trays were placed on the substrates for ovipositionby fly. Each incubator was sprinkled with 1-2 lit water dailyto maintain optimum moisture level. Larva collection started automatically in tray after one week. Daily larva production per incubator ranged between 4.5-5.0 kg irrespective of treatments (Total: 18-20kg). This quantity is sufficient to feed 450-500 birds

Fig. 5.Vermi-pits

Table 1: proximate composition of earthworm (Dry Matter basis)

Sl. No.	Parameters	Percent composition
1	Crude Protein	57.32
2	Fat	6.03
3	Crude Fibre	2.59
4	Total ash	11.25
5	Sand/silica	3.02
6	Calcium	1.20
7	Phosphorus	0.60

by partial feeding of maggot @ 20g/bird i.e. besides some green fodder and earthworm feeding. By this amount birds can receive about 2.5g crude protein (Table 2,Dry matter: 30%). The larvae crawl upward and through the outlet made of 2" pipe they come out to collected in tub kept below the outlet.

Fig.6 : Incubators for production of maggot production

Table 2: Proximate composition of maggot (Dry Matter basis)

Sl. No.	Parameters	Percent composition
1	Crude Protein	44.16
2	Fat	21.33
3	Crude Fibre	4.26
4	Total ash	6.35
5	Acid insoluble ash	3.16
6	Calcium	0.70
7	Phosphorus	0.38

Moringa Plantation: Seeds of PKM-1 variety procured from authorized vendor of TNAU who was located in Bareilly market. The seeds were utilized for the growing of Moringa plantation. Approximately 306 Moringa plants were grown at 2mX2m distance from row to row and plant to plant (Fig. 7). Another high density plantation was done at 1mx1m distance. The soil was prepared as per requirement of plant. The organic manure of poultry farms available of CARI, Izatnagarwas used for preparing the **seedlings**. The seeds were germinated in nursery for preparation of seedlings. **After seedlings** attained a height of 0.20-0.30 m, they were transplanted in already prepared main field at desired distance. For feeding of birds, plantwas pruned at 0.10m below the tip when plants attained a height of about 60-90 cm. About a week later, several side branches again sprouted/developed. When side branch reached 60cm length, they again pruned to 0.30m. By doing this, it induced profuse branching and more branches gave more pods/fruits and tree size at manageable height. The fertilizer application and watering as recommended were done along with weeding. Moringa acted as good resource of green fodder as well as nutrients for the poultry birds as it is nutritionally enriched.

Seasonal fodder: Fodder production area was earmarked (half acre, 64 x34 m approx.) separately for cultivation of seasonal fodder crops like cowpea (*Vignaunguiculata*) in summer and berseem (*Trifoliumalexandrinum*) in winter.In cowpea, birds are able to consume high quality, portein foliage, green pods, immature seeds and flowers. Berseem is also a fast growing succulent, palatable legume with high quality proteineousforage that has beenharvested 3-4 timesper season and fed to birds as green chopped forage when supplemented or allowed for grazing directly in the cultivated field. Moringa plants were also transplanted at 3m interplant distance in the trench made for vermin-farming. Barseem, spinach and methi (Fenugreek) seeds were also procured. The barseem seeds were mixed with rhizobium culture before sowing through broadcasting. After plantation of barseem and Moringa the plots were irrigated.

Fig. 7.Morniga plantation in Girigram integrated system

Chaff cutter: When green fodder including moringa was supplemented in or periphery of huts, then it was in chaffed form. Chaffing was done using a manual chaff cutter.

Other Structures: Foot bath (LXWXD=3.35mx1.8mx0.10m) was constructed at the entrance of the farm i.e.at gate in which germicidal solutions are used for killing of germs entering through vehicles, human foot etc. Approximately 2.4m spaces/gaps were provided between huts, both from front and from sides for proper ventilation and brick-on-edge pathways ranging from 0.6m (in front of the huts) to 1.6m (side of huts) have also been provided. A circular hut of approx. 5.5m diameter and 1.8-2.4m height, for the sitting/resting of labourers, further added to the aesthetic value of the site.

Standard Management Procedures:

Poultry Germplasm: Low input coloured birds suitable for Traditional backyard poultry farming like CARI-NIRBHEEK, CARI-SHYAMA, CARI-SALONI, KADAKANTH, ASHIL, CARI-RED etc. were used to fulfilment of all the essential features required for efficient production under this system. The crosses like CARI-NIRBHEEK,CARI-SHAYAMA and CARI-SALONI, phenotypically look like their original native breed with two or three times more egg production with bigger size and weight, better tropical adaptability and disease resistance along with capability of bearing the stress of sub-optimal feeding and management. It is worth mentioning that the birds kept under GirigramTakinikipark passed intense winter in newly constructed low input housing as well as supplemental feeding (~40%) compared to institute farm where the birds are housed in Pacca houses with curtains and heating provisions for young birds to provide optimum environment. The body weights at different ages were comparable in both the system however, the egg production in different crosses were on lower side in GirigramTakiniki park but accordingly the investment on feed was also less comparative to intensive system where birds were given 100% compound feed. It may be expected that with increase in supplemental feeding to 50-55% the egg production may improve in GirigramTakinikipark and become comparable to intensive system level.

Feeding: Birds are fed twice daily along with scavenging for 6-8 hrs (Fig. 8). They are supplemented with chopped moringa& green fodder (50-60g), earthworm (5-10g), maggot (5-10g) etc. as per availability during morning hours. During evening hours they are suppleneted with compound feed @ 40-50g/birds.

Scavenging/grazing: The birds are being let loose, batch-wise, for scavenging during day time for about 3-4 hrs.

Other management practices: Various management practices like vaccination, egg collection and its disposal, day-to-day care etc. are being adopted as per standard procedure.

Future plans for expansion:

1. Floriculture/Horticulture: The floriculture will not only generate additional income but also help in alleviating the problems like bad odour, flies etc. In additionit will give a beautiful look to the farm premises. The following two flower plants are proposed

Fig. 8.Grazing of berseem by birds

i) **Marigold:** Approx 1000 plants of marigold will also be sown. The expected yield per plant will be about 1.5 Kg with a total of 1500 kg (15 Q) Marigold flower. The sale price of Marigold flower is about Rs 50/ kg thereby may give an expected income of Rs 75000 per year. If these flowers will be fed to birds, due to its carotene content, yolk colour will be enriched and it may also improve the health of birds.

ii) **Rose:** About 500 rose plants will be sown along the internal boundary .The expected yield of Rose flowers will be about 500kg. The sale price of Rose is Rs. 100 per Kg thereby giving an additional income of Rs 50000/- per year. Rose petals can also be consumed by the birds, therefore, it may further save the feeding cost of poultry.

iii) Teak plantation: It is also proposed that approx 100-150 teak plants will sown along the boundary for long term income generation as well as keeping sheds cool during summer months. Attempts will also be made to grow plants like Cassia tora or Turmeric and Ginger as per availability of land.

iv) Indian bean (Sem): Indian bean (*Lablab purpureus*) can ve cultivated as creeper crop on the roof of the huts for its cooling during extreme summers. The pods and leaves can be used as poultry fodder.

2. Compound feed preparation: compound feed using dried moringa leaf, earthworm, maggots, grains, cakes and other agricultural by-products will be prepared for optimization of feeding, minimization of feeding cost and improving the productivity of birds. For this a solar drier may be procured in the coming future.

3. Marketing strategy: In future, for selling the eggs, a specially designed box for 6-12 eggs will be prepared. The boxes will have emblem of ICAR and CARI. Similarly, for flowers and vermin-compost also suitable packs with emblem of ICAR and CARI will be arranged. This will be helpful in enhancing more income under this model.

Analysis and interpretations: The above said project was undertaken to develop a model of backyard poultry integrated with moringa, seasonal fodder, vermi-culture, maggot, horticulture, floriculture etc. with strategic marketing on one acre with an objective to get hands-on-estimates of cost-benefit analysis as well as to boost productivity and profitability on unit area of land. The model named as "GirigramTakniki Park" got established in the Institute premises with birds' capacity of 3000 and a capital cost of approximately 12.60 lakhs. Total six huts were erected in which 2148 birds (1437 growers & 711 adults) of pure and improved Desi chicken were stocked. Simultaneously, Moringa plant, Cowpea (summer fodder) and Berseem (winter fodder) was grown as a feeding resources of these birds. Vermi-culture and maggot culture was also undertaken for protein supplementation and further reduction in the cost of production. Whenever, there was reduction in the production/availability of any one-two components like fodder, earthworm or maggots; compound feed supplementation was increased upto 60-70g/bird. In beginning, birds were under adaptation stress of winter and there were almost 3.0% mortality (61 birds). However, after crossing this stage, all birds showed optimum growth and production with minimal mortality of about 1.5% (30 birds). Weaklings, slow growers etc. were culled in beginning and marketed at the earliest for economization of productivity. Some fertile eggs of pure Desi chicken were used for hatching purpose. Rest eggs of Pure and improved Desi chicken were sold from the marketing centre of the Institute. Since produced products under this model were nearing to organic type, therefore, optimum strategic marketing as green egg/meat may generate more income in this model. Additional cultivation efforts of floriculture, horticulture, vermin-compost etc. may boost the economic returns under this project. Selling the eggs in a specially designed box comprising 6-12 eggs along with emblem of ICAR and CARI may further increase the economic returns. It has been observed from the reports of many agencies that sale price is 2-5 times higher for green eggs claimed to be produced under similar conditions. Similarly, selling of products like chicken meat, flowers, vegetables, vermi-compost etc. in suitable packs bearing emblem of ICAR and CARI will further enhance the net income under this model.

Therefore, with holistic approach like stocking birds in full capacity, adopting and implementing all the future techniques-cum-strategies along with smart marketing may helpful in generating net income to the tune of Rs. 6-10 lakhs per annum form a well-developed model of one acre land.

Jag Mohan & Vivek Srivastava

Duck integration models under village conditions with special focus on polythene duck pond-A CARI Initiative

Gautham Kolluri[1] and Simi Girija[2]
[1]Scientist and [2]Ph.D Scholar

Duck farming

Ducks are considered important next only to chicken. With 36 million number (FAO, 2008), duck constitutes about 7 to 10 per cent of total chicken population in India of which 90 to 95 per cent is of indigenous or non-descript type. Ducks are the second largest source of table eggs, producing 16 lakh eggs besides 38 million tonnes of meat. Free range nomadic duck keeping is the popular rearing system among farming communities at village level. Indigenous ducks pave a sustainable livelihood preposition for several poor rural farmers in the country.

Among indigenous types, Chara and Chamballi (Kuttinad) ducks of Kerala, Sythet mete and Nageswari ducks of eastern regions, Desi variety of West Bengal, Pati, Deo, Cinahanh and Rah Hanh varieties of Assam are hardy with mediocre egg production. Despite, developments in semi-intensive and intensive duck raising systems, nomadic/extensive/free range system of duck production is most commonly practiced in the country. West Bengal has the highest duck population followed by Assam, Kerala, Tripura and Jharkhand. Kerala, Andhra Pradesh, Tamil Nadu, Orissa and Manipur also have a sizeable duck population with significant production. Indigenous ducks are superior in adaptability, moderate in production, and high in disease resistance, therefore suitable for different production systems. Traditional, nomadic and extensive duck farming practices were more concentrated in the regions of eastern, north eastern and southern Tamil Nadu with more than 70 per cent of total duck population concentrated in north eastern zone.

Hardy nature with mediocre egg production makes indigenous ducks highly suitable for extensive system of rearing with no requirement for elaborate housing, medical and feeding attention compared to chicken. Ducks are resistant to commonly occurring poultry diseases like Leucosis, Marek's disease, Infectious Bronchitis and other respiratory troubles despite their frequent exposure to contaminated places and this might be due to the strong innate immune response they elicit. Ducks and chicken are considered as important hosts for avian influenza virus. However, influenza virus which is highly pathogenic for chicken rarely harms ducks.

Various traditional duck production systems observed in the country are

Backyard duck production systems

Mainly practiced in rural areas where the ducks are accessed to free range areas with confinement to enclosures during night. Well utilizes kitchen and other garbage waste.

Foraging/extensive system

Extensive system of duck rearing is essentially based on the use of natural resources in the form of grassland and ponds. It is system of rearing ducks in natural resources where a biological phenomenon simulates. Post-harvest paddy field provides a means of excellent foraging system for ducks. Besides, various eco-systems like ponds, rivers, canals, homesteads and other water bodies also pose advantages.

Free range or extensive duck rearing plays a vital role in rural areas for utilization of cheap natural feed resources, like fallen paddy grains, insects, snails, earthworms, small fishes, fingerlings, tadpoles, water plants like algae etc on which they survive mostly by scavenging, thereby simulating organic farming.

Duck-Rice integrated system

Native duck rearing in extensive system with an access to pond in Tamil Nadu (Authors collection)

It became popularized in the light of organic farming. This provides a dual beneficial role in which ducks clear the insects, snails, weeds in rice fields by feeding on them. They also enrich the rice fields with their excreta as manure thereby preventing the use of chemical fertilizers and pesticides for a beneficial ecological system. Water stirring caused by their activity inhibits the growth of weeds through photosynthesis reduction when the water becomes turbid. Their activities also enhance the rice root, stalk, and leaf development, thereby accelerating rice growth by through increased availability of nitrogen, phosphorus and potash. Around 200-300 ducks size/hectare of paddy field is a good fit. It can be increased in case of excessive weeding persists.

Rice duck technology causes the reduction of methane emissions from rice cultivation, subsequently global warming. ICAR-CARI, RC Bhubaneswar has initiated duck rice integration in collaboration with ICAR-Central Rice Research Institute, Cuttak. Following brooding, ducks are allowed to graze in the rice field after one month of rice plantation till harvesting. Ducks are used to remain in rice fields for 5-6 hrs daily. Also tend to increase the productivity of rice by 20 per cent and net profit to the farmers by 50 per cent. CARI model of duck rearing in polythene ponds and rural duck production has achieved success in income generation by rural women.

This system comprises of simultaneous rearing of ducks and fishes with mutual co-operation in which the fish benefits from duck manure that increases the algae and plankton (fish feed), while ducks survive with drinking and combating heat stress. Ducks are generally housed at the banks of ponds or floating shelters on water. Fishes of more than 10 cm length are preferred for this integrated system to avoid predation by ducks. Carps, tilapias and catfish with a stocking density of 50, 150 and 400 respectively are usually employed with 70 ducks of different age groups per 100 sq. m pond area. At the harvesting time, around 45-50 kg of fish can be obtained. This technology is the most profitable, since it provides cheapest animal protein in form of eggs, meat and fish at same time. Ducks are considered as living manuring machines with 25% organic matter with several elements like carbon, phosphorus, potassium, nitrogen and calcium. Integration of Chara and Chemballi ducks with Catla, Rohu and Mrigal initiated by Central Plantation Crop Research Institute (CPCRI) in Allepy, Kerala has led the farmers with profits. Duck fish integration has been practiced in Andhra Pradesh, Bihar, Karnataka, Orissa, Tamil Nadu, Tripura and West Bengal with majority led by Indian runners.

Duck rice integration system (Source: Practical Action) ***Duck-fish integrated system***

In the era of semi intensive and intensive poultry systems, duck farming still remains unchanged as dominant traditional system and suffers from marketing problems from beyond the farm gate and before the product reaches the consumer's plate. Marketing of duck products is associated with a unique set of conditions which make it highly risky that includes the perishable nature of the produce handled and prevalence of relative imperfection in the marketing mechanism.

Polythene pond rearing system

Duck fish integration-KVAFSU Model (Source: CASM, Palakkad, Kerala)

ICAR-CARI, Regional Center, Bhubaneswar has developed a breakthrough technique in duck rearing under Indian conditions. Polythene Pond rearing system eliminates the need for natural pond or river and ducks can be well managed anywhere by creating this artificial pond.

Pond preparation: A uniform pit with 1.5-2.5 ft depth can be dug on the ground to a dimension of 6ft x 4 ft and 5ft x 5 ft to achieve rectangular and square layouts respectively. This can facilitate at least ten adult ducks. Around 300 lit of water are required to fill the pit and half of water needs to be changed for every 10-12 days. The inner sides of the pond are completely lined with thick polythene sheets of 7-8 ft width. The outer edge of the sheet should be properly secured using large stones to avoid slipping of sheet inside, while filling with water. It can also be integrated with the surrounding ground in the soil.

Polythene Duck Pond-CARI MODEL (Source: ICAR-CARI Exhibition grounds)

Polythene Duck Pond In Practice At Village Conditions (source: The Hindu)

Duck tyre pond suitable for rearing of ducklings (Source: Pinterest, Garden ideas)

Summary

The increasing cost of feed, labour and maintenance is forcing turkey and broiler breeders to consider a more economical way of poultry production like artificial insemination (AI) technology. This technique has enabled the rapid dissemination of genetic material from a less number of superior males to a high number of females. Excellent fertility in poultry can be obtained by AI than natural mating. For the successful application of this technique good quality of semen samples collected from birds on alternate days basis, evaluated skilfully, diluted in proper diluent (species specific) with the desired number of sperm and inseminated to a depth of 2-4 cm in vagina *or nearer to sperm storage tubules (SSTs)* yield *an optimum fertility of eggs laid daily in succession by chicken hens for a week. Doses of spermatozoa /AI increases with the fresh to store or semen obtained from aged bird. Quality* evaluation of semen gives an excellent indication of the male reproductive potential and has been reviewed as a major determinant of fertility and subsequently hatchability of eggs. *Among the several factors that influence the semen quality,* sperm motility is a primary determinant of fertility in domestic fowls; however, visual examination of semen cannot be ignored for successful AI under field conditions. Dilution of low and viscous volume of avian semen is essential for handling and storage, enabling it to transport at distant farm for insemination of large number of hens. Currently, the technique of AI in most of the poultry species is well developed; however, there is a need for successful development programme of this technique in non-domesticated birds to assist in creating viable, self-sustaining populations of critically endangered species which are at the serious risk of extinction as vultures in India.

Background

Presently, birds are competing with human beings for food grains; thereby, the production cost of poultry is rising day by day. Hence, AI has been considered valuable tool for the poultry industry (Benoff*et al.*, 1981) due to the efficient utilisation of males, which is not possible under natural mating. This, in turn, decreases the cost of poultry production directly by reducing the number of cocks needed for male gamete production (Benoff*et al.*, 1981).Since 1960s, the AI technique has emerged as the most critical component of reproduction in turkeys and it is used almost exclusively for commercial flock production. The differences in the size of toms (large white strains of approximately 33 kg) and hens (approximately 9 kg at the onset of lay) which result in unsuccessful mating and consequent low fertilisation of the heavy broad-breasted strains after natural mating has forced the adoption of AI in commercial poultry production (Lake, 1983; Donoghue and Wishart, 2000). AI is also getting momentum in other poultry species. For example, as fertility in broiler breeds continues to decline as males are selected for growth, AI may become cost-effective in broiler breeder management (Reddy, 1995). Presently there is a need for successful development programme of AI in non-domesticated birds to assist in creating viable, self-sustaining populations. The component of successful application of the AI like semen collection, evaluation, dilution, storage, insemination of hens, timing of insemination, storage temperature, sperm doses/insemination and frequency of semen collection and insemination have been discussed .

Semen collection

To successfully perform the AI programme, a clean semen sample of sufficient volume is required regularly. The ancient method of semen collection allowed the cock to mate with hen; subsequently, hens were killed and semen was surgically collected from the oviduct. This method was very harsh and it forced the development of the current method of semen collection termed "abdominal massage method", as described by Burrows and Quinn (1937). This involves two persons and is very common for semen collection in chickens and turkeys. A two-person technique was also used for semen collection in pigeons (Klimowicz*et al.*, 2005). The erection of the copulatory organ and the ejaculation reflex in turkey, domestic fowls, guinea fowl (Lake and Stewart, 1978), quail (Marks and Lepore, 1965) and pheasant (Spiller *et al.*, 1977) occur simultaneously in response to the massage and the major portion of the spermatozoa are obtained in the first ejaculate. Adaptations of the massage method have been made for other avian species like waterfowls (drakes) which have a penis like copulatory appendages (Nishiyama*et al.*, 1976). In Japanese quail, the technique of semen collection was applied by Shit *et al.* (2010) and this requires the removal of foamy substance from the cloacal gland before semen collection by massaging. Several factors viz., age, season, lighting schedule, body weight, nutrition, management and spermatogenesis influence semen collection, quality and fertility of birds (Maule, 1962; Sturkie, 1986; and Mohan *et al.*, 2016). In addition, endocrine disruptors particularly bisphenol-A showed to have compromised sperm quality attributes (Singh *et al.*, 2015; 2016). Semen collection from cocks may also be influenced by handling of the birds and the training of the operator (Cooper, 1965). Male birds need to be routinely trained for semen collection for several days prior to the actual date of AI application to guarantee the good quality of semen. As the bird's phallus is located very close to the anus in the cloacal region, it enhances the probability of faecal contamination of the semen. Therefore, to collect clean semen samples, feed should be withdrawn 12 h prior to semen collection.

Frequency of semen collection

The rate at which semen is collected determines the success of AI. The number of good quality spermatozoa in a semen sample inseminated into a hen is one of the important factors determining the fertility level obtained by AI. It is important to note that the proportion of naturally degenerating spermatozoa in the vas deferens increases with long rests between semen collections. These spermatozoa in the vas deferens are reabsorbed by certain lining cells, a process termed vasoligation (Tingari and Lake, 1972). Thus, for a consistent supply of good quality semen during the breeding season, semen should be collected from males at a particular frequency. The collection frequency varies among breeds and species. A thrice weekly frequency (alternate days) maintained the optimum output of spermatozoa, resulting in good fertility in chickens (Lake and Stewart, 1978), while in Pekin breeder ducks two collections were shown to yield better results (Nahak*et al.*, 2015).

Evaluation of semen quality

In poultry, the quality of semen is an excellent indicator of reproductive potential of birds and has been reported as a prominent determinant of fertility and hatchability of eggs (Peters *et al.*, 2004) and is the major basis of profitability of poultry enterprises. There are two major reasons for the evaluation of semen quality in an AI programme: firstly, to ensure that only males producing semen of good quality are kept in the farm and secondly, to know the concentration of spermatozoa and the volume of semen, so that calculations for the appropriate dilution can be made to obtain 80–100 million spermatozoa/insemination. In 1960s and 1970s, inseminations were based on the semen volume/dose; in the 1970s and 1980s, inseminations were based on the number of sperm cells/dose; and in the late 1980s and in 1990s, inseminations were based on the number of viable sperm cells/dose (Van Wambeke and Huyghebaert, 1989). Determining sperm concentration has several advantages: it not only provides a basis for calculating the number of sperm/insemination dose but also serves as a measure of semen quality (Bakst, 1993; Senger, 2003). Semen collected from domestic cockerels contains an average sperm concentration of 5 billion sperm cells/ml (Gordon, 2005), whereas Hafez and Hafez (2000) reported 3–7 billion sperm cells/ml. Sperm motility is an indicator of live sperm and of the quality of the semen sample. Evaluation of sperm motility is conducted with fresh and diluted semen and generally analysed under the light microscope (100× magnification) (Hafez and Hafez, 2000). Sperm motility is a primary determinant of fertility in domestic fowls (Donoghue *et al.*, 1998). However, visual examination of semen cannot be ignored (Peters *et al.*, 2008). A semen sample of good quality is thick and pearly white in colour indicating a high concentration (Cole and Cupps, 1977). Appearance of any other colour is an indicator of contamination. Yellowish and green-coloured semen is indicative of faecal/urine contamination (Lake, 1983). A brownish red pigment or reddish colour demonstrates the presence of blood (Etches, 1996). However, the semen of domestic fowl ranges from a dense opaque suspension to a watery/transparent fluid (Hafez, 1978; Mohan and Moudgal, 1996). An excess of transparent fluid in semen was found detrimental to spermatozoa, as it is rich in calcium ions and cause clumping (Mohan and Moudgal, 1996). The morphology of spermatozoa can serve as a good tool to evaluate semen quality and shortcomings in the male. Blesbois (2007) described an eosin-nigrosin staining technique to examine the morphology of cockerel semen. Only morphologically normal spermatozoa are capable of ascending through the vagina of the hen to the region where the *sperm storage tubules* (SSTs) are located (Bakst *et al.*, 1994). Several physical and biochemical tests are also available for the evaluation of semen (Peters *et al.*, 2008; Biswas *et al.*, 2009; Mohan *et al.*, 2011; 2013). Computer-assisted sperm analysis (CASA) has been used by several researchers (Cerolini*et al.*, 2008; Santiago-Moreno *et al.*, 2016). Biochemical examination indicated a lower superoxide dismutase activity in turkey semen than in chicken semen suggesting that turkey sperm is more susceptible to oxygen toxicity during *in-vitro* storage (Froman and Thurston, 1981). Brown *et al.* (1971) examined several enzymes in spermatozoa and selected the release of glutamic oxaloacetic transaminase (GOT) as the best indicator of cell damage. Recently, RNA transcripts were developed as potential biomarkers of male fertility of mammalian species including chicken and protocol was standardized for isolation and purification of RNA from chicken spermatozoa (Shafeeque*et al.*, 2014).

Semen diluent and storage temperature

Semen diluents are the buffered salt solutions designed to dilute or extend the semen, maintaining the viability of spermatozoa by providing optimum environment and thereby escalating the number of insemination doses from a given volume of semen (Vasicek*et al.*, 2015) besides ensuring uniform distribution of spermatozoa in diluents. The composition of semen diluents are based on the biochemical attributes of poultry semen (Lake, 1995) and provides osmotic pressure (330–400 mOsm) and pH (7.0–7.4) identical with the seminal plasma (Thurston 1995; Miškeje*et al.*, 2013). Development of diluents initially began with the simple use of NaCl solutions followed by complex diluents containing osmotic regulators, energy substrates and buffers (Bootwalla and Miles, 1992). Some of the notable diluents for 24 h storage are Lake diluent (Lake, 1960), Beltsvillie Poultry Semen Extender (BPSE) by Sexton (1977), EK extender (Lukaszewicz, 2002), Tselutin extender (Tselutin*et al.*, 1995). Despite their enormous success in poultry industry, these diluents are reported to have wide range of variations in fertility. Recently developed CARI poultry semen diluent (Mohan *et al.*, 2017b) has been shown to have better fertility than previously described in various poultry species under study.

Generally, a low temperature (5°C or lower) has been accepted for storage of semen. This seems logical in view of the lowered metabolism of spermatozoa at this temperature. In any event, a refrigerator temperature of 2–5°C is attractive under practical conditions (Sexton, 1977; Van Wambeke, 1978). Brillard (2009) stated that, for long storage periods, semen should be subjected to low storage temperatures, ranging from 4-10°C. However, a lower temperature particularly 0°C should be avoided. Donoghue and Wishart (2000) advocated that for good fertility of stored semen ***in-vitro*** has to be preserved at 2–8°C. Slanina*et al.* (2014) found that turkey sperm can be stored at 4–8°C. Mohan *et al.* (2017a,b,c) stored chicken semen for 24 h at 7–8°C with very good fertility.

i) Dilution rate of semen

A 2-3 fold dilution (moderate dilution) is considered to be the optimum for *in-vitro* storage of chicken semen. A high dilution rate (above 5-fold) shortens the life span of spermatozoa by stimulating sperm motility and metabolic activity (Sexton, 1979; Parker and McDaniel, 2006). Hence, a high dilution of semen is not practical to use. In contrast, semen diluted at a low level (below 1:1) does not survive during storage at low temperature (Sexton, 1979). Recently, Mohan *et al*. (2017c) preserved chicken (WLH) semen in CARI poultry semen diluent for 24 h with different dilutions, *i.e.* 1:1, 1:2, 1:3, 1:4 and 1:5. Superior fertility (91.07±1.91%) was observed with the dilution rate 1:2 (89.10×10^{6}sperm/AI) whereas inferior fertility noticed with 1:1 (76.93±2.54%) and 1:5 (49.40±2.54%) during the fertile period of 1–5 days after AI. Beulah (2017) used freshly ejaculated diluted chicken semen in CARI diluent with dilutions of 1:2 to 1:20 under the same duration of fertile period and noticed a fertility higher than 90% up to 1:8 dilution (29.70×10^{6} sperm/insemination dose), whereas a fertility of 77% was observed at 1:20 (12.71×10^{6} sperm/AI).

Artificial Insemination (A.I) of hens

During natural copulation in fowls the semen is probably deposited by the cock in the shallow position in the vagina of the hen. During the AI, it is necessary to evert the distal part of oviduct (vagina) and deposit the semen to a depth of 2–4 cm (or as close as possible to the sperm host gland) to produce an optimum fertility of eggs laid daily in succession by hens for a week. Usually, chicken semen is inseminated at the depth of 2–3 cm in the vagina (Artemenko and Tereshchenko, 1992). Sometimes insemination can be made at the depth of 3–4 cm (Kurbatovet al., 1984). Insemination to the depth of 5–6 cm in chicken implies penetrating the uterus with the syringe. This type of insemination is detrimental to the health of birds and reduces fertility (Artemenko and Tereshchenko, 1992). After obtaining good semen samples, the actual insemination of the hen can be performed by involving a team of two persons (Quinn and Burrows, 1936). One person applies the proper pressure on the left side of the abdomen so that the hen everts (turns inside out) her vaginal orifice through the cloaca. This procedure is termed as cracking, venting or everting the hen. At the same time, the semen is deposited by the second person to a depth of 2–4 cm into the vaginal orifice concurrently with the withdrawal of pressure on the hen's abdomen. Insemination can be done with sterile straws, syringes or plastic tubes. In large scale commercial operations, automated semen dispensers using individual straws loaded with a set volume with the desired sperm concentration (AI dose) are commonly used. If hens are accustomed to egg production, it is relatively easy to evert the oviduct. The depth of insemination depends upon the species of the bird and length of the vagina. Avian spermatozoa are normally inseminated into the vagina from where less than 1% of the sperm enters in to the SSTs located at the utero-vaginal junction (Bakst et al., 1994).

i)Timing of AI

The time of the day at which insemination is performed both for artificially or naturally mated chickens, plays a significant role on fertility. In the evening, the incidence of the hard-shelled eggs in the uterus of the hens is rare. Hence, inseminations performed in the afternoon or evening yield higher fertility than those performed in the morning (Christensen and Johnston, 1977; Aisha and Zain, 2010). The presence of hard-shelled eggs in the uterus of the hens at or near the time of AI causes a decrease in the level of fertility. Most of the spermatozoa inseminated in chickens and turkeys within 1–3 h prior to or just after oviposition are eliminated by the contraction of the vagina involved in the process of oviposition (Brillard and Bakst, 1990).

ii) Doses of sperm and frequency of insemination

To maintain a constant high level of fertility throughout a breeding season a minimum number of good quality spermatozoa must be inseminated at regular intervals. The interval depends upon the type of bird but is generally about one week under farm conditions. If the interval between inseminations is extended beyond one week, the fertility declines significantly (Sexton, 1977). The hatchability of eggs is also reduced due to a greater incidence of infertile eggs and gradual increase in early embryonic mortality. The latter may in part be due to ageing spermatozoa in the oviduct (Lodge *et al.,* 1971; Lodge *et al*., 1974). For hens inseminated at weekly intervals, moderate doses of semen (80–100 million spermatozoa) can be sufficient to obtain consistent levels of high fertility in chicken (Lake, 1983; Tabatabaei, 2010). No advantage is gained by inseminating more than 100 million fresh, good quality spermatozoa into a female at any one time (Lake, 1983). When the semen is stored for 6 h at low temperature, 125–150 million spermatozoa should be inseminated *per* hen *per* week (Van Wambeke, 1987). Approximately 200–250 million spermatozoa were required to produce high levels of fertility with fowl semen stored after 24 h at 2-5°C (Van Wambeke, 1978; 1987). Mohan *et al.* (2017c) achieved high fertility (91.07±1.91%) after 24 h storage of chicken semen by inseminating 89.10×10^{6} sperm/AI. In old hens, single weekly doses as high as 250 million spermatozoa were inadequate to maintain fertility at levels similar to those observed in young hens (Brillard and McDaniel, 1986). It is well evident that the hen's requirement for spermatozoa increases with age. Using deep-frozen semen, the same number of spermatozoa/insemination ensures a great security margin for fertility (Van Wambeke, 1986).

JS Tyagi and Gautham Kolluri

Background

The three R's - reduce, reuse and recycle – is the need of the day to have neat and clean surroundings besides to cut down on the amount of waste we generate every day. This will help in to conserve natural resources, landfill space and energy. During 2015-16, poultry sector in India is valued at about ` 80,000 crore and was broadly divided into two sub-sectors –highly organized commercial sector (80%) and unorganized (20%). The unorganized sector also referred to as backyard poultry plays a key role in supplementary income generation and family nutrition to the poorest of the poor. It is estimated that with a poultry population of 729 million (30% layers at around 215 million and 40% broilers at around 480 million) small and medium farmers are mostly engaged in contract farming system under larger integrators and there are around 30 million farmers engaged in backyard poultry as per 19th livestock census. The needs of organized and unorganized sectors are very different. Due to low space and low capital requirement and fast return in comparison other business poultry farming is getting popularity among rural youth as a source of additional income. State and central governments are also promoting poultry farming to alleviate protein mal-nutrition as well as to create more employment to the rural population.

Additionally, poultry plays important social and cultural roles in the lives of rural people. The output of village poultry is lower than that from intensively raised poultry in commercial production systems, but it is obtained with minimum inputs in terms of housing, disease control, management and supplementary feeding. Village poultry have many advantages in mixed farming systems as they are small, reproduce easily, do not need large investments and can scavenge for food. Chickens are the most common species, but mixed flocks including species such as ducks, geese, turkeys or guinea fowls also often reared.

Under backyard poultry production the farmers have to buy young chicks form local vendors as commercial hatcheries only supply chicks in bulk .It has been observed some- times that the quality of such chicks is very substandard and this cause poor growth and egg production besides heavy mortality. If farmers have any provision for producing the chicks on their farm they could have probability of comparatively higher income. This is only possible through own chick hatching facilities by having egg incubator/s. Unfortunately, incubators suitable for rural conditions are not easily available, if at all available in the market are very expensive. Commercial incubator having hatching capacity of about 400 eggs usually cost more than ` 60,000. The poor farmers, who are inclined to adopt rural poultry for their livelihood have neither resources nor access to procure the costly incubators. Therefore need was being felt since long for cheaper, robust and locally made equipment which can fulfil the local demand and make new rural poultry technology viable for promoting self-employment. Keeping in mind the requirements of poor rural people and the three R's concept, a **Low Cost Poultry Incubator from "Recycled Waste" was designed and fabricated.**

Low cost poultry incubator

This technology offers an effective alternative to the costly incubators utilizing the scrap produced in the form of discarded consumer durables such as refrigerators with required modifications. A low budget incubator has been fabricated utilizing the waste material capable of hatching 400-500 chicken eggs. The required components can be easily sourced to fabricate these low cost incubators suitable for rural poultry farming on DIY (Do It Yourself) basis. The main feature of this technology is that it does not require complex technical knowhow and costs meagre amount of ` 5000-6000.

Key Features of **Low Cost poultry incubator from recycled waste**

I. Dedicated to the development of rural specific poultry simple incubator.
ii. Designed on DIY (do it yourself) principal.
iii. Use of discarded refrigerator body only.
iv. Both egg setting and hatching activities simultaneously.
v. Use of fresh air fan with little modifications.
vi. Ordinaries clinical thermometers.
vii. Modified digital temperature controller.
viii. Simple designed heater.
ix. Simple provisions for maintaining humidity.
x. Simple provision for manual turning of eggs.
xi. Provision for running on DC/AC supply.
xii. Less than 300 watt power requirements.
xiii. This may run on invertor /battery / solar panel.
xiv. Results: Hatchability more than 85% on fertile egg basis.
xv. Cost 5000 approximately.

Recommendation:

- Our low cost CARI rural poultry incubator can suffice the setting of 400 chicken eggs and may be operated even on solar panel/inverter/battery by poor rural poultry farmers in villages on Do it yourself basis and attains hatchability of 85% approximately.
- This incubator can be developed from discarded refrigerators (an initiative of Swacch Bharat) with as low as **Rs. 8000/- per unit** can be used by poultry farmers in rural areas. Our proposed technology will also address the problem of quality chick availability in smaller quantity in remote villages which are fragmented rural areas by and large infeasible to be catered by larger hatcheries.

Potential of technology

- This technology offers an effective alternative to the costly incubators utilizing the scrap produced in the form of discarded consumer durables such as refrigerators with required modifications. A low budget incubator has been fabricated utilizing the waste material capable of hatching 400 chicken eggs. The required components can be easily sourced to fabricate these low cost incubators suitable for rural poultry farming on DIY (Do It Yourself) basis. The main feature of this technology is that it does not require complex technical knowhow and costs meagre amount of **Rs. 8000**.

Calculating economics of CARI rural poultry incubator vis-à-vis commercial incubator

	CARI Incubator	Commercial incubator
Selling cost	Rs.8000	Rs.69000
Capacity for chicken eggs	400	400
Stage of eggs to be incubated	Multi-stage incubator (eggs of different stages or embryonic age can be incubated simultaneously and hatch successfully	Multi-stage incubator (eggs of different stages or embryonic age can be incubated simultaneously and hatch successfully

Suitable for poultry	Suitable for all poultry species *viz.*, commercial, native chicken, Japanese quail, guinea fowl and turkeys.	Suitable for all poultry species *viz.*, commercial, native chicken, Japanese quail, guinea fowl and turkeys.
Turning	Manual	Automatic
Accessories	Temperature and humidity sensors, removable fan and indicator lamps	Temperature and humidity sensors, removable fan and indicator lamps
Automatic cut off function	yes	yes
Spare kit	Not required	Required
Installation	Do it yourself	Requires technician
Compatibility on battery/inverter/solar panel	Compatible	Not claimed
Wattage	300	498
Consumption of electrical units for incubation-hatching cycle (22 days)	Approx.. 100 units	Approx. 200 units
Approx. operating cost @ approx. Rs.5/unit	Rs. 500/-	Rs. 1000/-
Total cost of production for hatching one chick (operating cost) and considering 85% hatchability	Rs. 1.50/-/chick	Rs. 3.0/-/chick

With our proposed technological intervention (CARI rural poultry incubator), a farmer can save nearly 50% production cost of hatching chick.

Principal outcome

Functionality assessment of low cost rural poultry incubator to complement the artificial insemination technology for a better reproductive and productive efficiency

Cost of available commercial incubators for hatching of poultry eggs is formidable for small poultry farmers/entrepreneurs especially in the rural set up where mostly native poultry or their improved versions are reared in semi-intensive/ free range systems. Availability of quality chicks in smaller quantities in remote villages is a real challenge as these far flung and fragmented rural areas are by and large infeasible to be catered by larger hatcheries. Therefore, the solution lies in providing a smaller and cheaper/affordable version of incubator which can be easily operated in rural set up without sucking on resources be it financial, energy or technical resource.

To complement our economic artificial insemination technology in terms of better fertility, embryonic growth and successful hatching of eggs, a low cost poultry incubator was designed and developed. Discarded refrigerators were collected and processed with an intact insulated cabinet. The cabinet was restructured into a forced draft incubator with provision of fan, temperature and humidity controlling system, air inlet and outlet, tray holders with manual turning mechanism. The overall wattage of the unit was less than 300W. The designed incubator was assessed for its functionality in terms of hatch of fertile percent and hatchability on total egg set basis during winter and summer seasons. Hatching eggs of different poultry species, white leghorn chicken eggs, broiler breeder (CARIBROVISHAL), native/desi chicken and diversified poultry species (quail, turkey and guinea fowl) produced as a result of our artificial insemination experiments were incubated as per their respective incubation periods. The hatchability on fertile egg set basis (FES) in broilers ranged from 88.15 to 92%. While in layers (White Leghorn), it was 62-87.18%. Hatchability in guinea fowl and turkey species was observed as 50 and 72% respectively (Tyagi and Kolluri, 2019).

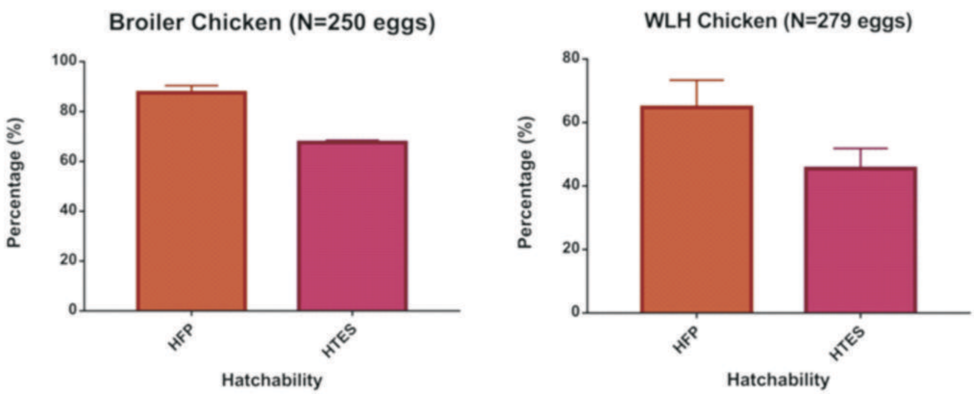
Conclusion: *The proposed low cost rural poultry incubator can be developed from discarded refrigerators and can manage setting of 400 chicken and 1000 quail eggs with success rate of 88.15 to 92% hatchability.*

Technological highlights:

CARI RURAL POULTRY INCUBATOR

- Capacity eggs- 400 chicken and 1000 quail eggs
- Designed on DIY (do it yourself) principle.
- Use of discarded refrigerator body only.
- Both egg setting and hatching activities simultaneously.
- Use of fresh air fan with little modifications.
- Ordinaries clinical thermometers.
- Modified digital temperature controller.
- Simple designed heater with provision of humidity controllers and manual turning of eggs.
- Provision for running on DC/AC supply.
- Less than 300 watt power requirements.
- Runs on invertor /battery/solar panel.
- Upto 90% hatchability on FES basis.
- Cost ₹ 8000 approximately.

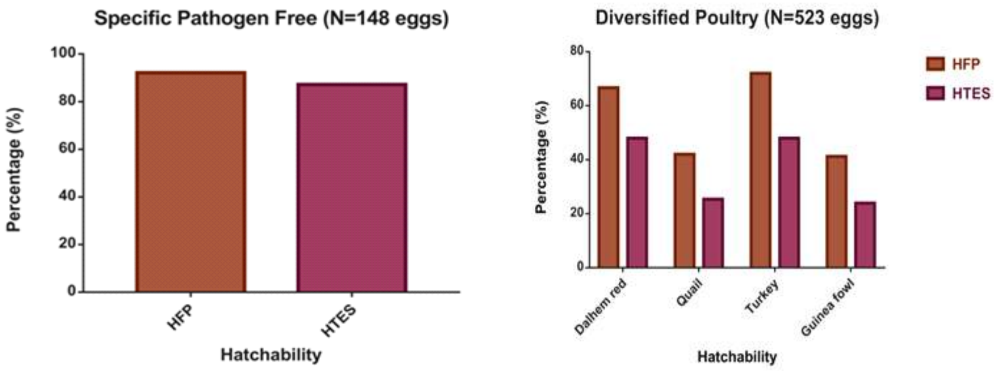
Fig. 2. Front view of Rural poultry incubator fabricated from discarded refrigerator



A B

With our proposed technological intervention (CARI rural poultry incubator), a farmer can save nearly 50% production cost of hatching chick. Considering, the meat producing broiler chicken population of 2812 millions (BAHS, 2019), the production cost using CARI rural poultry incubator is Rs. 1.5/- per chick The total

Fig.2. Hatchability and hatch of fertile percent performance on total egg set (TES) basis A. broiler breeder (CARIBROVISHAL) and B. layer (White Leghorn) breeder chicken hatching eggs produced by aritifical insemination using our low cost CARI rural poultry incubator



A B

Fig.3. Hatchability and hatch of fertile percent performance on total egg set (TES) basis A. specific pathogen free chicken (outsourcing from commercial company) and B. diversified poultry species hatching eggs produced by aritifical insemination using our low cost CARI rural poultry incubator.

cost that can be witnessed only in broiler chick production in the country is Rs. 1.5×2812 millions = Rs. 4,218/- millions and for commercial incubator it would be just double Rs. 3.0×2812 millions = Rs. 8,436/-. **This**

Formulating efficient and cost effective rations for poultry

Avishek Biswas

Feed and feeding represent about 70-75% of the cost of poultry production. As the costs other than that of feed are very difficult or even impossible to cut down, feed cost becomes major means for manipulation for profitable animal production. Moreover, poultry strains of high genetic potentiality are employed in well-organized farming system. Efficiency in feeding is also one of the key factors for successful poultry production. If feed is prepared in home one is sure of its quality. Moreover, home-prepared feed will be cheaper if raw materials are available in local market. A balanced ration is one that supplies all the nutrients in proper quantity and proportion that are needed to support optimum growth, egg production and health. A least cost balanced ration is formulated at low cost with out affecting nutrietive quality. The nutrients are the basic components of a ration which are supplied/adjusted by adding different feed ingredients, supplements and additives at different concentration. Therefore, composition of a balanced ration include both the composition of feed ingrediets as well as for nutrients especially of critical nutrients. For the purpose of feeding the nutrient composition is more important provided the socially acceptable ingredients are added at a quantity that does not exert any toxic effect on the body and not reduce accetability to the animals and farmers.Thus, feeds are formulated with the basic concept that all the nutrients are essential but not all ingredients or a particular ingredient is erssential. The components can be divided into compulsory (nutrients) and feed additives which are optional and added for specific purpose.

Feed formula is the details of ingredient and chemical constitution of a balanced ration obtained after a series of calculations. Feed formulation is an art but practical low cost feed formulation requires skill and good knowledge in poultry nutrition. A balanced ration is one that supplies all the nutrients in proper quantity and proportion that are needed to support optimum growth, egg production and health. A least/low cost balanced ration is formulated at low cost with out affecting nutrietive quality. The components of a balanced ration are carbohydrates, proteins and amino acids, fat, vitamins and minerals. The energy present in the feed is the effect of carbohydrates and fats. The optional components are feed additives like antibiotics, antioxidants, anti-stressors, drugs, etc.

Carbohydrates (starch, sugars and non-starch polysaccharides) are the largest component of the ration. The cereal grains and cereal by-products are major sources of carbohydrates followed by pulse and pulse byproducts, and vegetable protein meals/oilcakes. The protein sources are divided into two categories:

1) Vegetable protein supplements like soybean meal, ground nut oil cake, mustard/ rapeseed meal, sesame meal, sunflower meal, safflower meal, cottonseed meal, cluster bean meal, roasted cluster bean meal, rice gluten meal, maize gluten meal, dried distillery grains with soluble, etc. and

2) Animal protein supplements like fish meal, meat meal, meat-cum-bone meal, blood meal, liver meal, feather meal, etc.

The feed that is to be formulated should have at least 3% oil to meet the requirement of essential fatty acids and for absorption of fat soluble vitamins. Moreover, preparation of high-energy diet requires supplementation of fat or oil. The feed intake is decreased with increased energy concentration in diets and thus better feed efficiency is obtained when fat is added. Fat also reduces heat increment especially in summer, reduces the toxicity of aflatoxins and tannins, fat has extra- calorific value, increases palatability of diet and facilities operation of feed meal and in pellet making. However, the cost of feed is increased as fats and oils are costlier.

The requirements of vitamins and minerals are met though supplementation of vitamin premixes and mineral premixes. Two types of vitamin premixes are available in the market. One premix supplies vitamin A, D_3 and riboflavin sometime vitamin E and K in addition. The other premix supplies B complex, vitamin E and vitamin C. Choline (choloine chlotide 50%, 60% or pure) is also added separately. The minerals can be met by two ways i. e. either by supplementing mineral mixture (salt free) specially made for poultry or by supplementing calcium carbonate, dicalcium phosphate and trace mineral premix. The trace mineral premix can be prepared or procured from market. The later will reduce the cost. Salt is added separately in ration @ 0.3% -0.35%. Vitamins and minerals cost 5-8% of total feed cost. Feed additives are added for specific purpose as optional. Antibiotics and anti-stressors are added to reduce the mortality. Certain antibiotics also promote growth. Coccidiostat must be added if the young birds are being reared on litter. However, if the litter is sufficiently dry, the coccidoistats may not be required.

1. **Anti-oxidants:** When high-energy diets are prepared by addition of fats/oils antioxidants must be added to prevent rancidity and destruction of certain feed components by oxidation.
2. **Antibiotic supplement:** Certain rations, such as those used for broiler feeding, include a small amount of antibiotics as a growth stimulator. However, the antibiotics used for therapeutic purpose, should not be used as feed additive i. e. therapeutic antibiotics should be distinct from additive antibiotics.
3. **Coccidiostats:** Suitable coccidiostat (s) must be added if the young birds are being reared on litter. However, if the litter is sufficiently dry coccidoistats may not be required.
4. **Others:** Certain additives may also be added include pigments (xanthophylls in layer diet), probiotics, probiotics/ oligosaccharides, enzymes, drugs, toxin binders, anti-stressors, herbal liver or immune stimulants, etc. They are used only under certain conditions.

Certain points to be consider for ration formulation.

- ✓ The requirement of nutrients of birds for a particular functional purpose.
- ✓ The local availability of ingredients to meet such requirements.
- ✓ Quality of such ingredients as quality of finished product can only be achieved if the quality of raw material is good.
- ✓ Nutrient composition of available feed ingredients, and their cost. Cost per unit energy or protein is more important than cost as such.
- ✓ There is need to have a comprehensive knowledge on different feed ingredients that are used in feeds; their nutritional merits and demerits including effective or safe inclusion level, nutrient supply, palatability, anti-nutritional factors, bulkiness, etc.;
- ✓ Alternate feed ingredients to be selected in scarce of conventional ingredients, their safe or effective level of inclusion in feeds and compatibility with other feed ingredients that are mixed in diets.
- ✓ Moreover, the ingredients should not have tendency to segregate from each other when mixed and presented in the form of mash, and should assure keeping quality when stored. It becomes difficult to meet energy requirements as specified by NRC or ARC. However, the NRC specification if

translated to low energy may be beneficial.

There are different methods for feed formulation. However, the hit and trial method is better than even a small calculator can perform any method and it or in computer using Microsoft excel. Whatever the method is, first energy and protein requirements are adjusted. Then the limiting micronutrients are calculated. The limiting nutrients are supplemented. Feed formula needs revising depending upon change in bird's performance, availability, cost and composition of feed ingredients.

The ingredients are weighed and ground to appropriate particle size individually one by one. The vitamin, mineral and amino acid supplements, drugs, and other feed additives are first premixed with some quantity say one kg ground maize by thorough mixing. Then more maize is added and mixed. The process is repeated till the mixture is 5 to 6 kg.

If mixer is available, then the ingredients are added one by one in the mixer and the premix in between. The mixer is run for 6 to 7 minutes; time may change in different mixer, for complete mixing. If mixer is not available, it can be mixed on floor. The ingredients are arranged in layers according to amount, the largest ingredient at bottom and premix on top. Then the ingredients are mixed by hand/shovel for at least three times. The mixing should be proper. The basic principle of mixing is that any sample of the mixed feed should represent the composition of feed formula. Otherwise the birds will enjoy both feast and famine.

The physical quality of feed is adjudged from appearance of the feed. The feed should be free-flowing, fresh look, acceptable smell, and dustless. On press in mist it should not adhere. The nutritional quality is adjudged by feed efficiency and quality testing in laboratories. The poultry keepers should have a record on feed intake and body weight gain achieved in broiler on sale and number of eggs laid in case of layer. If feed intake remains within the range of 1.6-1.8 kg per kg gain in broilers, the feed is of good quality. Similarly the daily intake of feed should be 110 g per bird per day, or 130g per egg or 1.60 kg feed per dozon eggs.

Different efficient feed formulation method

❖ Pearson's square method

This is a simple technique of feed formulation that helps in achieving one desired nutrient by mixing two ingredients. Suppose, a feed mixture containing 18% CP is to be prepared by mixing soybean meal (CP 49.9%) and maize grain (CP 10.2%). Here the desired content of the nutrient (in this case CP) is written in the middle of the square. Then the values are deducted diagonally (40.9 – 18 = 22.9 or 10.2 – 18 = - 7.8 but written as 7.8) and written on the right side irrespective of the positive or negative value. The values of the right side at the face of ingredient are the quantity of that ingredient. In this case the values are 7.8 and 22.9 for soybean meal and maize, respectively. It means that out of 30.7 parts, 7.8 parts will be soybean meal and the remaining 22.9 part maize. Thereafter, the values are calculated in 100 parts. The Pearson's square method is useful for increasing or decreasing the nutrient density of a feed mixture. The Pearson's square method is useful even today to calculate the amount of concentrate and cereal/cereal mixture required to prepare a mixed feed from readymade concentrates with variable protein.

❖ Algebraic method

In this method, two or more ingredients could be mixed to obtain the desired quantity of one nutrient. For example, a concentrate mixture of 20% CP is to be formulated using maize grain/cereal mixture and soybean meal/concentrate.

Let X represents the concentrate and Y represents maize/ cereal mixture. Suppose, the concentrate contains

35% CP and cereal mixture contains 10% CP and the desired CP of the diet is 20%. The equations then can be drawn as-

$$X + Y = 100$$
$$0.35X + 0.10Y = 20$$

By solving these equations, as

$$0.35X + 0.35Y = 35$$
$$.35X + 0.10\,Y = 20$$
$$0.25Y = 15$$
$$\text{or } Y = 15/0.25 \text{ or } 60$$

Therefore, a mixture of 60 parts of cereal mixture (Y) and (100-60=) and 40 parts of concentrate mixture (X) will provide a mixed feed with 20% CP

❖ Hit - and - trial method

This is the general method of feed formulation by hand calculation or by calculator. Any number of ingredients can be used to derive one or more nutrients at a time. Low – cost diets can also be prepared by this method. The mathematical technique used in this case is slightly complex and requires time and the help of a pocket calculator. First, one nutrient (CP) is adjusted and subsequently other nutrients are adjusted one by one. The trace minerals, salts, vitamin premixes are mixed to meet the requirements. The task may be simplified by using a concentrate containing protein, vitamins and minerals and combination of cereals, their by-products and proteinic ingredients. However, the method is time consuming in general.

Use of MS-excel in hit and trial method

However, computer software program MS excel can be used to formulate feed for any categories of animals following the principles of heat and trial method. This method makes the calculation more easier, and concentration of any number of nutrients of many rations can be calculated, making the calculation easier and with in short period of time. In this programme, the different feed ingredients available and the name of the nutrients (to determine concentration) are listed at column A. The level of different feed ingredients is given in columns B and so on for any number of rations at a time. The cells following the levels of ingredients and supplements in a given column are used to calculate total amount of ration, and the concentration of different nutrients and also energy. Suppose maize, soybean meal, fish meal, rice bran, lime stone, DCP, trace mineral mix., salt, vitamin premix are listed and their levels are given in cells B1, B2, B3, B4, B5, B6, B7, B8, B9, respectively. Then, equations are made to calculate particular nutrient in a given cell. Suppose CP level is to be estimated, and the contents of CP in maize, soybean meal, fish meal, rice bran are 9.8, 48, 48 and 14%. Select the cell for calculating CP and put the equation as follows:

=B1*0.098+B2*0.48+B3*0.48+B4*0.14

Pressing enter button it will show the protein content. In this way equations can be written for different nutrients in successive cells under a column and the concentration of that nutrient can be known. The contents of ingredients can be changed following the concept of heat and trial method to adjust the nutrients in the ration at required level. If more rations are to be formulated using the similar ingredients, as in nutritional experiments with varying levels of one or more ingredients to study safe/effective level of inclusion or nutrients to study nutritional requirements, successive column can be used for formulation with the provision copy and paste facility in the programme. The different nutrients can also be adjusted

accordingly.
Extending the calculations one step further in excel sheet a ration for dairy animals, which constitute dry roughages, green roughages and concentrates, can be formulated efficiently. Moreover, it is feasible not only to change in amount of concentrate but also to manipulate composition of concentrate to adjust the requirements, as done manually in hit and trial method.

❖ Least –cost feed formulation

This method involves complex mathematical calculation (linear programming) and requires computer facilities. The organized poultry farmers and feed manufacturers use this method for formulation of low-cost diet. Varieties of information are required in this method like nutrient requirements, chemical composition, energy value, protein content, cost of ingredients, etc. The knowledge on day-to-day fluctuations in price of the feed ingredients will make the least cost formulation more perfect. Many nutrients or constraints may be taken into consideration in linear programming, which are not always possible by hit –and –trial method.

❖ Software specially developed for feed formulation

Software can specially be developed for formulation of different mixed feeds or concentrate mixtures and also total ration for dairy animals. MakeFeed, developed specially for poultry by Central Avian Research Institute, Izatnagar is one such software. It has many unique features and is windows based easy software for efficient balanced formulation of feed for a wide variety of poultry birds like layer and broiler chickens, quails, guinea fowls etc. for maximum production performance. Make Feed is a user-friendly and persons having little computer knowledge can utilize it effectively.

The present computer package Make Feed will be of immense benefit for both of small-scale farmers to feed industry manufacturers. The feeding cost alone being the major constraint in poultry enterprise, every effort has been directed to contain feed cost maintaining feed quality following optimum requirements of various nutrients including energy, protein, amino acids, minerals and vitamins. In this package, safe/effective inclusion levels of different feed ingredients have been considered for the formulation of protein-mineral-vitamins concentrates (15, 35, 40%). Moreover, there has been option for the user to add new feed ingredients and its nutrient composition in the package.

The users should first select the feed ingredient that they want to include in the ration. Then they should decide the particular type of ration to be prepared by using Make Feed software. The nutritive values of various types of formulated feeds would be available by default. However, users could also enter the nutritive values (like Crude Protein, Metabolizable Energy etc.) as per their choice.

Make Feed would give users two options for formulation of feed. First, Make Feed can prepare rations without considering the cost factor, and second, it can also formulate the feed that would be the least in cost. Apart from the default conditions that must satisfy the formulated feed, the users can add, modify or delete those conditions for the preparation of feed as required by them.

The user should have pre-loaded Windows 95 or later versions for running MakeFeed. The PC should also have at least 32 MB RAM and 640 MB free hard disc space along with CD-ROM drive. The user also should have Microsoft Office 97 (Professional Edition) or later version loaded in their PC. The software will be automatically installed in the PC from CD as described later in the manual.

In brief, MakeFeed is a simple, efficient and effective tool for formulation of rations for various classes of poultry, which would be immensely helpful for poultry nutritionists, farmers, entrepreneurs, scientists, teachers and students alike.

Anti-nutritional factors in poultry feed

Anti-nutritional factors (ANF's) are substances that when present in animal feed or water reduce the availability of one or more nutrients. It is important to have knowledge of anti-nutritional factors because they can adversely affect the health of your poultry flock. There are certain anti-nutritional factors, which reduce feed intake and nutrient utilization. The anti-nutritional factors are generated in naturally occurring feedstuffs by the normal metabolism of the species from which the material generates. They act by different mechanism, e.g. decomposition or inactivation of some nutrients, diminution of the digestive or metabolic utilization of food, alteration of hormone level, etc. Some examples of anti-nutritive factors are soluble non-starch polysaccharides, protease inhibitor, tannins, haem-agglutinins, gossypol, oxalates, saponins, mimosine, cyanogens, etc. In addition, fatty acid (erucic acid and other fatty acids), salt or ester (oxalates and phytates) and certain anti-vitamins are also anti-nutritional factors. Protease inhibitors are widely distributed in leguminous seeds like soybean, guar, etc. and cause growth inhibition, reduced protein utilization and hypertrophy of pancreas. They are destroyed on heating or toasting. Trypsin inhibitor activity of solvent-extracted soybean meal is destroyed by exposure to flowing steam for 60 min. or by autoclaving under 5Lb/in^2 for 45 min, 10 Lb/in^2 for 30 min, 15 Lb/in$^{2\ for}$ 20 min. or 20 Lb/in^2 for 10 min. Atmospheric steaming (100^{0}C) destroys 95% of trypsin inhibitor content of de-hulled and defatted raw soybean flakes within 15 min. Dry heat is not effective in elimination of Phytohaemagglutinins (lectins) component but soaking and cooking is helpful. Glucosinolates may be removed from meal by extraction with hot water, dilute alkali or acetone or decomposed with iron salts or soda ash. The feed enzymes have been designed to curb the viscous effect of non-starch polysaccharides present in various feedstuffs. Similarly, phytase has been proved to be highly effective in reducing the anti-nutritional property of phytate, present in all plant feedstuffs, besides augmenting availability of costlier mineral phosphorus. The goitrogenic products may be removed by extraction with acetone or water or by steam stripping of volatile isothiocynates. A satisfactory method of HCN extraction involves closed steam distillation with hydrochloric acid at 100°C for at least three hours. In general, feed ingredients containing cyanogens can be processed by cooking, followed by discard of cooking water or fermented or boiled then dried. Saponins can be extracted with hot water followed extraction with ethanol or methanol.

Table 1: Anti-nutritional factors presents in feeds of plant origin.

Management of anti-nutritional factors:

Feedstuffs	Toxic factors
Raw soybean and its meal	Trypsin inhibitor, phyto-haemagglutinin, antigens, lipoxygenase, goiterogen, saponin, estrogen, phytic-acid and oligosaccharides (NSPs – 30.3%)
Groundnut and its meal	Trypsin inhibitor, goiterogen, tannins, oligosaccharides and lectins
Mustard or rape seed and its meal	Goiterogens (thioglucosides or glucosinolates), tannic acid, erucic acid, sinapine (cholinester), pectins and oligosaccharides (NSPs - 46.1 %)
Safflower seed and its meal	Estrogenic factor, Two phenolic glucosides (Bitter flavour) and Fibre
Sunflower seed and its meal	Chlorogenic, quinic-acid and Fibre (Tannin like compounds)
Sesame seed and its cake	Phytate (5g/100g) and Oxalates (35 mg/100g)

Linseed and its cake	Linamarin (cyanogenic glucoside), antipyridoxine (Linatin) factor and mucilage (HCN Level → 10-300 mg)
Kapok seed meal (seeds of silk cotton tree)	Tannins, tyrosine and fattyacids with cyclopropene rings
Copra meal (coconut meal)	Fibre (mannans) and Estrogenic factor
Palm kernel meal	Fibre (half of the fibre –NDF high levels of gala ctomannans β-(1,4)-D mannans) and Sharp shells
Cotton seed and its meals	Gossypol (phenol like compound), cyclopropenoid fatty acids, tannins
Cotton seed and its meals	Gossypol (phenol like compounds) cyclopropenoid fatty acids, tannins
Guar meal (*Cyamopsis tetragonoloba*)	Guar gum (18-20%), antitrypsin factor and antivitamin E factor
Castor seed and its meal	Ricin (toxalbumin)-Phytohaemagglutinin, Ricinine (Toxic -alkaloid), Ricinus allergen(Protein Polysaccharide)
Neem seed and its meal *(Azadirachta indica*)	Bitterness → Limonoids → Triterpenoids Bitter principles: Protomeliacins, Limonoids, Azadirone, Gedunin, Vilasinin and Secomeliacins Nonisoprenoid polypenolics-Flavanoids, Tannins and coumarin *viz.* Nimbin, Salannin and Azadirachtin Dried seeds – limonoids – 0.001 to 0.1%, Azadirone, 0.45% and Epoxy Azadirone, 0.72%, Azadiradione, 0.7% and Salanin, 0.95%
Mahua cake (*Madhuca latifolia*)	Mowrin (Saponin) and Tannins
Karanja cake (*Pongamia glabra*)	Fat bound toxic factors – Karajnjin and Pongamol (Flava noids) (NSPs – 38%)
Lupin meal	Quinolizidine alkaloids, pectins, oligosaccharides, high manganese, saponin.
Peas	Protease inhibitors, tannins, Lipoxygenase and lectins
Rubber seed meal	Hydrocyanic-acid (20-40mg/kg)
Maize	Selenoamino acids (seleniferous), Estrogen (mouldy), Trypsin inhibitor
Wheat	Tyramine, Trypsin-inhibitor, NSPs (11.4%)
Rice	Estrogen and haemagglutinins
Rye	Amylase and protease inhibitor and NSPs (13.2%)
Oats	Amylase inhibitor and estrogens
Triticale	Trypsin and chymotrypsin inhibitor (NSPs)
Some varieties of barley	β - glucan (NSPs – 16.7%)
Some varieties of sorghum	Tannins
Rice-polish and rice bran	Trypsin inhibitor and antithiamine factor
Chunies	Antitryptic factor
Sal seed and its meal	Tannic - acid (tannins)
Tapioca meal (*Cassava*)	Cyanogenic glucoside (HCN – 1000 – 3000 mg/kg DM)
Fish meal and meat meal	Gizzerosine and histamine (Biogenic amines)

- ✓ Dry or moist heat treatment or solvent extraction can achieve inactivation of estrogens.
- ✓ The heat generated during the commercial production of cotton seed meal helps to bind 80 to 90% gossypol with protein rendering it non-toxic. Higher levels of gossypol can be tolerated, if iron salts are added to diet @ 1 to 2 ppm iron for every 1 ppm of free gossypol. Solid substrate fermentation involving certain fungi is capable of reducing 90% of free gossypol of cottonseed and eliminating its toxicity in chicks.
- ✓ Removal of tannins from de-oiled salseed meal, include cold water processing, boil water processing, treatment with acids 0.1 N, HCI (1:10 w/v), 2.5% HCI), alkalis (0.01 N, NaOH, 0.1 N, $NaHCO_3$, 0.05-5% $Ca(OH)_2$), Salt (3% NaCI), extraction with either acetone (30%) or ethanol (4%) or methanol and autoclaving with tannin removal of 36-58, 42-80, 13-65, 12-68, 43-57, 41-49, 31-100, 38-53, 63-72, 33-38 and 17-100%, respectively.
- ✓ Autoclaving soya bean meal can reverse the increased requirement of metals. In both, vegetable and animal kingdom oxalic acid is found as free and in salt form. The nutritive value of linseed meal for chicks can be considerably improved after extracting the meal with water and autoclaving and supplementing with pyridoxine hydrochloride.

ANF's can produce a significant reduction in the performance of poultry even at low concentration. Many chemical preservatives are used to prevent mould in stored grains. Organic acids such as propionic, acetic, butyric, fumaric, formic, benzoic, tartaric and citric acids can be effectively used. Change of feed contaminated with ANF's, keeping the poultry farm and utensils free from dust and fungi, use of suitable adsorbents in combinations, dietary manipulations and use of antioxidants are some of the measures for combating deleterious effects of a ANF's in poultry. Anti-nutritional factors are inherent natural component of certain feedstuffs. Several processing methods have been applied to detoxify the anti-nutritional factors, however, those methods, except for toasting of legumes and free gossypol in cottonseed, have not received industrial attention due to excessive processing cost, nutrient loss in processing, cumbersome processing methods, etc. Therefore, the best way of management of the anti-nutritional factors is suitable dilution of feedstuffs based on their concentration in feedstuffs to restrict their levels much below the tolerance levels of birds to be fed.

Mycotoxins are low molecular weight toxic secondary metabolites produced by certain strains of filamentous fungi (*Aspergillus*, *Penicillium*, *Fusarium* and *Claviceps*), which invade crops in the field, during harvesting or storage under favourable conditions. These species of fungi are ubiquitous in nature and under ideal conditions of temperature and humidity, often infest economically important crops. The presence of mycotoxins in commodities is presently unavoidable and, therefore, to avoid their occurrence in the food chain requires management strategies that would prevent contaminated commodities from entering food and feed processing facilities. Various methods to decrease or eliminate mycotoxins are being studied and several approaches such as physical methods of separation and detoxification, biological and chemical inactivation, and decreasing bioavailability to host animals are being used and/or investigated.

Processing of contaminated feeds for toxin inactivation: *The physical and chemical treatments, found useful for inactivation of aflatoxins in contaminated feeds or ingredients includes:*

- ✓ Raising the moisture levels up to 20% and autoclaving at 5 PSI for one hour followed by drying in an oven at 80°C with or without addition of sodium hydroxide (15 g per kg).
- ✓ Agitation of feed with $Ca(OH)_2$ @ 2% followed by addition of formaldehyde at 15% moisture followed

by autoclaving at 15 PSI for half an hour and drying.

- ✓ Ensiling after addition of liquor ammonia (6%, v/w) at 20% moisture for 20 days followed by drying at 35°C in an oven.

Precautions to be taken at the farm:

- ✓ Feed troughs should be periodically emptied, and disinfected with a 5% sodium hypochlorite solution. Continuous topping up of feed through is a bad practice. Feeder system should be turned off weekly so that the animals will be forced to clean out all the feed in the troughs before it becomes excessively old and moldy
- ✓ Animal houses need to have adequate ventilation. The air inside these houses can be very humid due to respiration and defecation. The whole house including its facilities should be thoroughly cleaned before placing new animals into the houses.
- ✓ Leftover old feed should not be brought back to the mill after removing the flock as old feed can be a source of contamination
- ✓ Do not use recycled bags if they are wet or exhibit signs of mouldiness.
- ✓ Reduce stress to animals
- ✓ Reduce intake of suspected contaminated feed by 50% or replace completely
- ✓ Dietary manipulations. Because mycotoxins typically reduce nutrient absorption, one approach to alleviate these effects has been to increase levels of critical dietary nutrients

General recommendations to reduce the effects of a mycotoxicosis

- ✓ Increase the level of protein and energy in the diet, as well as the levels of some vitamins, especially riboflavin and D3, given that these vitamins help animals, especially poultry, to detoxify mycotoxin such as AFB1. On the contrary, a deficiency in thiamin has a protecting effect against aflotoxicosis since its deficiency mobilize the lipid reserves, interfering with the hepatic metabolism of aflotoxins.
- ✓ Provide the contaminated feed to adult animal, except breeding animals. The susceptibility to mycotoxins decreases with age.
- ✓ Use low level of broad spectrum antibiotics with vitamins and electrolytes in drinking water.
- ✓ Increase the levels of methionine and cystine in the diet. These amino acids are the precursors of glutathione, which forms conjugated complex with AFB1 inside the animal and especially in the liver. These complexes are then eliminated through feces and urine.
- ✓ Maintain animals at relatively low temperature. Poultry are more susceptible to aflotoxicosis at high temperatures.
- ✓ Reduce or eliminate factors that could produce stress in the animals such as sudden changes in temperature and moisture, vaccination, lack of water, inadequate ventilation or high levels of ammonia.
- ✓ Reformulate the feed using a lower concentration of contaminated ingredients.

- ✓ If the contaminated ingredients (s) cannot eliminated, give the feed containing the ingredient (s) to animals that are less sensitive, or not sensitive to the mycotoxin that is contaminating the feed.

Poultry Biosecurity Measures: Mitigating the on-farm losses

Gautham Kolluri

1. Background

Despite the vigorous growth and development, poultry industry in India is facing challenges of emerging and new emerging diseases especially of viral origin with the periodical evolvement of more virulent strains. This continues to pose a serious threat to poultry production and the development of more effective coping strategies remains a significant challenge all the time. Possible sources of contamination inside the farm are the introduction of equipment from another farm; Feed and chick delivery vehicles, vehicles for lifting of farm birds; improper disposal of used litter; visitors, interchanging of farm personnel within the farm, veterinarians, company personnel; improper litter, manure and carcass disposal; backyard poultry, wild birds, rodents and other wild activity. Opened water sources nearby farms; replacement of birds; the introduction of chicks from contaminated hatcheries; contaminated vaccines, feed and water. Understanding the potential sources of infection in a farm is essential to deploy its curtailing measures.

Biosecurity is a strategic and integrated approach to analyzing and managing relevant risks to human and animal life and associated risks to the environment. Biosecurity yet seems to be simple but complex phenomena. Bio-exclusion (to preclude the introduction of disease into the farm) and Bio-containment (to stop the spread of disease within the farm) are the two main targets of biosecurity. Cleaning and disinfection in combination pave for effective decontamination and are the key components in routine biosecurity in poultry farming. Decontamination kills or reduces bacteria, virus, parasite, and molds. Biosecurity is the efficient use of common sense hygiene procedures in preventing the adverse effects of a disease. The efficient biosecurity system always comprises of two parts *i.e.,* internal biosecurity and external. External is about controlling traffic and prevention of introduction of disease into the farm and it accounts for 70%. While water sanitation, shed disinfection, shed distance, internal moments, carcass and waste disposal mark the internal biosecurity measures and this is mainly to prevent the spread of pathogen within the farm. Another aspect of biosecurity is that animal health management that minimized the incidence of spreading the significant disease for the public health/food safety.

Every farm must operate two levels of biosecurity:

Level 1- routine protocols being implemented on daily basis and

Level 2- high-risk biosecurity protocols in the event of outbreaks.

2. Possible sources of infection:

- The introduction of equipment from another farm.
- Feed and chick delivery vehicles, vehicles for lifting of farm birds,
- Improper disposal of used litter.
- Visitors, interchanging of farm personnel within the farm, veterinarians, company personnel.
- Improper litter, manure and carcass disposal.
- Backyard Poultry, Wild birds, rodents and other wild activity. Opened water sources nearby farms. ·
- Replacement of birds.
- The introduction of chicks from contaminated hatcheries.
- Contaminated vaccines.
- Contaminated feed and water.

Understanding the potential sources of infection in a farm is essential to deploy its curtailing measures.

Accordingly, operations (Martin, 2016) should focus on establishing three disease barriers on their farm:

2.1. Physical barrier- keeping disease and its vectors from making contact with the animals. All these

Disease	Appropriate Disinfectant of choice
Coccidiosis	Sodium hydroxide and ammonium salts
Aspergillosis	Phenols, *Enilconazole spray (1.5 g/10 so. feet), *Copper sulfate (1:2000)
Candidiasis	1% Sodium hydroxide, 5% solution of Iodine*
Chlamydiosis	3% Hydrogen peroxide* (lime should not be used)
Staphylococcus infections	More than 7.5% Sodium chloride solution spray
Clostridial infection	Formalin (reduces number but not completely eliminate infection)
Mycoplasmosis	Phenol, Formalin and Beta proiolactone. However, regular cleaning and disinfection is recommended.
Infectious coryza	0.25% Formalin
Ornithobacterium infection	20% Glutaraldehyde based solution, 1% Sodium chloride, 0.1% Benzalkonium chloride solution.
E. coli infection	8.5% Sodium chloride* solution prevents growth
Pullorum disease	1:1000 Phenol, 1% Potassium permanganate, 2% Formalin
Lymphoid leucosis	Sodium dodecyl sulphate, ethyl ether detergents
Marek's disease	Complete dust reduction and disinfection with multi combinations.
Avian encephalomyelitis	Formaldehyde fumigation, Betapropiolactone
Egg drop syndrome	1% Phenol, 1:1000 Formalin, 0.5% Glutaraldehyde solution
Chicken infectious anaemia	Higher concentrations of iodine and hypochlorite disinfectants
Infectious bursal disease, Ranikhet disease, Avian Influenza, Infectious bronchitis and Infectious Laryngotracheitis	Higher concentrations of *triple salt containing Potassium monpersulphate, Hydrogen sulphate, Potassium sulphate

Usage of antibiotics in food animals including poultry in India (2013) and their projected increase by 2020 (Van Boeckel *et al.*, 2017)

Antibiotic use (In tons)	Usage (2013)	Projected increase by 2030
Total antibiotics usage	2633	82
Tetracyclines	628	41
Penicillins	731	69
Sulfonamides	315	77
Macrolides	232	92
Aminoglycosides	84	40
Quinolones	119	243
Cephalosporins	49	29
Amphenicols	67	51
Pleuromutilins	9	11
Polymixins	29	159
Others	372	142

Curbing Antibiotic use in real field conditions does not seem to be practical always because of high infection pressure in broiler and layer farms. However, antibiotic use and days can be reduced by supplementing them with probiotics and immune stimulants. Strategies minimizing the antibiotic reductions in the farm must be aimed at i) Good farming management and hygiene practices ii) Targeting only affected birds for therapeutic purpose iii) Adequate nutrition and gut health. Use of competitive exclusion products, probiotics and prebiotics and essential oils which can also reduce the risk of infection in the farms. Despite several herbal alternatives proved to have antibacterial effects, considering the infectious pressure and bird's susceptibility complete replacement of antibiotics is questionable. However, complementing herbals with antibiotics for the therapeutic purpose would reduce the antibiotic dose thereby solving the issues to some extent. It is observed that biosecurity protocols reduced the antibiotic use and antibiotic treatment days have declined by 29% (Dewulf, 2016). Replacing AGPs relies upon a holistic approach to improve animal health status and performance through better management, bio-security, vaccination, diagnostics and feeding strategy. α-monoglycerides such as α-monoproionin and α-monobutyrin are reported to have potential antibacterial actions that can be used to replace antibiotic growth promoters confidently. Mono-glyceride derivatives of lauric acid i.e., α-monolaurin have antiviral properties. These ingredients are active in the entire gastro-intestinal tract. Depending on the chain length of the fatty acid, they are active against gram negative or gram positive bacteria and against fat enveloped viruses. Micro-encapsulation concept has been integrated in delivering the phytogenic active compounds and essential oils yield a stabilized biological action. Electrolyzed oxidizing water (Nontox) provides a real alternative to formaldehyde. This is the result of electro-chemical activation of salt and water. The disinfecting action comes from free radicals in combination with active chlorine compounds such as HClO and ClO^- This reported to leave no residues on the surface of hatchery with no buildup of bacterial resistance.

4. Vaccines, Vaccination and its Impact

Vaccination is the last line of defense while eliminating the source of infection and cutting off the routes of transmission are the first line and second line respectively which are associated with biosecurity.Therefore **v**accination must always be complemented with biosecurity measures. The choice of vaccine to be administered depends on the type of bird being vaccinated, history of breeder's vaccination and infection pressure in the farm. Vaccination protocol is essentially based on biosecurity level, immunity status and risk assessment of disease epidemics. Protocols vary from region to region as per the endemic situation of a particular disease. The unwanted introduction of new vaccination protocol may incur additional cost and chance of increasing the likelihood of infection in future. Optimization of vaccination, medication and disinfection protocols may reduce the cost of production almost by `40/- per bird (Findings from a recent study in China, 2016).

4.1. Safety tips for poultry vaccines

i) Check the source, quality, expiry date and temperature of vaccine before procuring.

ii) Ensure to maintain the cold chain of the vaccine all the time right from the procurement until administration into birds. During transportation of vaccines, the vials can be placed in an insulated flask or thermal box filled with ice packs or ice.

iii) Vaccines should obtained directly from the trusted sources or reputed dealers. Always store vaccines at 4-8 °C in the refrigerator but not in the upper freezer cabinet.

iv) Keep all the records regarding the batch/lot and serial number and the date of production and expiry of vaccine to be used. It is better to place the entire label of vaccine vial or vaccination record.

v) Vaccines will come with diluents and droppers; hence it is always advised to use large capacity boxes or flasks for transportation.

4.2. While vaccinating the birds

i) The ultimate success of vaccination depends on the way the vaccine is administered. Hence it is always advised to vaccinate the birds with trained personnel only.

ii) Check the flock for signs of coccidiosis, or other diseases, that may interfere with vaccination.

iii) Vaccinate only healthy birds. Birds tend to look dull with closed eyes, head down and off feed must not be vaccinated.

iv) Handle birds carefully while administering vaccines individually to each bird.

v) Follow the manufacturer's procedures strictly for vaccination.

vi) Vaccinate only the desired number of birds from a vial.

vii) Immune stimulants and multi-vitamin supplements must be provided before and after vaccination respectively to improve vaccination efficiency and reduce vaccination stress.

viii) Vaccinate the birds during cooler parts of the day preferably in the early morning.

ix) Do not use any chemicals for sterilization, such as dettol, savlon soap etc. since this reduces the efficiency of vaccine. For clean vaccination, it is advised to use gloves.

x) Do not use unclean and contaminated droppers, syringes, needles etc.

xi) Always sterilize all the vaccine materials in boiling water before and after use.

xii) Change the needles regularly to minimize the spread of infection.

xiii) Using automatic vaccinator/syringes will reduce time and labour and increase vaccination efficiency.

xiv) The entire vaccine must be used within 2-3 hrs, once the vaccine vial is opened.

xv) Keep also the prepared (reconstituted) vaccine on ice while vaccinating the birds. Remove small quantities for use, frequently.

xvi) While using inactivated/killed vaccines, it is necessary to bring them to room temperature before injecting into birds.

xvii) Shake the reconstituted vaccine frequently during vaccination.

xviii) Destroy the leftover vaccine and vaccine vials etc. immediately after use in an appropriate manner.

4.3. Vaccination methods

i) Live vaccines must be given either through oral or nasal or ocular or parenteral route. While killed vaccines must be given only in form of injection either subcutaneously or intramuscularly by using a syringe with a 22 gauge needle (depending upon the bird' size).

ii) Injection sites for subcutaneous are back of the neck and wing, while common sites for intramuscular route are breast and thigh muscles. When injecting oil emulsion killed vaccines, subcutaneous route is recommended.

4.3.1. Eye drop or nasal route of vaccination

Individual birds must be picked up and handled very gently, and diluted vaccine must be administered as one drop as one dose/bird. Closing of eyes after eye drop indicates its uptake.

4.3.2. Drinking water vaccination

It is a mass method of vaccination that vaccinates larger number of birds within a short period of time. Of various live vaccines administered, water vaccination is most commonly employed in field situations because this provides less chance for handling birds thereby stress in layers. In broilers, individual vaccination of chick through ocular or nasal route is also being practiced in several pockets of the country. Drinking water needs to be treated before mixing the vaccine, since the organic matter in the water decreases the vaccination efficiency and is as follows.

i) Protection of virus particles from heat, ultraviolet rays, chlorine, sanitizers, organic matter, and moisture is extremely important and therefore water sanitizers, antibiotics and any other supplements needs to be avoided in drinking water on the day of vaccination.

ii) Treatment with skim milk powder before vaccination is aged and common practice till now. Skim milk powder often forms clumps in the water and therefore must be mixed with warm water of 60°C before final dissolution. Addition of skim milk powder @ 2-6 g/liter, ice flakes (for 2-8 °C temperature) prior to mixing of vaccine for 15-20 min stabilizes the drinking water and increases the vaccine efficacy. Skim milk and other stabilizers bind chlorine and metallic ions thereby making vaccine virus free and available for the bird. Commercially available vaccine stabilizers with colour indicators help in the identification of vaccine uptake by birds. Several water dyes are available commercially which indicates the uptake of vaccinated water.

iii) As a rule of thumb for 1,000 broilers, 1,000 doses of vaccine should be dissolved in as many liters of water as the age of the birds in days. This is the minimum volume and it can be doubled if climatic or other reasons justify it.

iv) Ideal length of water-withdrawal for vaccination of broilers is 1-1/2 hours. The ideal time for consumption of vaccinated water is 2-3 hours.

v) Amount of water (liters) required for vaccination in broilers and layers is

vi) No. of days (age on vaccination) = Liters/1000 birds. For e.g. 14 days=14 liters/1000 birds

vii) In floor houses, number of drinkers should be increased during vaccination time. In litter sheds, dirt in bell drinkers, mixing of litter, feces and birds secretions with vaccinated water changes its pH and reduces its efficiency. In automatic drinking system, water pipelines, water tanks, automatic dosing systems and filter tanks needs to be flushed with specific water disinfectants or sanitizers before the day of vaccination to avoid the buildup of slime dirt and biofilm. Bell and nipple drinkers need to be cleaned to remove mixed up litter and feces. It is important to ensure the presence of no residual water in drinking systems as they dilute the vaccine dose.

viii) Ensuring equal distribution of vaccine in caged birds seems to be a tough task, because water lines may not be filling all the same time. The amount of vaccine received by birds in an upper tier may be higher than those in the lower tier. To overcome this, the night before the vaccination all the water pipelines can be emptied by letting the birds drink. This also alleviates the chance of residual water reducing the vaccine efficiency. On vaccination day, all the drinker lines can be primed with vaccine thereby allowing all the birds to have an equal chance. Vaccination early in the morning is recommended since this is the time when birds will exhibit peak activity and therefore peak water consumption. With the improvement in biosecurity, flock immunity monitoring and risk analysis of disease, the burden of excessive and misuse of vaccines can be alleviated without increasing the risk of disease occurrence.

4.3.3. Parenteral route of vaccination

Sub cutaneous route is commonly employed at neck region in chicks for administering Marek's disease vaccine in layers, parent chicks and antibiotics and B-complex vitamins in broiler chicks. Intra-muscular route is commonly employed for administration of killed vaccines and mesogenic strains of Newcastle disease. Breast muscle, thigh muscle and neck muscles are commonly used sites. Wing web route is employed only for fowl pox vaccination and piercing through wings.

Post-Harvest Losses in Eggs and their mitigating strategies

Nagesh Sonale*, Gautham Kolluri, Rokade, J.J.

Introduction

India has emerged as one of the world's largest producers of eggs and broiler meat, experiencing a significant transformation in poultry industry over the past two decades. This evolution has shifted the industry from a small-scale backyard activity to a major sector with numerous integrated players. To achieve this transformation, country has made substantial investments in breeding, hatching, rearing, and other processing activities. The expansion of poultry production in India has been driven by technological advancements, increased scale of production units, and ongoing efforts in upgrading and modification. Several factors have contributed to the growth of the poultry market in India. The rising adoption of healthy diets, the popularity of protein-rich and eggetarian (vegetarian with the inclusion of eggs) diets among fitness enthusiasts and gymgoers, and initiatives by government organizations to enhance productivity and product quality have played a crucial role. The application of new technologies has also facilitated the multifaceted growth of the poultry industry and related sectors, not only in terms of size but also in productivity, sophistication, and quality. As a result of these developments, India secured its position as the world's third-largest producer of eggs, producing 129 billion eggs in 2021-2022. Looking ahead, the market is expected to reach INR 3,477.8 billion by 2028, with a projected compound annual growth rate (CAGR) of 10.18% during 2023-2028 (IMARC Group). However, despite India's prominent position in the poultry industry, the per capita availability of eggs and meat in the country remains relatively low. The per capita availability of eggs is 91, while for meat, it is 4kg, both of which fall far short of global consumption levels and the Indian Council of Medical Research (ICMR) recommendations of 180 eggs and 11kg of meat per person per annum.

In addition to these challenges, the poultry industry in India also faces post-harvest losses in egg and live bird production. This is one of significant issue among egg production includes the economic losses of approximately 10% owed by cracking of eggs during routine handling. Cracked eggs not only lose their physical quality but also pose a risk of infection by disease-causing organisms, resulting in financial losses. A study by Hegazy (2016) revealed that post-harvest losses in the Indian egg supply chain ranged from 10% to 25%. Furthermore, the livestock produce, including meat, poultry, and fish, suffered the highest post-harvest losses, amounting to 30% or $48 billion. The lack of proper infrastructure such as adequate cold chains and underutilization of by-products like broken eggs, egg shell contributes to these losses (Bechoff et al., 2022). It is crucial to address these losses and focus on preserving the quality of the produce, to feed both domestic demands and also for export expansion. Therefore, this chapter aims to discuss in detail the post-harvest losses in the eggs, the contributing factors, and steps to mitigate these losses.

Post harvest losses

To define post-harvest losses, they can be described as the degradation in both the quantity and quality of food production from harvest to consumption. Intrinsic changes, including internal and external biochemical alterations, impact factors like color, flavor, nutritive value, caloric composition, and calorific value of poultry meat and eggs, even without significant changes in weight or volume. These losses are more prevalent in developing countries and are primarily caused by poor post-harvest management practices such as moisture loss leading to weight reduction, physical damage, spoilage, rotting due to senescence, and bacterial/fungal infections. The assessment of post-harvest losses considers losses occurring during harvesting operations and beyond (MOFPI, 2022), (Kader, 2002).

Egg is the most precious commodity, whose biological value is very high compacted with full of protein and healthy fats. Further, eggs are the cheapest commodity which can be offered even by the poorest. Among all livestock by-product eggs contain the highest biological value (or gold standard) for protein. One egg has only 75 calories but 7 grams of high-quality protein, 5 grams of fat, and 1.6 grams of saturated fat, along with iron, vitamins, minerals, and carotenoids. The egg is a powerhouse of disease-fighting nutrients like lutein and zeaxanthin. These carotenoids may reduce the risk of age-related macular degeneration, the leading cause of blindness in older adults. And brain development and memory may be enhanced by the choline content of eggs. This all component is present in the egg yolk and egg albumin, which are covered and protected by egg shell, it is composed of calcium carbonate this cover can easily break with rough handling or improper transportation. Break or crack in the shell can lead to high economic loses as well as affect nutrient quality of the whole eggs. The overall total post-harvest losses in eggs were 6.55 percent. A study of ICAR-CIPHET (2015) reported overall post-harvest losses of 7.19 percent for eggs at the national level. Hegazy (2016) in his study detailed on post-harvest losses in India was mainly due to lack of supply chain of eggs were in the range of 10 to 25 percent. Postharvest losses result from direct physical losses and quality losses that minimise products' economic value (Herlekar, et al., 2014). In extreme cases, these losses can amount to 80% of total output so reducing postharvest losses is recognised as an essential component of food security (Lat, 2017). Losses are particularly high for underdeveloped countries (about 50%) and most of them are attributed to inefficient technology and low expertise in the handling of produce and lack of logistical support. Since in India, the egg production is not equally distributed in all the state, where transportation from high to low producing states are mandatory. At this situation, transporting the eggs at huge quantity in tropical condition without any proper cold chain facility can lead to increase in quality loses ultimately results in post-harvest loss.

Types of post-harvest loses in Eggs

Average eggshell thickness is about 0.30 mm. There are about 10,000 pores on the shell surface each one 0.0017 mm in diameter totalling 1.8 mm 2 in open space to support gas exchange and moisture loss. The egg shell composed of calcium carbonate covering which can be easily break by normal pressing also, due to which special care must be taken during all farm operation from collection to till it reaching to end consumer.The occurrence of shell breakage can be categorized into a number of stages. Opportunities for breakage occur: 1) before lay, 2) at the point of lay, 3) during collection, 4) during processing, and 5) during shipping. The incidence of breakage at these stages varies. It is approximately 3.5 % at the point of lay; ranges of 1 to 11% during the collection stage (Eggleton and Ross, 1971) and is approximately 1% during shipping. The degree of breakage during collection is quite high, because equipment maintenance and management such as gathering intervals, belt speeds, and number of right-angle turns has a major influence at this stage (Hamilton et al., 1979). The major postharvest losses in eggs were categorized as physical, chemical and microbiological losses.

Physical Losses:

a. ***Handling and collection:*** mainly due to improper handling and collection of eggs at the farm especially eggshell having damages such as cracks, body checks, blind checks, toe cracks, leaker conditions, etc. (Aboonajmi, 2020).

b. ***Grading/sorting***: Grading done to fetch a better price for their produce. Except in some big commercial farms, sorting/ grading was done manually which facilitates more losses further.

c. ***Packaging***: The eggs were also packaged in a variety of materials such as bamboo baskets, plastic crates/boxes/bags and cardboard/plastic eggs trays to attract more consumers. When the packaging was done by automated machines, the losses observed were low in comparison to the packaging done manually.

d. ***Storage and transportation***: The farmers stored the eggs at normal temperature in godowns/ at home. The eggs were stored for a short duration of time ranging 1-2 days before they were picked up by the aggregator/ retailer/ wholesaler. Few eggs ended up cracked or leaked during transfer from the godown. In a few cases, eggs ended up getting spoiled when in storage for a longer time as there was no provision for temperature and humidity control. During transportation, improper stacking of eggs trays as well as inadequate packaging were observed as the main reason for losses.

Post-harvest losses of livestock produce in percent at national level

Farm Operations									Market operation						Overall total loss
Crop	Harvest-ing	Collection	Sorting/ grading	Drying	Packaging	Farm level storage	Transport	Total loss in farm operations	Godown	Wholesalers	Retailers	Processing unit	Transport	Total loss in storage	
Egg	-	1.52 ± 0.0504	1.23 ± 0.0786	-	1.10 ± 0.0423	0.24 ± 0.0058	0.30 ± 0.0152	4.40 ± 0.1038	0.05 ± 0.0049	0.39 ± 0	0.44 ± 0.0093	-	0.39 ± 0	1.63 ± 0.0545	6.03 ± 0.1173 (7.19)

Chemical losses: During egg storage, some components of albumen and yolk may alter and tend to deteriorate egg quality. The main factors directly associated to egg deterioration are temperature and relative humidity conditions, besides manipulation and storage time. An intense transformation occurs 72 h after posture, the dense layer of albumen becomes liquid, and consequently loses its quality. Approaching preservation methods and shortening the time duration between laying and transportation to the retail market can helps to get rid of chemical losses (Oliveira, 2013). Spoilage of eggs starts as a result of cracking the eggshell, improper washing, and inadequate storage conditions. The chemical changes associated with eggs were as follows:

- ✓ Loss of water
- ✓ Loss of carbon dioxide
- ✓ Change in pH 7.6 to 9.7 in egg white
- ✓ Thick albumin changes to watery/thin.
- ✓ The breakdown of proteins
- ✓ Increase in the amount of free ammonia.
- ✓ Increase in water-soluble inorganic phosphorus.
- ✓ Increase in free fatty acid in yolk fat.
- ✓ Deterioration in the flavour of eggs occurs by the invasion of micro-organisms and by the changes that take place in fat and protein

Microbial deterioration and losses

Under healthy breeding conditions, the egg content is sterile. However, the eggshell surface can be contaminated by a diversified microflora. The microbial contamination can lead to spoilage problems.

Bacteriaaremorecommonspoilageorganism. Bacteria cause rots in eggs, whereas Fungi causes spots in eggs. The microflora of the eggshell is dominated by Gram-positive bacteria such as *Pseudomonas, Staphylococcus, Streptococcus, Aerococcus and micrococcus*. Other minor contaminant sare Gram-negative bacteria, suchas *Salmonella, Escherichia* (Caner, 2015).

Overall Economic Impact due to post harvest loses.

The highest contribution in the economic loss was by livestock produce (21.70%) poultry meat, milk, marine fish and inland fish (livestock produce). These commodities are responsible for 67.69 percent of the total loss of 1,52,790.42 crore. The total monetary loss is 2.35 percent of national GDP for 2021-2022 (NABCONS-2022).

Corrective measures

Post-harvest infrastructure of the egg and poultry meat can be minimized by implementing standard corrective measures. Live shrink loss results due to various stressors to which the broilers are exposed to during transportation. Hence, attempts were made to ameliorate the stress and reduce the live shrink loss by any one of the following methods:

Farm level measures

- Promotion of 'grow out houses' (cage free and ventilated barns) leading to reduced stocking densities and other welfare problem associated with cages.
- Mechanical grader and sorters need to be promoted at farm level for eggs.
- Sustainable food packaging: The Egg Guardian, is a conceptual package design for eggs, aimed at reducing waste. The product is reusable, and made from aluminum due to its recyclable qualities, durability, and ability to be easily cleaned.
- Need of cold storage units at farm level for eggs.
- Increasing the availability of reefer vans.

Market level measures

- Promotion of cold storage facilities at retailer level.
- Country wide expansion of modern retail stores like FIPOLA retail stores prevalent in southern states of India with well managed backward integration.

packaging to increase shelf life of products and to prevent loss during transport.

iii. Training and capacity building

- Acquaintance with equipment, demonstrations of slaughtering of birds and handling of eggs through extension activities supported by farmers' cooperatives to impart skill among labourers

iv. Policy advocacy

- Need to increase eggs processing capacity.
- Supporting collectivization of smallholders through co-operatives and producer companies to ensure the supply of inputs and to facilitate and enable market linkages.
- Creation of an institutional framework and policies for utilisation of the food waste into value added products.

Conclusion:

Minimizing post-harvest losses in eggs requires a multidimensional approach involving pre-harvest practices, proper handling, storage, transportation, and quality control measures. This scientific study provides evidence-based recommendations to mitigate losses and ensure the availability of safe and high-quality eggs. Implementing these corrective measures will contribute to improved food security and economic sustainability in the egg industry.

- Research emphasis must be on the topic related to Post harvest loss in poultry.
- Cold chain maintenance is poor in India so policy intervention from government side is highly needed.
- Emphasis on strong extension campion for consumer awareness regarding safe and clean production.
- Scientific training to poultry producer as well intermediator.
- Establishing Cold storage house on minimum rate for all poultry producers.
- Focus on Value addition - Entrepreneurship.

indicates around Rs. 4,218 million can be realized as a profit using our CARI incubator technology.

1. Background

Animal proteins are integral components of human diet. In general, all animal derived proteins have wider acceptability by the consumers because of good nutritional profiles. But, all they have also some negative nutritional influence which may affect the quality and consumer's acceptability. Consumers want foods they eat not only taste better but also be safe, natural and of course contain fewer chemical additives such as preservatives. Thus, the future belongs to new products and new processes with the goal of enhancing product performance, quality and safety. Indeed, a reliable and consistent access of safe, fresh, natural, nutritious, flavourful and healthier reformulated meat products needs to be explored as an urgent health claim priority.

There are diverse possibilities in value addition of poultry products. As in other foods, in order to achieve healthier products, it is necessary to avoid undesired substances which otherwise be reduced to appropriate limits, and to increase the levels of other substances with beneficial properties. Inclusion of functional compounds like omega-3 fatty acids, Vit E, conjugated linolenic acid (CLA), selenium (Se), herbs, spices, pre-and probiotics, phytochemicals, bio-active peptides etc in animal feed or their direct application in product formulation could essentially influence consumer's health. In a study, it has been reported that 100 g of poultry meat tissues enriched with ω-3 fatty acids could meets 70-130% of the RDA for humans. Some studies have shown that CLA can reduce the risk of certain types of cancer and also cardiovascular diseases. Selenium and Vit E have been shown to reduce the risk of prostate and colon cancer, while carotenoids may reduce breast cancer risk. Extensive evidence also showed that foods rich in ω-3 polyunsaturated fatty acids are associated with reduced risk for all-cause mortality, coronary heart disease and stroke. In this lecture, it will be provided an overview on strategies for developing functional poultry products that can be realized by adding natural bioactive compounds in feeds/foods or reduction and elimination of some unwanted compounds that are important for health.

2. Value addition of poultry products

The best moment to alter the composition of foods is perhaps during one of the preparation stages. At this stage reformulation is used as far as possible to develop a range of derivatives with custom-designed composition and properties. For this, there are two possible types of complementary intervention. The first involves reducing some compounds normally present in these foods to appropriate amounts, for example, fat, SFAs, salt, nitrites and so on. The second is to incorporate ingredients that are potentially health-enhancing (functional), for example, fibre, certain types of vegetable protein, MUFAs and PUFAs, antioxidantsetc. There are numerous aspects to be taken into account in the development of these kinds of products. The new derivatives must have the appropriate technological, sensory and nutritional properties, and be safe and convenient for consumption, etc. Ignoring such requirements, which are demanded by the reference products if they are to be improved, not only compromises the success of the derivatives concerned but also projects a bad image of these compounds and creates a lack of confidence which is difficult to surmount. Some examples of poultry product value addition are- reduction of fat content; modification of the fatty acid profile; reduction of cholesterol; reduction of calories; reduction of sodium content; increase of ω-3/6 fatty acids and Iodine contents, reduction of nitrites and incorporation of functional ingredients.

2.1. Value addition of poultry meat products

The value addition of poultry meat and meat products are carried out by reduction of fat content and modification of fatty acid profile, reduction of cholesterol, reductions of sodium, nitrite and calories in processed meat products, incorporation of functional ingredients (dietary fibres, polysaccharides, protein, herbs and essential oils, vitamins and minerals, natural antimicrobials, prebiotics, probiotic and synbiotics) and most importantly adopting meat fermentation technology. There are numbers of value added meat products, discussed as under based on their processing methods-

2.1.1 Fresh processed meat products: Fresh processed meat products are composed of comminuted meat mixes with varying quantities of fat and non-meat ingredients are added in smaller quantities for improvement of taste, flavour and binding. Heat treatment (frying, cooking) is applied immediately prior to consumption to make the products palatable.

2.1.2. Raw-cooked meat products: Raw-cooked meat products are the product composed of meat, fat and non-meat ingredients which are processed raw, i.e. by comminuting and mixing. The resulting viscous mix/batter is portioned in sausages or otherwise and thereafter submitted to heat treatment, i.e. "cooked". In addition to the typical texture the desired palatability and a certain degree of bacterial stability is achieved.

2.1.3. Pre-cooked cooked meat products: Precooked-cooked meat products contain mixes of lower-grade muscle trimmings, fatty tissues, skin, blood, liver and other edible slaughter by-products. There are two heat treatment procedures involved in the manufacture of precooked-cooked products. The first heat treatment is the precooking of raw meat materials and the second heat treatment the cooking of the finished product mix at the end of the processing stage. Precooked-cooked meat utilizes the greatest variety of meat, meat by-product and non-meat ingredients.

2.1.4. Emulsion based meat products: Products like loaf items or sausages, patties, meat balls, nuggets, kababs etc are emulsion meat products They are conveniently prepared by mixing and cutting of ground meat in a bowl chopper with iced, table salt, sodium nitrite, sugar and so one to an end point temperature of 10 - 12°C. Some non-meat items such as liquid eggs, vegetables, soya nuggets, several cereal flours, agricultural waste etc are added in the product formulation may reduce the cost of the finished products. Eggs could be incorporated as whole eggs liquid or cooked eggs or in combination up to 20 -30 % level in the formulation with cost and nutritional advantage. Egg protein is superior to meat protein with higher biological value but cheaper in cost. The inclusion of vegetables, and in particularly fibres, in meat system improves functional properties besides reducing risk of colon cancer, obesity, cardiovascular diseases, and several other disorders. Several cereal flours, gram flours, bread crumbs, milk solids, whey proteins, soya products etc could be incorporated up to 10% to reduce cost and increase yields. *Sausages/salamis* are vacuum encased in a casing and fully cooked using different cooking methods. Smoke may also be applied to the products and that will results completely different taste and flavour than regular products. *Meat block/slices* are ready to eat meat product which can be used as base for various recipe or preparation of meat products. The emulsion so prepared previously filled up in rectangular shape aluminiummoulds. The filled up moulds were placed in an autoclave and cooked at 15 lb pressures, 121°C temperature for 20 min. The cooked samples were cooled to room temperature, packed in colourless low density polyethylene bags and then chilled before slicing them into nuggets or slices. *Burger patties* are one of the most popular products among the ground meat items, and are generally used as fillings for burgers, rolls and sandwiches. For preparation of a medium size patty about 75 g of meat batter is taken and moulded into round shape which is then cooked in pre-heated oven at temperature of 180°C for 25 min.

2.1.5. Restructured meat products: Restructured meat products are generally prepared from less expensive cuts, tough cuts, meat trimmings or combination of these. In this technology, small pieces of meat or meat trimmings are joined together to get bigger pieces. The bigger pieces can be again cut into smaller pieces of desirable shapes and sizes.

2.1.6. Raw fermented meat products: Raw-fermented sausages are uncooked meat products and consist of more or less coarse mixtures of lean meats and fatty tissues combined with salts, nitrite (curing agent), sugars, spices and other non-meat ingredients filled into casings.

2.1.7. Coated/ breaded/ enrobed products: Emulsion based, restructured, freshly processed or any other type of meat products can also be converted into coated or breaded meat products. The characteristic of such products is the coating of meat surfaces with flour, fat/flour mixes and/or bread crumbs etc.

2.1.8. Cured meat cuts: In curing, generally intact muscle is subjected to some process to ensure distribution of salt (NaCl) and other curing agents throughout the product. After curing, smoking of meat is done to preserve and provide characteristics aroma and flavour to meat products.

2.1.9. Dried meat products: The advantages of dried products are the less storage space requirement, ease of transport, convenience and variety products having very long shelf life at room temperature. Most importantly, manufacturing schedule for dried meat products can be adjusted as per availability of raw materials and labour.

2.1.10. Development of combination meat products: Combination of meat products can be prepared using chicken meat and turkey meat, inclusion of poultry by-products (SGH, liver etc) or eggs. Eggs can be successfully incorporated up to 30% in the product formulation which have very good binding properties with desirable acceptability and lower the price tag.

2.1.11. Development of economic formulation: Economic formulations can be developed using variety of non-meat ingredients like vegetables, textured soy proteins, cereal flours, poultry by-products etc. This will provide wider acceptability by the Indian consumers besides nutritional improvement through supplementation of flavonoids, dietary fibres etc.

2.1.12. Speciality products from gizzards, livers and other edible by-products: Pickle from gizzards and liver based meat paste are two best examples of speciality products that ensure effective utilization of edible by-products besides providing nutrient rich meat products to consumers at a very affordable price.

***2.1.13. Shelf-stable meat products*:** Preparation of thermally processed meat products such as canned meat products and retort packaged products with extended shelf-life at ambient temperature promotes distribution and marketing. The hurdle technology concept proved very successful in development of many shelf stable traditional and novel meat products like Tandoori chicken, Meat pickles, Chicken snack sticks, Wafers, Finger chips, Breast fillets, Fermented sausages, Kurkure, Noodles, Biscuits, Curanclesetc

2.1.14. Traditional/Heritage meat products: In the recent years, our traditional meat products getting wider market in many western countries. Indigenous meat products are unique in their flavour, simplicity and ease of preparation. They have the potential of becoming value added convenience products of good palatability. Popular indigenous meat products are meat pickle, samosa, tandoor chicken, seekh kebab, tikka and kofta.

2.2. Value added egg products

The important factor associated with poultry eggs is that there is no religious taboo attached with consumption and can be consumed by person of any age groups. Thus, there is great opportunity for '**Start-up India**' initiative in area of development processed egg products. The main triggering factor being the fact that eggs are the cheapest source of animal protein and due to high biological value, quality of egg protein is very high as compared to other foods. Therefore, eggs can be utilized in development of protein enriched innovative value-added egg products with other cereals which are lacking in protein. In this away, the protein rich value-added egg products can be made available at affordable price. As egg contains nutrients required for human body needs during rapid growth, and therefore egg products can be developed for young children and teenagers. Several value added egg products are available in the market. These include egg powder, yolk granules, egg omelette mix, albumen flakes, scramble egg mix, pickled eggs, albumin rings, egg roll, egg crepe, egg waffles, egg patties, egg nog, instant egg noodles, egg rashmalai etc. which are gaining popularity among the consumers.

2.2.1. Egg powder: It is prepared from whole liquid egg by spray drying method. *Omelettes* can be prepared by mixing one parts of egg powder with three parts of lukewarm water along with salt, spices and condiments to suit the taste. The egg powder also finds application in several egg based food products and no-food industries.

2.2.2. Yolk granules: The egg yolk is homogenized, filtered to remove vitelline membrane, pasteurized, whipped and then sprayed on a perforated belt passing through a heated chamber. The dried foam produced is then crushed to desired granulation. The product finds use in the manufacture of sponge cake, doughnuts and cookies because of its excellent emulsifying and binding properties. Yolk granules can be packaged in a way similar to that of egg powder.

2.2.3. Albumen flakes: This is a dried crystalline product prepared from the albumen (white) of egg by pan drying method. The product is used in the preparation of angel cake, candies, and confectionaries.

2.2.4. Egg omelette mix: Ready to use products like dehydrated egg omelette mix has been developed to minimize the time required for its preparation either at home or in restaurants and fast food outlets. Omelettes are prepared by mixing one part of dehydrated omelette mix with three parts of water and stirring for about 3 to 4 times till uniform in consistency before frying.

2.2.5. Scrambled egg mix: Like omelette mix another ready to use convenient product, dehydrated scrambled eggs mix has been formulated using whole egg liquid, milk powder, table salt, white pepper and hydrogenated veg. oil for quick preparation of the product.

2.2.6. Angel cake: This is prepared from egg albumen. The egg albumen, monocalcium phosphate, salt and sugar are mixed and whipped by wire whip for 5 min at high speed in an electric mixer bowl. The other ingredients like cake flour, wheat starch and sodium carbonate are incorporated and blended into batter of uniform consistency prior to backing it in a hot air oven at 190 °C for about 30 min. The finished product is delicious and has very soft texture.

2.2.7. Sponge cake: Whole egg liquid or yolk is used in the preparation of sponge cakes. Although cake flour is the principal ingredient in such cakes, sponge cake made from batter containing about 18% yolk is called gold cake and that having 25% liquid whole egg is known as pound cake. In addition, salt, sugar, potassium bitartarate and vanilla are used in the formulation. The baking time and temperature are more or less the same as those for angel cake preparation.

2.2.8. Canned egg curry: This is ready-to-eat canned egg product. The hard boiled and peeled eggs are fried in edible oil to light brown colour. The gravy is prepared by mixing and frying spices and condiments (garlic, ginger and onion) to suit salt. The peeled eggs and gravy are mixed in the ratio of 55:45, filled in lacquered metal cans leaving 1.5 cm head space, exhausted and hermetically sealed. The sealed cans are then subjected to retorting (1kg/cm^2 pressure for about 20 min) to ensure sterilization of the product without burning or over cooking. The canned egg curry should have characteristic taste and flavour without any disintegration of eggs during one year of its storage life under ambient storage.

2.2.9. Pickled egg: A simple, cost-effective and efficient technology developed for pickling of quail eggs/ chicken eggs (pullet eggs) for storage and marketing at ambient temperature in ready-to-eat form. The process can be easily practiced in rural areas without much investment, skill and dependence on refrigeration. Methodology for both oil based as well as vinegar based quail egg pickles have been standardized and the technology for vinegar based quail egg pickle has been commercialized.

2.2.10. Albumen rings: Albumen rings are egg snack food, prepared by cooking blended egg albumen in ring molds and battering and breading the coagulated albumen prior to deep fat frying. It can be popularized as egg snacks at growing fast food outlets. Batter-breaded albumen rings contain 11.5% protein and 3.2% fat.

2.2.11. Egg Roll: It is a nutritious, tasty and convenience egg product suitable for meals or as snack foods. This product offers a potential market at growing fast food outlets. Egg roll filled with of 80% scrambled egg and 20% chicken meat mixture (Shallow pan fried) was rated best in flavour, texture and overall acceptability and contain 14.8% protein and 25.7% fat. Egg roll had a refrigerated shelf-life of 8 days in vacuum and 6 days in aerobic pack.

2.2.12. Egg Waffle: It is a nutritious and versatile snack food perfect for the breakfast. Waffles are light and crispy and right up to the last bite. This product offers a potential market at growing fast food outlets. Egg waffles prepared from 65% liquid whole egg with 10% wheat flour and 5% granulated wheat are most acceptable and has an ambient shelf-life of 4 days in vacuum and 3 days in air packs, while at refrigeration temperature they were acceptable for 10 days in vacuum and 6 days in air packs with satisfactory microbiological quality.

2.2.13. Egg Crepe: Egg crepe is typically a thin pan cake prepared with wheat flour or buckwheat flour, salt, milk and melted butter. All these ingredients along with eggs are mixed properly in blender and then pour thin liquid onto a hot frying pan, often with a trace of butter on the pan's surface. The batter is spread evenly over the cooking surface of the pan by tilting the pan.

2.2.14. Baked egg: A simple process of preparing baked egg has been standardized. Recipe of most acceptable baked egg was standardized using liquid whole egg, grated cheese and skim milk solids with finely chopped onion, ginger paste, chopped green pepper and salt. Moisture and protein in the finished product were 66.5%and 12.82%, respectively. The finished product was also found to have satisfactory microbiological quality. The egg was acceptable for 12 days in vacuum and 10 days in aerobic pack at refrigerated storage.

2.2.15. Egg tikka: Egg tikka was prepared with coatings containing mashed potato, refined rice flour, bread crumbs, black pepper and salt. Hard cooked peeled and halved egg lengthwise were covered with the coating mixture, dipped into the beaten egg white, rolled over the bread crumbs and deep fried in refined vegetable oil until golden brown in colour. The shelf-life was 20 days under vacuum and 18 days under aerobic packaging under refrigerated storage.

2.2.16. Egg cutlets: Process of preparing egg cutlets has been standardized. The recipe includes egg and minced chicken meat with grated cheese, onion paste, and refined wheat flour, mustard powder, spice mix, salt and each of while vinegar and soy sauce. The shelf-life was 14 days in vacuum and 12 days in aerobic packaging at refrigerated (4 ±1 °C) temperature.

2.2.17. Low sodium salted chicken eggs: A simple technique for preparation of intact low sodium salted chicken shell eggs has been developed which obviates the need for using salt with low level of sodium prior to serving boiled eggs and hence a convenient product for egg vendors.

2.2.18. Egg rasmalai: It is a nutritious and delicacy item for all age groups of people. In preparation, shell eggs are broken in a bowl and mixed well with milk powder until desired consistency achieved. On the other hand raw milk is heated in a pan and after generous heating sugar is added. The batter prepared previously is fall on heated milk as lumps which were then heat slowly. After completion of cooking cardamom and essence are added and chilled for two hrs before serving.

2.3. Technologies commercialized and patented by CARI, Izatnagar

The following technologies developed by CARI, Izatnagar are patented. The many of the other technologies developed have been transferred for commercial exploitation in the country.

i) Oil based chicken gizzard pickles
ii) Vinegar based chicken gizzard pickle
iii) Mixed chicken loaf
iv) Cooked chicken stock
v) Cooked chicken rolls

Technologies commercialized are to the many successful entrepreneurs in the different states of the country like Uttar Pradesh, Haryana, Tamil Nadu, Andhra Pradesh, Punjab, Kerala, etc

i) Quail egg pickle (Vinegar based)
ii) Salted eggs
iii) Egg rasmalai
iv) Functional chicken meat bites
v) Functional poultry meat wafers etc.

2.4. Future strategies

The figures related to growth of meat and egg production seems to be satisfactory but we are much behind than developed countries. There are enough opportunities to transform poultry meat sector into more profitable and sustainable enterprise.

i) It is require to establishing hygienic poultry dressing plants in rural set-ups and effective utilization poultry slaughter waste tackle to environmental pollution and huge monetary losses.
ii) Refurbishing and upgrading of retail market chain for ensuring safety and sustained demand of different poultry products.
iii) It is require developing semi-convenience, convenience and RTE processed poultry products to improve product diversification since there a great potential in India due to increase in double income families, increase in disposable income and less time availability for cooking.
iv) In processed meat sector, there is need to develop innovative processes, economic formulations, processing, bio-preservation and eco-friendly packaging conditions for convenience, value added, traditional, designer and shelf stable meat products.
v) It is require to evolving efficient processes like ultra-pasteurization-cum-aseptic packaging of liquid egg for shelf-life extension, extraction of different biomolecules from eggs etc. in view of their growing commercial significance.

vi) Improved processing technology for traditional poultry products which are in great demand both in domestic and export market.

vii) Improved packaging (vacuum, MAP/CAP, retort, aseptic) using eco-friendly food packaging materials for proper storage and distribution of poultry products.

viii) Developing package of practices for raising poultry for quality meat and egg production under different agro-climatic conditions.

2.5. Conclusion

Value addition of poultry products through dietary approaches provides better option for consumers who want those products with different nutritional health benefits than conventional ones. However, major changes that can also be brought in egg and meat products are through manipulation of raw materials, alteration of product's formulations and process modification for increase of protein with concomitant decrease in fat, enrichment of meat with fatty acids, fat-soluble vitamins and probably certain minerals. Numerous nutritional and non-nutritional factors have been demonstrated to alter fat deposition and cholesterol contents in meat. However, healthier meat and poultry products should be produced economically, saleable profitably, and safe for human consumption. Design must be taken into consideration the particular production facilities, available materials, technical know-how, and economic resources of the producers. Moreover, the welfare aspects and production potentiality of animals and birds, and also environmental issues must be taken care of in the process of value added egg and poultry meat products.

Role of Agribusiness Incubators in Entrepreneurship Development with Special Reference to Poultry and Allied Business

Sandeep Saran

Abstract

Agribusiness incubators play a crucial role in fostering entrepreneurship in the agricultural sector by providing support and resources to budding entrepreneurs in developing their business ideas and ventures. This article explores the role of agribusiness incubators in entrepreneurship development, with a specific focus on the poultry and allied business sector. It begins by defining agribusiness incubators and highlighting their significance in fostering innovation and growth in the agricultural industry. It also examines the specific challenges faced by entrepreneurs in the poultry and allied businesses and how incubators address these challenges. Additionally, the article explores into the various support services offered by incubators, including access to finance, infrastructure, mentorship, and networking opportunities. Besides, it highlights success stories of entrepreneurs who have benefited from agribusiness incubators in the poultry and allied business sector. Lastly, the article concludes by emphasizing the importance of agribusiness incubators as catalysts for entrepreneurship development and the need for continued support and investment in these incubators.

Introduction:

Entrepreneurship plays a pivotal role in driving economic growth, innovation, and employment generation. In the agricultural sector, entrepreneurship has the potential to transform traditional farming practices into sustainable and profitable agribusiness ventures. However, aspiring entrepreneurs often face numerous challenges, including limited access to capital, inadequate infrastructure, lack of market knowledge, and limited technical expertise. Agribusiness incubators have emerged as crucial entities that provide a nurturing environment for entrepreneurs, fostering their growth and success. This article examines the role of agribusiness incubators in promoting entrepreneurship development, with a specific focus on the poultry and allied business sector.

Definition and Significance of Agribusiness Incubators:

Agribusiness incubators can be defined as organizations or programs that support entrepreneurs in the agricultural sector by providing them with various resources, including infrastructure, technical assistance, mentorship, and access to markets and finance. These incubators act as catalysts for entrepreneurship development by nurturing innovative ideas and transforming them into viable agribusiness ventures. They create an enabling environment where entrepreneurs can access critical resources, gain industry-specific knowledge, and receive guidance from experts in the field.

The significance of agribusiness incubators lies in their ability to bridge the gap between innovative ideas and commercial success. They help entrepreneurs overcome initial hurdles, such as lack of funding, by providing access to finance through partnerships with financial institutions or government schemes. Furthermore, they offer networking opportunities that connect entrepreneurs with potential investors, suppliers, and customers, thereby facilitating market linkages. Agribusiness incubators also play a crucial role in capacity building by providing training and mentorship programs that enhance entrepreneurial skills and agricultural knowledge.

Challenges in the Poultry and Allied Business Sector:

The poultry and allied business sector faces unique challenges that can hinder the growth and success of entrepreneurs. Some of the key challenges include:

- *Lack of technical expertise*: Poultry farming requires specialized knowledge in areas such as breed selection, disease management, feed formulation, and biosecurity measures. Many aspiring entrepreneurs lack the technical expertise needed to run a successful poultry business.
- *Limited access to finance*: Starting a poultry business requires significant investment in infrastructure,

equipment, and working capital. However, entrepreneurs often struggle to secure adequate financing due to the perceived risks associated with the poultry sector.

- *Inadequate infrastructure*: Poultry farming requires appropriate infrastructure, including well-designed poultry houses, feeding systems, and waste management facilities. Limited access to such infrastructure can hinder the establishment and expansion of poultry enterprises.
- *Market access and information*: Entrepreneurs often face challenges in accessing markets and obtaining reliable market information, leading to difficulties in identifying potential buyers and negotiating favorable prices for their products.
- *Statutory Compliances*: Changing policy environment such as banning of battery cages, prescribing floor space requirements for layers, making NOC compulsory from the State Pollution Control Board for poultry farms having over 5000 birds as also other legal compliances are treated as challenges to starting a poultry business venture.

- **Role of Agribusiness Incubators in Addressing Challenges:**

Agribusiness incubators play a crucial role in addressing the challenges faced by entrepreneurs in the poultry and allied business sector. They provide tailored support services that help entrepreneurs overcome these hurdles and establish sustainable businesses. Some key roles of incubators include:

- **Technical assistance and training:** Incubators offer training programs and workshops that equip entrepreneurs with the necessary technical skills and knowledge required for poultry farming. This includes training on breed selection, disease management, nutrition, biosecurity, and modern farming practices.

Access to finance: Incubators facilitate access to finance by connecting entrepreneurs with financial institutions that offer loans or investment schemes specifically tailored for the agricultural sector. They also assist in preparing business plans and financial projections, increasing the chances of securing funding. The incubators also inform the prospective entrepreneurs about various government schemes in operation to provide them subsidies and other sops as may be available in the schemes.

- **Infrastructure and facilities:** Agribusiness incubators provide entrepreneurs with access to shared infrastructure and facilities, such as poultry houses, feed mills, processing units, and cold storage facilities. This reduces the initial capital investment required by individual entrepreneurs and helps them establish their businesses more efficiently.
- **Market linkages:** Incubators help entrepreneurs establish connections with market players, including suppliers, distributors, and retailers. They also provide market intelligence and support in identifying potential buyers, thus facilitating market access for entrepreneurs.
- **Mentorship and guidance:** Incubators offer mentorship programs where experienced industry professionals guide entrepreneurs in various aspects of business development, including production management, marketing strategies, and financial management. This mentorship plays a crucial role in improving decision-making and enhancing business sustainability.

Support Services Provided by Agribusiness Incubators:

Agribusiness incubators offer a range of support services to entrepreneurs in the poultry and allied business sector. These services are tailored to meet the specific needs of entrepreneurs and include:

- **Business development support:** Incubators assist entrepreneurs in developing robust business plans, conducting feasibility studies, and formulating marketing strategies. They provide guidance on product differentiation, branding, packaging, and market positioning to help entrepreneurs gain a competitive edge.
- **Training and capacity building:** Incubators organize training programs and workshops to enhance the entrepreneurial and technical skills of individuals. These programs cover a wide range of topics, including farm management, financial literacy, market intelligence, and regulatory compliance.
- **Access to finance:** Agribusiness incubators collaborate with financial institutions and government agencies to facilitate access to finance for entrepreneurs. They assist in preparing loan applications,

connecting entrepreneurs with potential investors, and guiding them through the fundraising process.

- **Networking opportunities:** Incubators organize networking events, trade fairs, and industry conferences that provide entrepreneurs with opportunities to connect with other stakeholders in the poultry and allied business sector. These events foster collaboration, knowledge exchange, and potential partnerships.
- **Research and development support:** Incubators collaborate with research institutions and universities to provide entrepreneurs with access to cutting-edge research and technological advancements. This enables entrepreneurs to adopt innovative practices, improve productivity, and enhance the quality of their products.

Success Stories of Entrepreneurs in Poultry and Allied Business:

The impact of agribusiness incubators in the poultry and allied business sector can be witnessed through several success stories. These stories exemplify how entrepreneurs, with the support of incubators, have transformed their innovative ideas into profitable and sustainable ventures. Some of the success stories are given hereunder while others can also be seen at the Institute's website https://cari.icar.gov.in/ss.php

These success stories highlight how agribusiness incubators have played a pivotal role in transforming

Success Stories

Commercial Japanese Quail Farming

M/s A.H. Bater Poultry Farm

Mobile No.: +91-9358426268, 9058024069

Mohd Haleem, a successful poultry farmer, was unemployed in 2003. At the time of trouble, his friend gave him a book entitled **"Bater Palan"** and suggested him to start commercial Japanese quail farming. He came to know about ICAR-**Central Avian Research Institute, Izatnagar, Bareilly** and contacted scientists of the Institute regarding Japanese quail farming. The scientists of the Institute not only encouraged him to do quail farming but also suggested him to start with 500 fertile eggs of Japanese quail, initially. The eggs were hatched and after rearing the chicks, he finally, set up his Quail farm (10 × 15 feet) by the end of 2003 by the name of **M/s A. H. Bater Poultry Farm** at Noor Nagar Puliya Affan Colony ERA G. S. Road, Meerut-250002 in Uttar Pradesh. Thereafter, he multiplied his stock and gradually enhanced his farm capacity to 2000 parent stock.

He continued to hatch the eggs which were produced from 2000 parent stock till 2006 and then further enhanced the business and farm capacity to 4000 parents. At this stage, he purchased a hatcher and some more parents and fertile eggs from CARI for expanding his business. At the end of 2006, the farm capacity was 10000 chicks per month.

In 2009, his farm capacity increased to 5000 parents. He added 10 new farmers in the same business and started to distribute chicks directly to farmers. By 2014, he had procured 3 hatcher -setters, and also started Turkey and Kadaknath farming along with Quail farming under the guidance of the CARI scientists.

By 2017, he associated 50 more farmers with his farm, and now the capacity of the farm had increased to 25000 quails, 1000 RIR chicken, 500 Turkey, 500 Kadaknath and 300 Guinea fowl. The following farmers joined hands with M/s A.H. Bater Poultry Farm and purchased birds-

Name of the farmer	Capacity of the farm
Mr. Satya Kumar (Meerut, U. P.)	6000 birds
Mr. Sokendra (Hapur, U. P.)	4000 birds
Mr. Pradeep (Haryana)	20000 birds
Mr. Surendra (Haryana)	10000 birds
Mr. Pradeep (Bhopal, M. P.)	15000 birds
Mr. Randhawa (Punjab)	5000 birds

Many more farmers also joined from different states. The students and farmers from Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut often visited his farm to get hands on training in poultry farming. Later two farmers opened their own poultry farms with 1000 birds' capacity under the guidance of Mr. Haleem. His initial capital investment was Rs. 15,000. Now he has 25 sheds (size ~30'x20') with a capital investment @Rs. 70000 per shed. His marketing strategy includes direct retailing, live sale in local markets and local meat wholesale markets. Total turnover at present is more than Rs. 1.5 crore per year. He has employed 3-4 people to help and support his business on a monthly salary of Rs. 8,000 per person. He is constantly in touch with CARI, Izatnagar for diversified poultry germplasm and technical support.

Success Stories

M/s Cocks Coo Organic Farm

Faridpur, Bareilly

COCKS COO ORGANIC FARM

Mr. M.P.S. Yadav, initiated his startup venture M/s Cocks Coo Organic Farm in Dec. 2017 in the village Sahajanpur, Ilaka Mehtarpur Karor, Block and Tehsil Faridpur, Bareilly, U.P. under contractual arrangements with M/s Shuguna Foods Pvt. Ltd. having its branch office in Bareilly, U.P. He got his firm registered vide registration No. B 14894 (under societies registration act, 1860), and also designed an attractive logo for his products. He got his son trained at CARI, Izatnagar in poultry farming in 2017.

His total investment was Rs. 17.25 lakh towards establishing his **Commercial Broiler Farm,** with a capacity to produce 6000 broilers in deep litter in all-in-all-out rearing system. He took a bank loan of Rs. 12.50 lakh for establishing his broiler farm. During winters, the contracting firm allows 1 sq ft per bird whereas during summers, the space allowance is increased to 1.5 sq ft per bird. Thus, during summers, he is able to produce 4500 birds per batch as against 600 birds per batch in winters. He has also employed two persons on his farm on a monthly salary of Rs. 7,000/- each. Mr Yadav, having motivated with the success of his broiler farm decided to expand the capacity of his farm and his second shed of similar capacity has almost been constructed. He is able to gross about Rs. 16-18/- per bird. After meeting expenses on labour, litter and electricity, he is able to save around Rs. 10/per bird. Now he is a well-established poultry farmer in this region.

aspiring entrepreneurs into successful agribusiness owners. The comprehensive support provided by incubators in terms of technical assistance, access to finance, mentorship, and market linkages has enabled these entrepreneurs to overcome the initial challenges and establish sustainable businesses.

Conclusion:

Agribusiness incubators play a crucial role in fostering entrepreneurship development in the poultry and allied business sector. By providing aspiring entrepreneurs with access to finance, technical assistance, infrastructure, mentorship, and networking opportunities, incubators create an enabling environment for business growth and innovation. They address the specific challenges faced by entrepreneurs in the poultry sector, such as limited access to finance, inadequate infrastructure, and market information gaps. The success stories of entrepreneurs who have benefited from agribusiness incubators further underscore the importance of these entities in nurturing and supporting agribusiness ventures.

To continue fostering entrepreneurship in the poultry and allied business sector, there is a need for continued support and investment in agribusiness incubators. Governments, financial institutions, and industry stakeholders should collaborate to strengthen existing incubators and establish new ones in underserved regions. Furthermore, research and development efforts should be intensified to provide entrepreneurs with access to cutting-edge technologies and innovative farming practices. By investing in agribusiness incubators, we can unlock the full potential of entrepreneurship in the poultry sector, promoting sustainable agricultural practices, enhancing food security, and driving economic growth.

***

Nutritional Manipulation to Combat heat stress of Poultry.

Nagesh Sonale*, Gautham Kolluri, Rokade, J.J.

Introduction

Poultry production is undergoing rapid growth in developing countries, becoming a significant sector within the livestock industry worldwide. According to the FAO's estimate in 2012, global chicken meat production reached 103.5 million tons annually, accounting for approximately 34.3% of total meat production (Pawar et al., 2016). Chickens are recognized as highly efficient sources of protein, particularly through their meat and eggs, and they play a crucial role in providing economical and nutritious food compared to red meat and other protein sources (Leinonen et al., 2014). Recent two-decade poultry industry has become a leading player in the livestock sector in many parts of the world (Sebho, 2016).The country currently holds the 3rd position in egg production and the 5th position in chicken meat production worldwide. The layer market, which focuses on egg production, has been growing at a rate of 6 to 7 percent per year, while the broiler market, which focuses on chicken meat production, has been growing at a rate of 8 to 10 percent per year.

However, the poultry farming system is vulnerable to various climatic factors, with environmental stress gaining significant attention in recent years, driven by public awareness and the abundance of scientific information (Lara and Rostagno, 2013). The global poultry industry faces several challenges, including climate change, increasing per capita demand for meat and eggs, and the emergence and spread of diseases. Among these challenges, environmental factors pose substantial obstacles to the growth and productivity of poultry. In particular, the frequency and intensity of heat waves have been on the rise and are expected to worsen in the coming decades. As chickens are highly susceptible to high temperatures, their growth and productivity are negatively impacted by global warming, leading to substantial economic losses in the near future. The effects of heat stress on poultry production have been magnified by the worsening effects of climate change and rising global temperatures worldwide (Tellez et al., 2017).

Impact of stress on poultry production & Economic losses

Heat stress is a major cause of poultry stress and can have significant negative impacts on poultry rearing. Chickens lack sweat glands, making it difficult for them to regulate their body temperature, when they exposed to high temperatures, chickens experience heat stress, which can lead to various physiological and behavioural changes.

Rapid panting is a common sign of heat stress in chickens, indicating their distress and efforts to cool down. Other noticeable symptoms include reduced mobility and poor appetite. As homeotherms, chickens have the ability to maintain their body temperature within a narrow range. However, exposure to extreme environmental conditions or excessive metabolic heat production can disrupt this balance, leading to a cascade of thermoregulatory events that may have lethal consequences for the birds (North and Bell, 1990).

The economic impact of heat stress on the poultry industry is substantial. In the poultry sector alone, annual economic losses due to heat stress range from $128 to $165 million. In the broader U.S. livestock industry, the total annual economic loss is estimated to be $1.69 to $2.36 billion (Lara and Rostagno, 2013). Research has shown that broilers subjected to chronic heat stress experience reduced feed intake (16.4%), lower body weight (32.6%), and higher feed conversion ratios (>25.6%) at 42 days of age. Numerous studies have demonstrated impaired growth performance in broilers under heat stress conditions.

It is important to note that stocking density plays a significant role as a potential compounding factor in the effects of heat stress on poultry. Both productivity and welfare can be compromised by high stocking densities. Overall, heat stress and other forms of stress in poultry production result in negative impacts on various production parameters, leading to substantial economic losses for the industry. Mitigating heat stress through improved management practices, ventilation systems, shade provision, and appropriate nutritional interventions is crucial for maintaining poultry health, welfare, and productivity while minimizing economic losses. following are the major impact which affect on the poultry performance:

Increased mortality
Decreased appetite
Growth stagnation
Poor feed conversion
Increased production costs
Easily contracted diseases and sickness.

Physiology of heat stress in birds

Poultry birds have a comfort zone, which is the temperature range of 23.9°C to 26.7°C, where they are comfortable and can carry out basic life processes effectively. As the environmental temperature rises above the comfort zone, birds employ various mechanisms to lose heat, primarily through radiation from different parts of their body such as the feet, comb, and wattles. They may also modify their behavior, such as wing spreading and panting, to dissipate heat. Although most of the poultry body is covered with feathers, heat dissipation through areas like the wattle, head, comb, and feet is limited. Panting is a vital process adopted by poultry birds to facilitate heat loss during heat stress conditions. The air sacs in the respiratory system play a crucial role in transferring body heat to the surrounding environment through respiratory evaporation, helping to decrease and maintain normal body temperature.

In addition, poultry under heat stress conditions have reduced feed intake, water consumption, body moments, and consequently become depressed, dull and lethargic. From a practicable perspective, it is crucial to consistently and properly monitor water utilization, feed intake, sleep interval, movement, and other behavioural activities when conditions are favourable for the development of heat stress in commercial poultry production. The prompt decrease in water intake, reduced feed consumption, behavioural changes, and physiological appearance of the body are the best and key indicators of birds experiencing heat stress.

Nutrition Strategy to Reduce heat stress.

Despite advancements in management technology, housing, ventilation, and cooling systems, the adverse impacts of heat stress on poultry productivity, morbidity, and mortality remain a challenge in poultry farms, particularly during severe hot weather (Abo Ghanima et al., 2020). To further address this issue, alternative approaches, particularly nutritional manipulations, have gained attention. Complementing proper management practices with specific dietary manipulations can help maintain good health and performance in poultry flocks during periods of high ambient temperature. These dietary manipulations include such as Feed additives, natural antioxidants, minerals, electrolytes, phyto-biotics, probiotics, fat, and protein as feed additives can help mitigate the negative effects of heat stress. These additives can support the birds' antioxidant defence systems, electrolyte balance, gut health, and immune function, thereby improving their resilience to heat stress.

Protein and amino acids supplementation

Reduced FI in chickens raised under heat stress condition cause a reduction in protein consumption Imbalance of dietary amino acids due to reduced FI alters amino acid transporters' gene expression in various tissues (Fagundes et al., 2020). Increasing protein level and amino acids concentrations in poultry diets are recommended to compensate the reduction in FI during hot weather conditions (Laganá et al., 2007).

VitaminE(α-tocopherolacetate):

Vitamin E has been shown to play a crucial role in reducing physiological stress by mitigating the effects of stress hormones such as corticosterone and catecholamines (Eid et al., 2006). It helps protect cells and tissues from damage caused by lipoperoxidation, which is the result of free radicals (Attia et al., 2016). The importance of vitamin E in poultry nutrition becomes particularly significant during stressful conditions, such as heat stress. Its antioxidant properties help maintain the redox balance within cells, reducing the detrimental effects of oxidative stress on poultry health and performance.

Vitamin C (Ascorbic acid)

In birds, vitamin C is primarily synthesized in the kidney from glucose. Under normal conditions, birds are capable of synthesizing sufficient amounts of vitamin C. However, during stressful situations, such as heat stress, the ability of birds to synthesize vitamin C becomes inadequate (Gursu et al., 2004). By providing vitamin C supplementation, the birds' antioxidant defenses are reinforced, helping to counteract oxidative stress induced by heat stress. Ascorbic acid acts as a free radical scavenger, neutralizing reactive oxygen species and reducing oxidative damage to cells and tissues. This antioxidant property of vitamin C supports the birds' overall health and helps alleviate the detrimental effects of heat stress..

Vit-A (Lycopene)

Lycopene (an acyclic isomer of β-carotene) is a member of the carotenoid found primarily in tomatoes and is recognized to improve the production and activity of antioxidant enzymes and detoxifying ROS. Supplementation of 200 or 400 mg lycopene/kg to broilers diets enhanced their FI, BW and FCR when exposed to heat stress condition (Sahin et al., 2016). Under heat stress conditions, lycopene is involved in enhancing the antioxidative status via activation of the antioxidant enzymes such as SOD and GSH-Px and reducing MDA level in broilers.

Zinc (Zn)

Zinc (Zn) plays a crucial role in combating the negative effects of heat stress in poultry. It is involved in suppressing free radicals by activating antioxidative enzymes, such as glutathione peroxidase (GSH-Px), superoxide dismutase (SOD), glutathione S-transferase, and hemeoxygenase-1. These enzymes help neutralize reactive oxygen species and reduce oxidative stress in the body. Supplementing the diet with 40 mg of Zn per kilogram of feed has been shown to have positive effects on broilers raised under heat stress conditions.

Calcium:

Calcium is one of the main factors that affects egg production in poultry especiallylaying hens. There is a linear relationship between Ca consumed in feed and egg production. Reduction ofCa intake during heat stress conditions causes a decreased Ca level in plasma and thereforeegg production is negatively affected. Mir et al. (2018) indicated thatfeed intake and related Ca intake of poultry exposed to heat stress decrease but addition ofhigh levels of Ca tothefeedunbalances the equilibrium of nutrients. However, Ca level inthedietcouldbeincreasedbyadditionofgrittopreventthis.Gritisretainedforalongtimeinthegizzard socould provide regularCato theintestineand blood.

Chromium(Cr):

Chromium supplementation is important because glucose isused intensively by broiler sandlaying hensex posed to heat stress and concentrations of serum Cr also decreased in poultry exposed to heat stress. Chromiumdecreases oxidative stress and lipid peroxidation, and it also decreases hepatic nuclear proteinand increase in the body temperature of layer quails exposed to heat stress (Sahin et al. 2010).

Electrolytes

It has been demonstrated that the thermoregulating system (production and dissipation of heat) of farm animals might be modulated by supplemental electrolytes such as sodium bicarbonate (NaHCO3), ammonium chloride (NH4Cl) and potassium chloride (KCl), and potassium sulphate (K2SO4). Hence, dietary electrolytes could improve blood carbon dioxide, bicarbonate and potassium in heat-stressed bird (Gamba et al., 2015).

Betaine

Betaine functions as a methyl donor in the liver. Endogenously synthesized from choline, betaine donates its methyl group to regenerate methionine, the central methyl donor in transmethylation. The inclusion of betaine in the diet of heat-stressed poultry can provide benefits by acting as a methyl donor, supporting methylation processes, enhancing the synthesis of important compounds like carnitine, and serving as an osmolyte to maintain cellular hydration and balance. These functions contribute to the alleviation of heat stress and the optimization of performance and well-being in poultry.

GAA (Guanidino acetic acid)

When GAA is included in the diet, it improves feed conversion and survival rates during chronic cyclic heat stress. The supplementation of GAA helps maintain the energy balance and supports the cellular energy needs of heat-stressed broilers. dietary supplementation of guanidinoacetic acid (GAA) improves the performance and survival of finisher broilers under heat stress conditions. It enhances the energy status of breast muscles and has an arginine sparing effect, leading to improved feed conversion efficiency and overall resilience to heat stress. (Majdeddin M. et al., 2020).

Conclusion

With the aggravation of climate change and global warming crisis, heat stress has been considered as the profound stressor affects poultry industry in tropical and subtropical regions. Dietary modifications are essential for overcoming the adverse impacts of heat stress in poultry. By implementing appropriate nutritional strategies, poultry farmers can enhance growth, laying performance, meat and egg quality, antioxidative status, and immune response in heat-stressed birds. These nutritional interventions are crucial for maintaining the sustainability and profitability of the poultry industry in the face of climate change and global warming challenges.

CONTACT US :

ICAR-CENTRAL AVIAN RESEARCH INSTITUTE

Izatnagar, Bareilly-243122

Website: https://cari.icar.gov.in

Phone: 0581-2303223