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LiVe2Africa
Sustainable Development of Livestock for Livelihoods in Africa

EUROPEAN UNION

EFFECTIVE UTILIZATION OF TECHNOLOGIES AND INNOVATIONS FOR THE PROMOTION OF LOCAL POULTRY LIVESTOCK VALUE CHAINS IN AFRICA






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PREFACE

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Poultry is one of the fastest growing sectors in the livestock value chains and offers hope for food and nutrition security as well as economic development of communities in Africa. The sector has witnessed an increase in the development of technologies and innovations which have contributed to improved production and productivity. Africa is increasingly becoming a key player in acquiring, generating and applying knowledge to development challenges. Utilization of modern technologies and innovations for conservation of the elite breeds, feeding, distribution of superior indigenous genetic resources and value addition to poultry products, offers promise to enhanced development of the sector. The application of these technologies and innovations significantly contributes to increased production and productivity in local poultry industry. It is therefore, imperative that the capacity of all stakeholders across the value chain is enhanced to increase the uptake and utilization of the modern technologies and innovations developed for the poultry sector. Robust training is pertinent as it ultimately culminates in increased technologies transfer and adoption across Africa. This training manual will provide the information necessary for effective utilization of available technologies and innovations to improve production and productivity.

This training manual provides vivid pictorial and graphic illustrations which will enhance the understanding of all stakeholders across the poultry livestock value chain.

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ACRONYMS

AAGRIS	African Animal Genetic Resources Information System
ACGG	African Chicken Genetic Gain
AnGR	Animal genetic resources
BSF	Black soldier fly
CAGR	Compound Annual Growth Rate
CTLGH	Centre for Tropical Livestock Genetics and Health
DDGS	Dried Distillers Grain Solubles
DNA	Deoxyribonucleic acid
EDTA	Ethylenediaminetetraacetic acid
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GMP	Good Manufacturing Practices
GPRS	General Packet Radio Service
GPS	Global Positioning System
GRAS	Generally Recognized As Safe
GSM	Global System for Mobile Communications
GVA	Gross Value Added
HACCP	Hazard Analysis and Critical Control Point
IACUC	Institutional Animal Care and Use Committee
IB	Infectious Bronchitis
IBD	Infectious Bursal Disease
ILRI	International Livestock Research Institute
LIT	Low Input Technologies
MG	Mycoplasma gallisepticum

NARS	National Agricultural Research Systems
ND	Newcastle Disease
OD	Optical density
OECD	Organization for Economic Co-operation and Development
PCR	Polymerase Chain Reaction
PCV	Packed Cell Volume
PEST	Political, Economic, Social, and Technological
PGCs	Primordial Germ Cells
PLF	Precision Livestock Farming
PUFA	Poly unsaturated fatty acids
QPM	Quality Protein Maize
QTL	Quantitative Traits Loci
REO	Respiratory Enteric Orphan
RNA	Ribonucleic acid
RNAi	Ribonucleic acid interference
SPIDES	Short Periods of Incubation During Egg Storage
SWOT	Strengths, Weaknesses, Opportunities and Threats
VC	Value chain
WTO	World Trade Organization

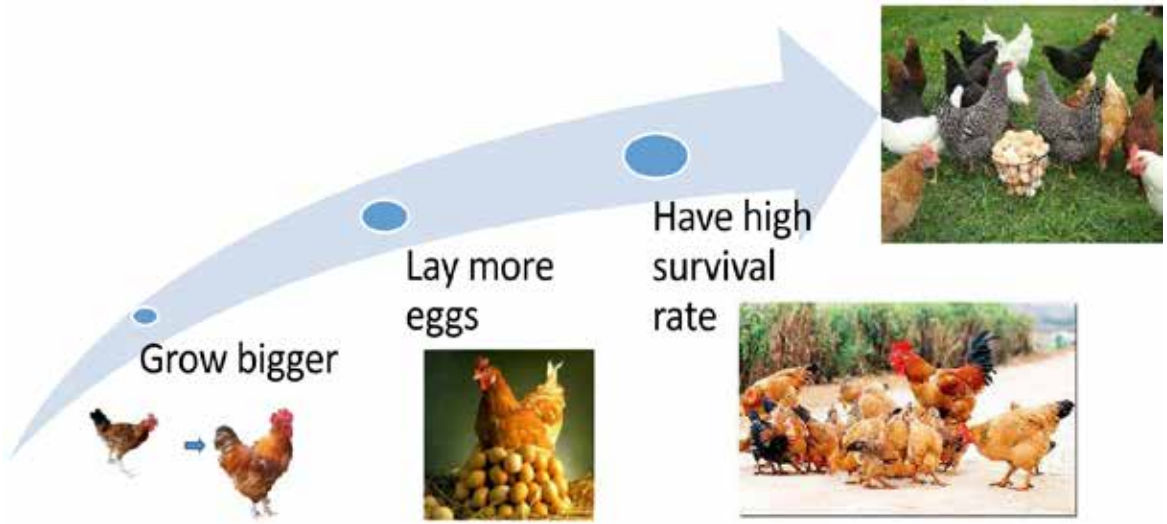
INTRODUCTION

Family/traditional poultry farming is in principle a small-scale poultry production by households using family labour and, and when possible, locally availability feed. Poultry can roam freely, foraging for the larger part of their feed. Some farmers provide supplements to their poultry. Most of the labour on managing the poultry is provided freely by family members.

Family poultry farming represents one of the many integrated and complementary activities of the farming system that contribute to the general well-being of many households. Local poultry are often used simultaneously for several objectives and can be as efficient as specialized commercial breeds considering multiple productivity vocations including incubation and brooding, meat, and egg production as well as cultural uses.

Poultry are a source of high-quality proteins and trace elements, financial support; eases pest control, produces manure, and play an essential role in socio-cultural activities. Most importantly, poultry farming can be easily managed by women and children. Other reasons why family poultry farming should be given priority: (1) directly reduces poverty by generating income, (2) indirectly provides funds for education (3) directly promotes gender equality and empower women, (4) indirectly reduces child mortality through improved nutrition, (5) directly improves maternal health.

The objective of this manual is to help transform smallholder poultry production in Africa, by providing poultry that can:



Nutritive value of chicken meat

chicken meat is a good source of protein and vitamins and minerals, such as:

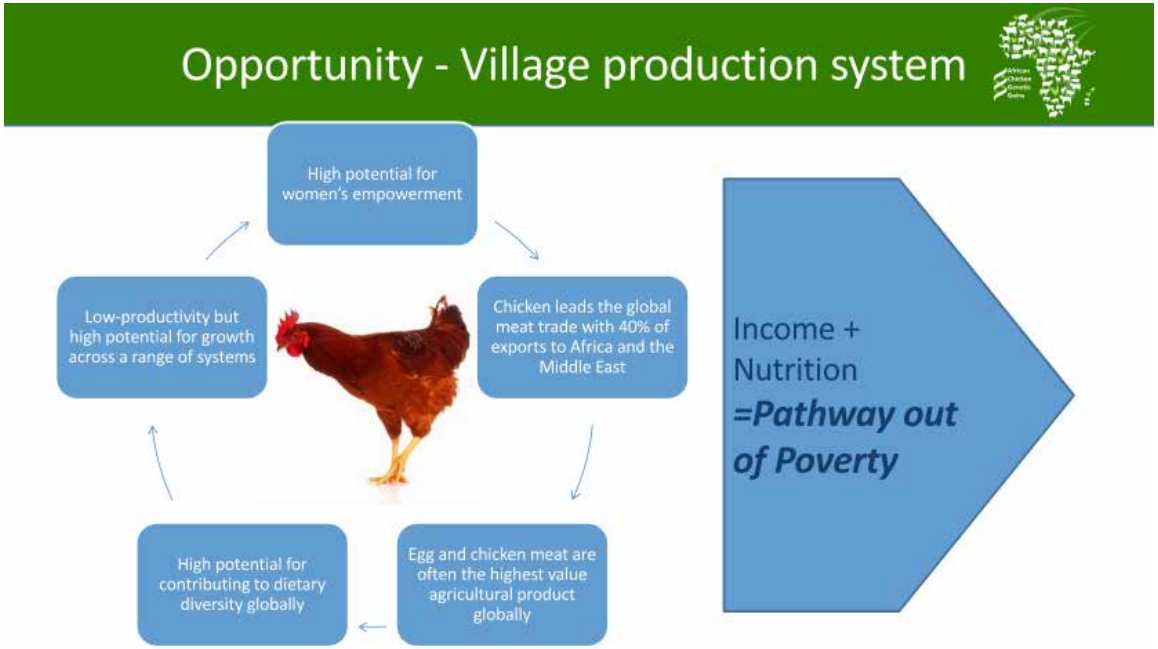
- iron,
- selenium,
- zinc, and
- B vitamins.

It has several advantages as half of the fat is made up of the desirable monounsaturated fats, and only one-third of the less healthy saturated fats. Chicken meat is therefore considered as a healthy meat. Chicken meat does not contain the trans-fats that contribute to coronary heart disease.

Chicken meat is rich in the omega-3 fats and is an important provider of the essential polyunsaturated fatty acids (PUFAs), especially the omega (n)-3 fatty acids. The meat of scavenging chicken is a particularly good source of these fats due of their diverse diet.

Why to go for family poultry farming

- There are many reasons why one should embark on family poultry farming:
- Low initial investment but higher economic return.
- A unit can be started with as low as two chicken to a large flock.
- Feed cost is negligible due to better utilization of agricultural by-products and leftover feed and grains.
- Egg and birds can be sold in local market with high price, because there is a growing demand for local chicken.
- The consumers are willing to pay higher prices for high quality chicken meat or egg.
- Boost up in family income for better utilization of family labours who are not able to perform other agricultural works like old family member or women.
- Backyard poultry farming acts as "ready cash", because as per family need the birds and eggs can be sold at any time anywhere with cash in hand.
- Quality of chicken and egg is better in terms of organic farming as the birds are raised in stress less environment with natural input.
- They are self-sustaining i.e. can raise their own replacement stock
- They are hardy birds that can survive hard conditions
- Management requirements are minimal when compared with those of exotic breeds
- They are tolerant to some diseases and parasites
- Their products fetch more money than those from exotic birds, due to their taste and preference by most communities



Source: African Chicken Genetic Gain (ACGG-ILRI)

Local poultry farming however has few limitations that should be known when starting the business

- local poultry have a lower growth rates when compared with exotic birds
- They produce fewer small-sized eggs and comparatively little meat when compared with exotic birds
- People keep them not for commercial purposes
- They have been neglected by breeders/scientists despite their potential

Nutritive value of eggs

Eggs are a wholesome, nutritious food with high nutrient density because, in proportion to their calorie count, they provide 12% of the daily value for protein and a wide variety of other nutrients so crucial for growth and good health like:

- Protein
- vitamins,
- essential amino acids
- minerals such as folate, iron, phosphorus, Selenium, Choline and zinc etc.

CHAPTER I: GENERAL CHARACTERISTICS AND FACTS ABOUT AFRICAN CHICKEN

1.1. Some definitions

Class -Used to designate a group of birds - developed in certain regions or geographical areas. They are American, Asiatic, Mediterranean and English.

Breed - refers to an established group of birds within a species related by breeding, possessing a distinctive shape, conformation, plumage colour, comb type, general body weight and breeds true. Ex. Aseel, Rhode Island Red, Leghorn, Cornish, etc.

Variety- used to sub-classify breeds. There may be many varieties within a breed differentiated by plumage colour, pattern and comb type Ex. White Leghorn, Black Leghorn, Brown Leghorn, Barred Plymouth Rock etc.

Strain - Sub classifications of a breed. Normally a strain is named after the person who has evolved them or it can also be named after the institution where it is developed. They are developed duly giving importance to certain specific traits like egg production, early maturity, better feed efficiency, egg weight etc. Ex. Meyer strain of White Leghorn, Forsgate strain of White Leghorn, Sterling strain of Rhode Island Red.

Lines - Sub classes of a strain developed such that the gene(s) responsible for a particular trait is fixed so as to be utilized for production of commercial hybrids.

Indigenous poultry is a name used to refer to local breeds of poultry that are adapted to harsh environmental conditions that include extensive, small-scale village, free range and organic production systems. They are also referred to as traditional, scavenging, backyard, village, local or family poultry

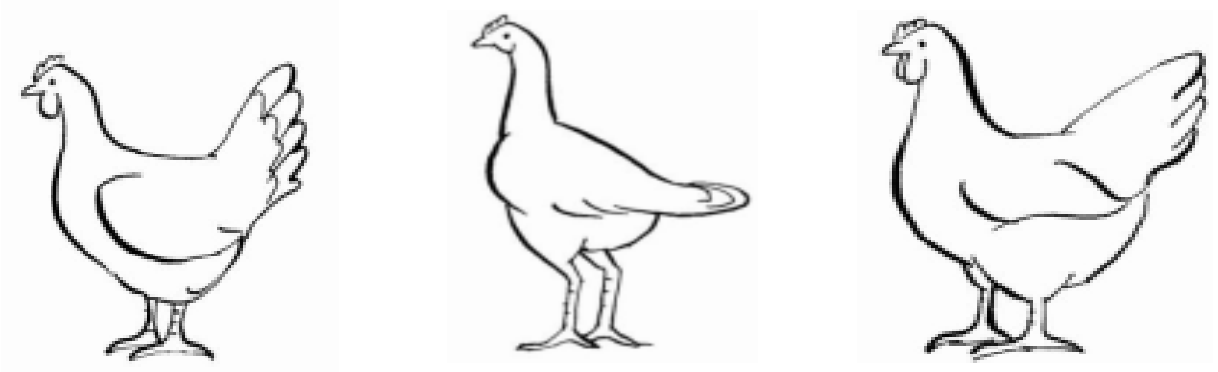
1.2. General characteristics of the African chicken

Their characteristics include:

- Generally hardy, adapted to harsh environmental conditions, rustic.
- Self-reliant, feed themselves by looking for kitchen wastes, insects, worms, lizards and plant seeds, leaves and others.
- Are generally of small sizes with slow growth rates.
- Meat and eggs have good, attractive pigmentation, leanness, good taste
- Good brooding aptitudes,
- Age at sexual maturity is between 133-169 days under extensive system.
- Poor egg production (40-50 eggs/year under an extensive management system).
- They have good fertility and hatchability rates.

Local chicken are genetically adapted to harsh environment characterized by limited feed and water resources, poor weather and climatic conditions, exposure to pathogens, and predators. They are also characterized by genetic variability, hardiness, good brooding aptitudes. There is diversity in African chicken genetic resources, with dual purpose and locally adapted breeds, which require minimum attention for them to satisfy the local and international markets for meat and eggs.

There are also a number of locally improved or adapted breeds which can support the commercial production systems in Africa. The development orientation could roughly be guided in rural settlement by the morphological characteristics of the animals



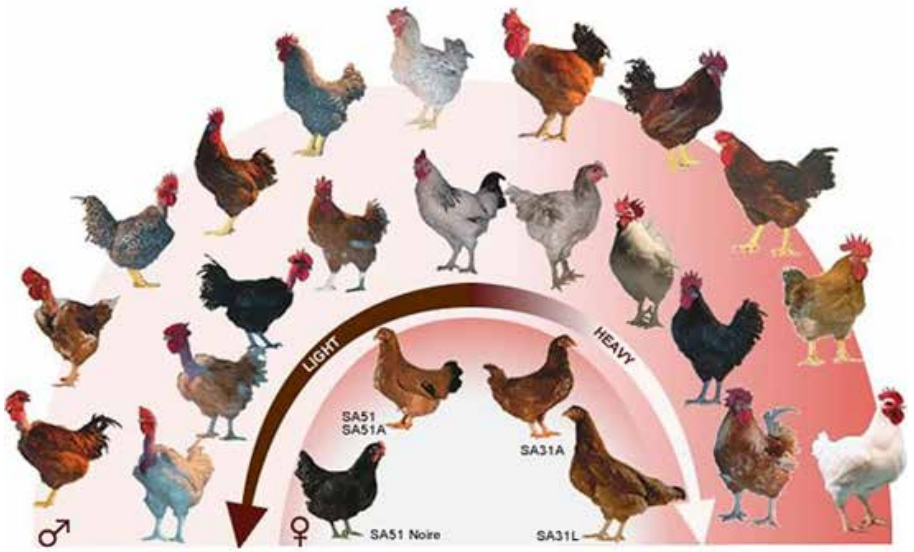
Egg types ***Meat type*** ***Dual purpose***

Figure 1. Morphological features of chickens

Sources *: NAFIS,* http://www.nafis.go.ke/livestock/chicken-chicken/indigenous-chicken-kienyenji/breeds-of-indigenous-chicken/
Figure 2. *A chicken breeding pen*

Below are some of the most promising indigenous and locally adapted chicken breeds found in Africa are presented in Table 1

Table 1. Some of the indigenous and locally adapted chicken breeds found in Africa

The SASSO family picture of breeder roosters and hens	
Kuroiler (composite)	

Shika Brown National Animal Production Research Institute (NAPRI) in Shika, Zaria,	
FUNAAB Alpha chicken	

Noiler	
Fulani	

Table 2. Some performance parameters of cocks at 20 weeks

	Fulani	FUNAAB Alpha	ShikaBrown	Kuroiler	Sasso	Noiler
						
Live weight (kg)	1.3	2.1	1.7	2.9	3.0	2.6
kg Feed/kg body weight	8.5	5.2	7.0	4.6	5.4	5.7
Protein (g/kg meat)	114	269	158	320	348	213
Fat (g/kg meat)	11	29	15	35	42	15

Source: *African Chicken Genetic Gain (ACGG-ILRI)*

Table 3. Some performance parameters of indigenous and locally adapted hens

	Fulani	FUNAAB Alpha	ShikaBrown	Kuroiler	Sasso	Noiler
						
Age at 1st Egg (weeks)	18	17	17	18	19	17
Ave Egg Weight (g)	42	51	54	55	55	39 (at 1st month of lay)
No. of Eggs/Week (3rd month of lay)	3	4	5	4	3	2 (2nd month of lay)
Chicks Hatched/100 Eggs	60	55	74	81	85	84

Source: *African Chicken Genetic Gain (ACGG-ILRI)*

Some ecotypes of chicken breeds in Africa have high genetic potential that is unfortunately not fully or efficiently utilized.

Figure 3. *Kabir chicken from the GreenGold Agroventure Farm in Cameroon*

African farmers also have some exotic strains of chicken which are locally adapted for meat, egg and mixed production. These include Vedette, Rhode Island Red, Plymouth Rock, New Hampshire, Orpington, Brahma, Cornish, Leghorn, Sussex, Flaveroles, among others. Below are 10 productive chicken breeds for backyard meat and/or eggs production, and also for commercial production. They are adaptable to varying climatic conditions.

Table 4. Some exotic strains of chicken locally adapted for meat, egg and mixed production in Africa.

Sussex Sussex chicken are dual-purpose birds and lay about 250 eggs annually in varying shades of light brown. They have eight different colours, the most common being the pure white body with a black neck and tail feathers. They are very calm and are comfortable with free range systems.	
Rhode Island Reds (RIR) RIR are dual-purpose chicken, meaning they can be raised for their eggs or meat. They are one of the most popular backyard and commercial chicken breeds because they are hardy and lay many eggs. This breed can lay about 250 brown medium sized eggs a year. They have brown and black feathers giving them a dark appearance.	

Plymouth/Barred Rock They are predominantly grey with white stripes around their bodies. Barred, black frizzle, blue, partridge, buff, Columbian, silver pencilled, black, and white colors are available. They are better suited for the free-range system and are very friendly and hardy. The hen lays about 280 light brown eggs a year.	
Australorp The Australorp breed one of the most productive chicken breeds and originates from Australia. They are raised for both eggs and meat because they are very good layers and are hardy. Australorp lay about 250 brown eggs per year. They forage very well and come in black, white or blue colours.	

Wyandotte The Wyandotte is a dual-purpose breed and lays about 200 brown eggs annually. They have a docile temperament. They have attractive plumage with gold, blue and silver colour variations. The	
Jersey Giant The Jersey Giant chicken breed is dual-purpose and the hen lays about 260 brown eggs a year. Jersey Giant chicken are large-framed. These blue, black, and white chicken are the largest of the purebreds. The have a docile temperament and are excellent for beginner flocks.	

Leghorn Leghorn chicken are productive layers. The hen lays about 280 white eggs a year. They are not of a docile temperament. They are rather flighty and easily startle. However, they are very productive layers. They thrive particularly well in warmer climates.	
Orpington This breed is also dual-purpose. They are good layers and are hardy. The Orpington are fluffy and have multiple colours, blue, buff, black, white and lavender. They are attractive and friendly.	

Barnevelder The Barnevelder is a cross between the Dutch Landrace and Asian jungle fowl and is native to Holland. A Barnevelder hen lays around 200 eggs per year. These eggs are small to medium-sized and of a light speckled brown colour. This breed is mostly a black with brown tipped feathers. This breed is better suited for the backyard. It is not a good flyer therefore, there is no need to clip their feathers.	
Marans They appear like Plymouth Rocks and are mostly dark grey with white flutters. Marans are dual purpose and lay about 200 eggs a year. They are renowned for their vibrant dark brown and tasty eggs. The birds and their eggs are usually medium in size. Marans are gentle and do not require much space to roam. However, they are not of a docile temperament and therefore, not good pets.	

1.3. Why breeding in family poultry

Breeding refers to mating chicken for either maintaining/increasing the current flock or for selecting specific individuals for improvement in one or more characteristics (e.g., for size, weight, egg production, meat quality, behavior, plumage, comb type, or a combination of factors).

Breeding techniques generally consist of introducing an improved cock while avoiding inbreeding and popularize the F_1 population, or introducing fertile eggs, chicks, or pullets of improved breed.

Breeding could be targeting:

Selecting for meat Qualities and rate of growth.This entails choosing and evaluation age and making the necessary assessments. These assessments could be based on:

- skull width – A wide skull on a chicken is a strong indicator of good growth potential
- Heart girth – A good heart girth is an indicator that there is enough space for the internal organs to be of good size, maximizing the bird's potential for growth and development.
- Back fatness, length, and breadth – A fat back makes for a more attractive carcass on a table bird. Good length and width contribute to the quality of the dressed bird as well. Flat backs are one indicator of good bone development in a bird.
- Body depth, capacity – As with heart girth, this aspect of the bird's body indicates whether there is ample or restricted space for internal organs.
- Breast and keel – The keel is examined for its straightness & length (for good carcass appearance) and the breast is inspected for development of good meat proportions. The amount of meat on the breast will ultimately drive the bird's appeal to the consumer.
- Weight – Young birds can be weighed to determine overall growth rates for the fock. Weight has the advantage of being an impartial record that can allow comparison of different generations of birds.
- Color – Early in the flock's management color is observed in all of the birds. Although ideal color is nice, it is not a necessity in the early stages of selection for production traits in a breed. Unless a bird is completely off color, it can be acceptable as breeding stock early on in a recovery program.

- Appetite equals rate of growth – A bird's body grows according to the inputs it receives. Thus, a bird that eats larger quantities of food will grow faster than a bird that eats smaller quantities of the same food.
- Protein equals rate of growth – Just as the amount of food consumed affects the rate at which a bird grows, so does the quality of the feed provided.
- Wide feathers – Birds with wide feathers grow at a faster rate than birds with narrow feathers. This has largely due to the fact that narrow feathers allow more body heat to escape and thus less of the food consumed goes into growth.
- Mortality – Extremely slow or excessively fast maturing chicks tend to suffer higher mortality than chicks which grow at a "normal" rate. Excessively fast maturing chicken have thinner gastro-intestinal tracts, which allow for faster nutrient uptake. But the thinness of these tracts can also make for proneness to intestinal blowouts and infections.
- Size – Mature size and rate of growth are not positively correlated. Both mature size and rate of growth are important considerations for potential breeding stock.

- ***Selecting for Egg production.*** The first and most basic knowledge a chicken producer should have, is to know how to identify which hens are in production.

Table 5. Characteristics of a Hen in and after production

Characteristics of a Hen In production	**Characteristics of a Hen out of production**
• Soft, enlarged comb and wattles • Wide, moist vent. • Increased distance between the pelvic bones • Increased distance between pelvic arch and keel • Velvety skin • Soft, pliable, enlarged abdomen	• Short, hard, shriveled comb and wattles • Small, puckered, and dry vent • Little distance between the pelvic bones • Short distance between pelvic arch and keel • Tight, coarse skin • Firm abdomen

Superior egg layers could be identified and selected based on the following criteria

- Pelvic bone arch and the keel to pelvic bone spread – Each value is measured during peak production periods in mature laying hens. The distance between the two bones in a hen in production is a good indicator of relative egg size. Ideally, the bones themselves will be relatively thin. The distance between the pelvic arch and the rear tip of the keel bone is a good indicator

of the size of the egg organs and the number of eggs produced (relative to breed) – having little fat and gristle coating them

- Molting Ability – Birds should be selected for their molting abilities. Individuals that drop feathers almost all at once are preferred over birds that take longer to molt. The quicker the molt, the quicker the birds get back to the business of laying eggs. It is preferable that the molt occur later in season for optimal persistency of lay (such birds lay eggs for a longer period of time during the year).
- Abdomen – A soft pliable abdomen is a good sign of a healthy hen. Sometimes a hen will be found that has very good spread between the keel bones and the pelvic arch but also has a hard abdomen. Such a hen very likely has a cancerous tumor, though occasionally an egg is mistaken for such a hard lump.
- Body Capacity – The space within the body of a chicken is filled with various organs. When one section of the body is narrow or lacks space, the organs of that area must be reduced for space and thus tend to function below optimum.
  - Birds with good width between their legs often are better layers, as this is one indicator of body capacity.
  - Birds with full, well-rounded breasts and with legs set well back tend to be more productive. This is another trait that indicates body capacity.
  - The body of high capacity egg layers is not quite rectangular, when viewed from the side – it is deeper at the rear than in the front of the bird. This allows more room for egg organs.
- Birds that begin to lay early in the year, while the days are short, tend to be better egg layers.
- Pullets that come into production between 180 and 215 days of age tend to develop into excellent layers
- Pullets that begin to lay early tend to lay smaller eggs
- First-year hens that lay 25 or more eggs during August and March in the year following hatching tend to be better producers.
- Egg size and body size are correlated.
- February is the month that maximum first-year egg size is obtained, nearly regardless of hatch date.
- Second-year egg production is usually reduced from first year by 20%.
- High-producing hens tend to have brittle or broken feathers. This is caused by putting so much of their resources into producing eggs.
- Monroe Babcock, creator of the Babcock B2000 commercial egg-layer, recommended using hens for breeding that lay before 10 am. He noted that such hens tend to lay more eggs, and are generally healthier and long lived.

Table 6. Estimating Egg production using Chicken Body measurements

Keel/Pelvic Spread (measured by span of fingers)	Pelvic Bone Thickness (measured by span of fingers)	Approximate Annual Egg Production
6.0"	.5"	205 eggs
6.0"	.375"	235 eggs
6.0"	.25"	265 eggs
5.5"	.5"	175 eggs
5.5"	.375"	205 eggs
5.5"	.25"	235 eggs
5.0"	.5"	145 eggs
5.0"	.375"	175 eggs
5.0"	.25"	205 eggs
4.5"	.5"	130 eggs
4.5"	.375"	160 eggs
4.5"	.25"	175 eggs
4.0"	.5"	80 eggs
4.0"	.375"	110 eggs
4.0"	.25"	138 eggs

- It should be noted that the actual number of eggs laid by a hen are influenced by a number of factors including genetic potential and management. The intelligent chicken farmer will manage birds to provide optimum conditions for egg production.
- Light stimulates the pituitary gland, thus leading to egg production. For optimum egg production 14 hours of daylight is required. Using a light bulb in the hen house to add 2-4 hours per day will bring hens into lay in about three weeks.
- Water is required to produce eggs. Chicken may stop laying due to lack of good consumable water. Chickens will drink more

clean water than dirty water.

- Stress will reduce egg production. Moving chicken to new pens or adding new chicken (such as new roosters) can reduce or stop egg production for a few weeks.
- Fattening feeds, such as corn, scratch feeds, and oils, can reduce or stop egg production.
- Fat hens lay poorly. The fat coating around the pelvic bones gives a good indicator of the condition of the hens. Adding 1-2 tablespoons of apple cider vinegar per gallon of drinking water, along with feeding a good basic layer ration, can get hens back into production.
- Oats fed along with a good base layer ration tend to encourage egg production.
- Chickens that were fed low quality feed may never develop to their full potential. The first three weeks are the most critical to proper development.
- Inexpensive, low quality layer rations often lead to poor egg production. Feed a good, well-balanced layer ration.
- Hens need to feel secure in order to lay well. Provide well designed nest boxes in ample quantities to avoid crowding. (A good rule of thumb is four hens per nest.)
- Overcrowded chickens do not lay at their peak because of the stress they are undergoing.
- Chickens that are exposed to ammonia may become sick and often lay poorly during exposure. Keep chicken house clean – if there is a smell ammonia then the chicken are already stressed.
- Sick chickens lay poorly. Maintain the health of flock and address disease issues quickly.
- Internal and external parasites will reduce or prevent egg production. Check hens periodically to be sure they are in good condition and not troubled by parasites.
- Brittle and broken feathers on hens can be an indicator of a lack of calcium (as well as of high egg production). Provide oyster shell free choice, as high producing hens may require more calcium in their diet than is contained in their layer ration.
- Unless having granite pebbles laying around, one can assume that birds will benefit from supplemental grit. Grit helps grind the feed and contributes to better feed efficiency, and thus is well worth the cost and effort to provide.

Selecting for adaptability

1. One should never use a bird in the breeding pen that had been treated with medication that year. While the bird may seem healthy, that the bird suffered disease is one indicator of low immune function. Also, in some cases of disease, the symptoms may have dissipated but the animal may not have completely recovered.
2. Culling all birds that become sick is one way to positively select for disease resistance in breeding stock within the region in which the flock is located. Many chicken breeders have found that after a few generations of culling all sick birds, illness will no longer be found in the flock. This practice should not be expected to work for highly pathogenic diseases.
3. Master breeder James P. Rines used to say "Your flock will have only what you tolerate." This saying can be broadly applied to all aspects of breeding, including disease resistance.
4. Selecting for vigor requires selecting from amongst the dominant cockerels and pullets when choosing future breeding birds.
5. Select male and females that have bright red combs without dark tips. Dark tips can be an indicator of heart trouble.
6. Select birds with bright, strong eyes with well-formed irises and correct eye color for breed. Some diseases, such as leucosis, prevent the iris from forming a nice round shape and may leave the eye off colored.
7. Very active and animated individuals are often highly fertile and vigorous.
8. Birds that have thick, well-fleshed shanks for their breed tend to be more vigorous.
9. Fertility into old age and longevity are indicators of vigor.
10. Eggs from the best layers tend to hatch as well or better than those from poor layers.
11. Evidence indicates that breeding from only two-year old and older hens increases longevity and reduces mortality within a strain.
12. Keep track of your most productive hens. Male progeny from these hens should be favored during selection and mated, when possible, to hens that lay near the top of the flock's ability in order to produce highly productive offspring.
13. First- and second-year egg production should guide retention. Hens with high records from these two years should be used as long as productive.
14. Malposition of chick or air cell accounts for chicks that do not make it out of the eggshell – this is highly heritable. Cull all chicks that are unable to hatch unassisted.
15. Overly large eggs result in chicks that have faults such as extruded yolks and other incubator-related weaknesses and hatchability

problems. Placing too much emphasis on large egg size can result in poor hatchability for the flock.

16. Rough, coarse comb texture can be linked to reduced fertility.

1.4. Overview of SWOT Analysis of the Chicken Sector- for eggs and meat

It is important to identify problems and opportunities as well as the weaknesses and strengths found and developed by the chicken farmers in order to identify the conditions/factors/situations/practices that can enable the sustainability of the production.

Table 7. SWOT Analysis Chicken Sector- both for eggs and meat

STRENGTHS	WEAKNESSES
1. Low cost protein for human consumption 2. Good growth rate- the Compound Annual Growth Rate (CAGR) is around 5% for eggs and 7% for chicken; The CAGR of Gross Value Added (GVA) for last 5 years for egg and chicken is 13% and 15% respectively. 3. Livestock contributes 12% to rural household monthly Income; Chicken alone can contribute half of the same	1. Lack of infrastructure facilities for value addition such as chicken processing, warehousing, cold storage, refrigerated vehicles 2. Frequent maize & soya price fluctuations leading to availability issues of chicken feed and price distortions 3. Small farms, losing out on economies of scale and biosecurity 4. Lack or undefined standards leading to impending cheaper imports
OPPORTUNITIES	THREATS
1. 95% Raw/ Wet market – can transform 2. Work on developing alternate breeds and Low Input Technologies (LIT) birds for upgraded family chicken 3. Untapped potential for the export & value-added chicken products. 4. Consolidation of integrated operations would strengthen chicken supply chain	1. Avian influenza, Newcastle disease and other emerging/re-emerging chicken diseases 2. Natural disasters

1.5. Growth Drivers and Emerging Trends for eggs and meat in Africa

In Africa, chicken sector growth may be attributed to many factors like:

1. rising incomes and a rapidly expanding middle class,
2. emergence of vertically integrated chicken producers that have reduced consumer prices

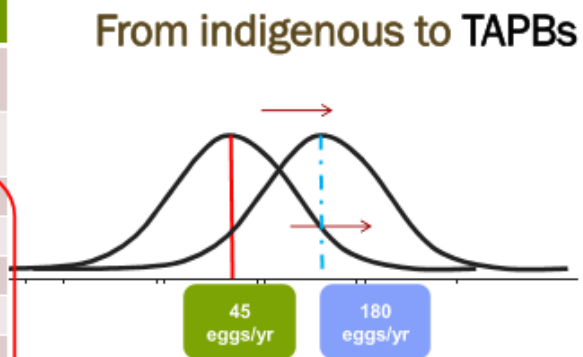
3. lowering of production and marketing costs.

Integrated production, market transition from live birds to chilled and frozen products, and policies that ensure supplies of competitively priced corn and soybean are keys to future poultry industry growth in Africa. Further, disease surveillance, monitoring and control will also decide the fate of this sector.

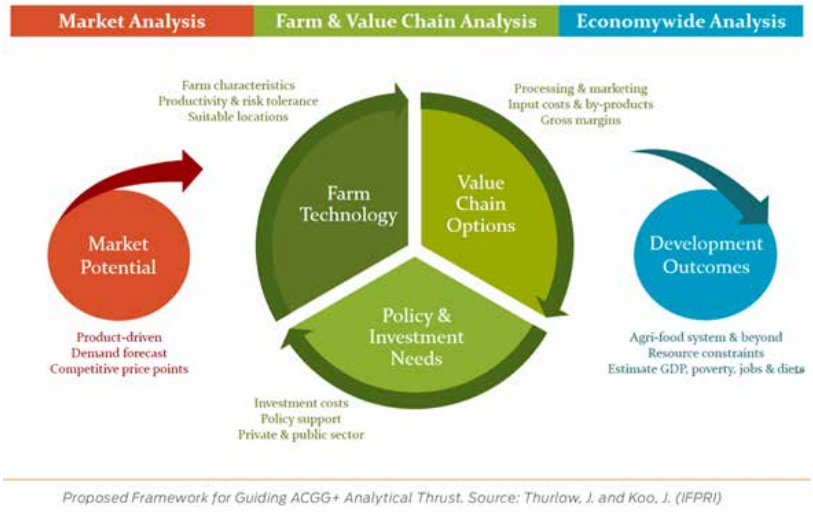
These achievements and growth rates are still being sustained despite the regular outbreaks of avian influenza which was a severe setback for the industry, showing the resilience of the subsector, perseverance of the private sector and timely intervention by the government.

Table 8. Average egg production from few chicken breeds in Africa

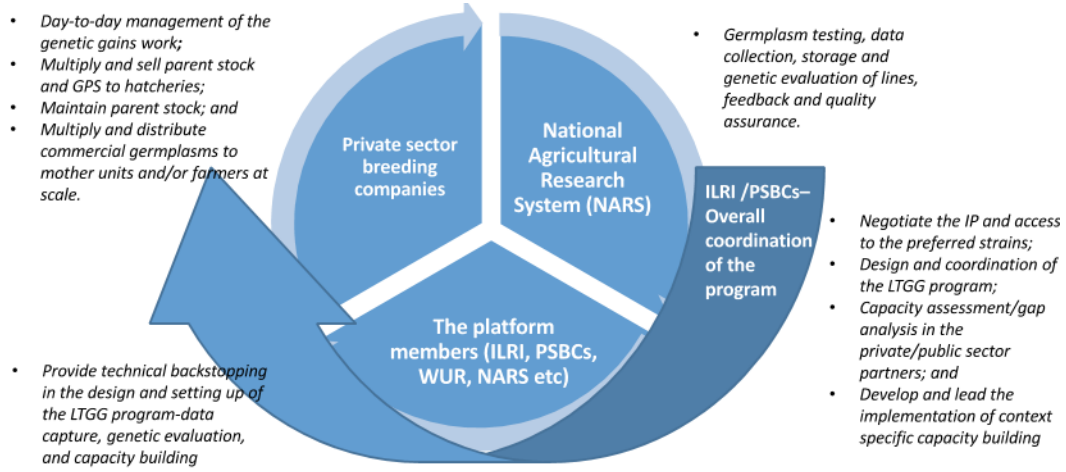
Geography / Conditions	Breed	Average eggs/ year
West Africa scavenging (sub)-humid	Indigenous	33
East Africa scavenging (sub)-humid	Indigenous	58
Egypt	Fayoumi	146
South Africa	Koekoek	204
Ghana (intensive feeding)	Naked Neck	288
Ghana (intensive feeding)	Frizzle Feather	287
Uganda	Kuroiler	180
India	Rainbow Star	160-180
India	CARI lines	198-220
Developed world	"Exotic"	300+



Source *: Mwacharo et al 2008; Dessie et al 2011*

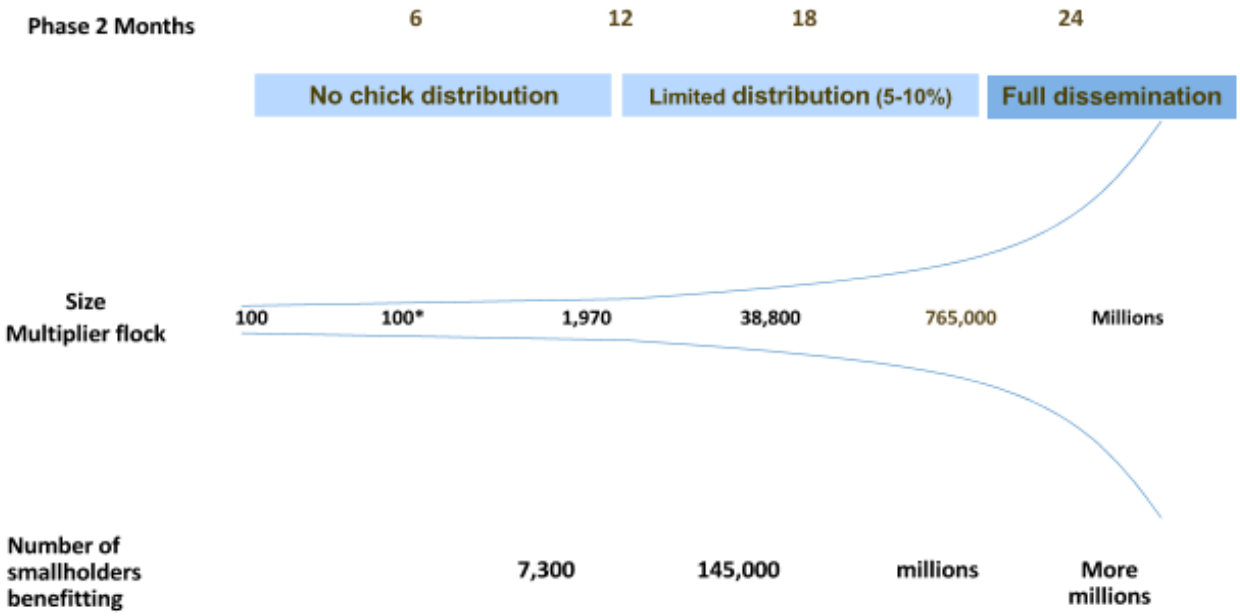


Proposed Framework for Guiding ACGG+ Analytical Thrust. Source: Thurlow, J. and Koo, J. (IFPRI)



Source:*African Chicken Genetic Gain (ACGG-ILRI)*
Figure 4. *Proposed model framework and analytical impetus in the chicken market analysis.*

Chicken's high rate of reproduction enables rapid scale distribution could begin after 12 months.



Source:*African Chicken Genetic Gain (ACGG-ILRI)*
Figure 5. *Model of rapid scale distribution of chicken*

This model can be implemented simultaneously in multiple geographical areas and countries.

1.6. Local poultry value chain in Africa

1.6.1. Profile of the local chicken sector in Africa

Modern local chicken supply chains are attracting investors, with companies starting with feed mills and hatcheries and building from there. Smart local poultry value chain, encompassing breeding, grow-out farms and processing facilities are emerging from all

the African regions.

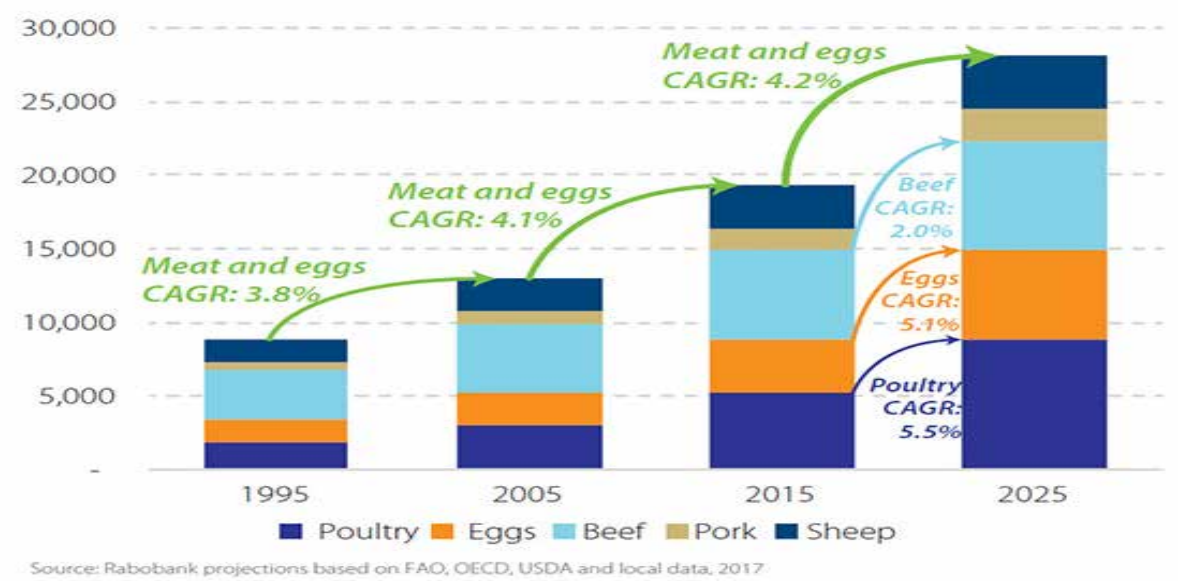


Figure 6. *Profile of the African local chicken sector*

The African poultry and egg industry are in a fast growth mode with huge investment opportunities in distribution through butcher shops and restaurant chains. Opportunities for investors are in several areas, including:

1. Meat processing: Developing a modern poultry value chain
2. Breeding: Establishing a modern breeding supply chain
3. Equipment: Supplying the appropriate and climate-smart equipment for the growing industry
4. Animal nutrition: Setting up feed mills to supply more modern compound feed, distributing premixes and additives, utilization of advanced feeding systems
5. Grains & oilseeds: Developing adequate supply for local feed manufacturing

1.6.2. Component and actors of the value chain

A value chain here is defined as a sequence marked by value growth and coordination at each stage of production, processing and distribution, driven by consumer demand. It encompasses a range of support functions, such as input supply, financial services, transport, packaging, market research, value addition and promotion of farmed products (CTA, 2012).

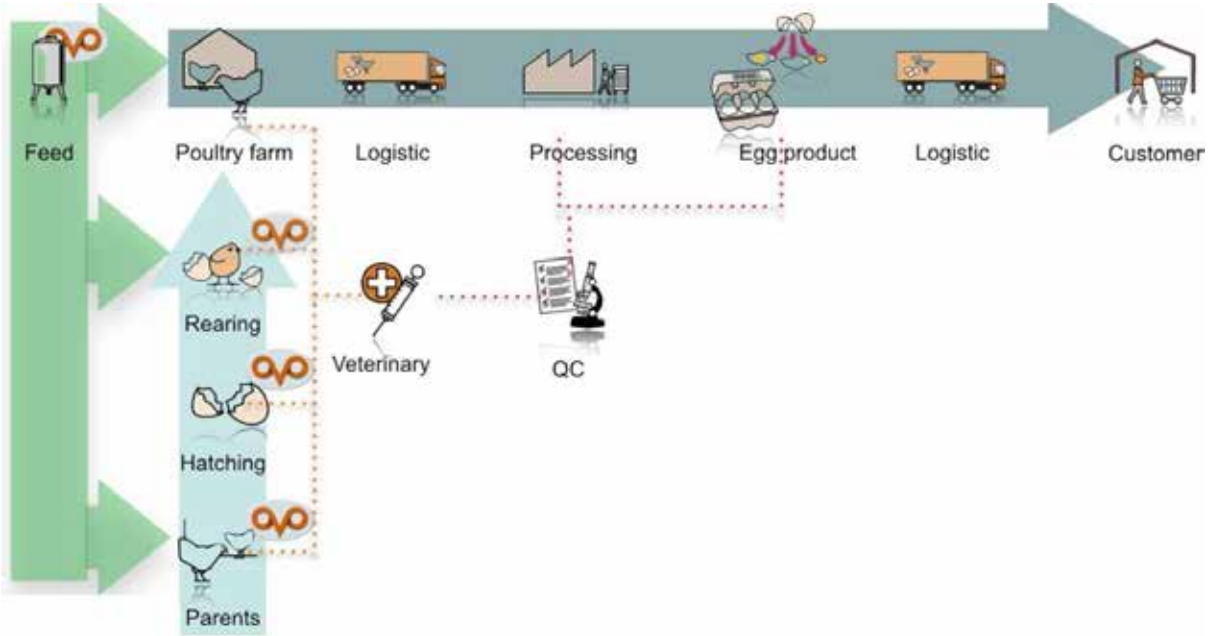


Figure 7. *Component of the chicken value chain*

The stakeholders considered are input providers, farmers, processors, packagers, distributors and retailers; in essence, all the links in between the genesis of a product and its journey to the consumer as illustrated below.

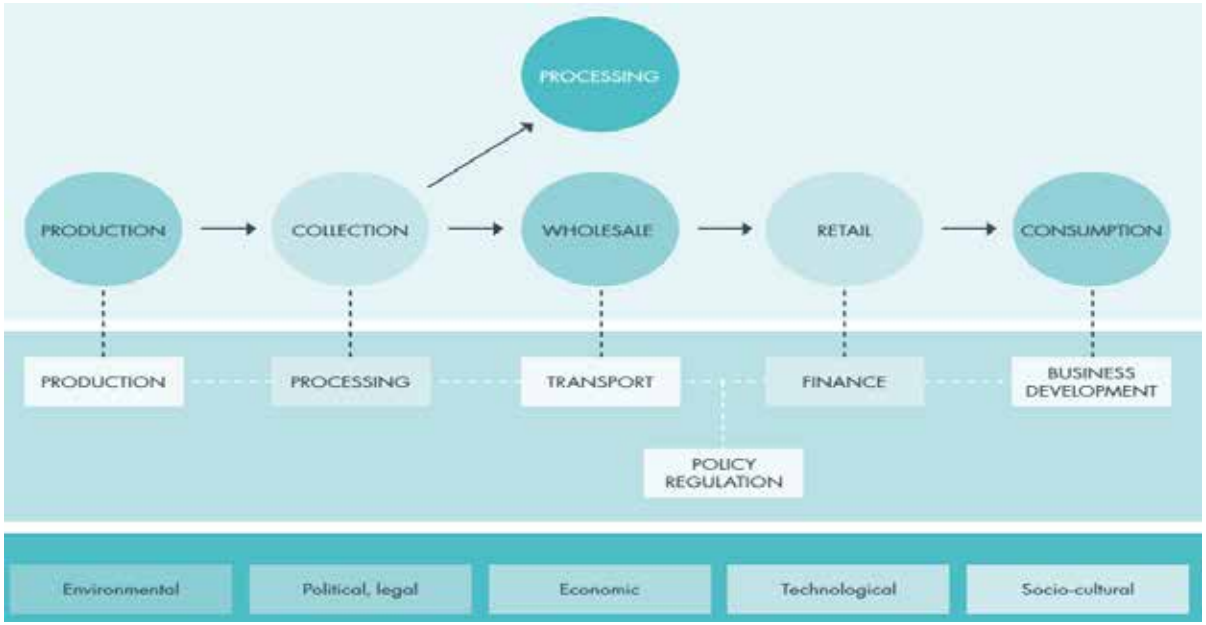


Figure 8. *Major livestock value chain components and potential areas of advisory and technical interventions.*

1.6.3. Governance mechanisms of the value chain for local poultry farmers' organisations

An organisation chart should be available showing individual responsibilities and the reporting structure of the business. The commitment of senior management to the effective implementation of the requirements of the value chain guide should be clearly demonstrated and communicated.

The responsibilities of key personnel should be documented particularly in the areas of welfare, hygiene, Good Manufacturing Practices (GMP), health and safety and contingency planning.

Management should be able to demonstrate an adequate level of technical support with appropriate qualifications and other

resources for the effective implementation of the VC Guide.

Management should define the person(s) with responsibility for:

1. Ensuring compliance with regulatory requirements and the VC Guide,
2. Non-conforming product management,
3. Corrective and preventive action management,
4. Welfare (who ideally should be independent of the production function).

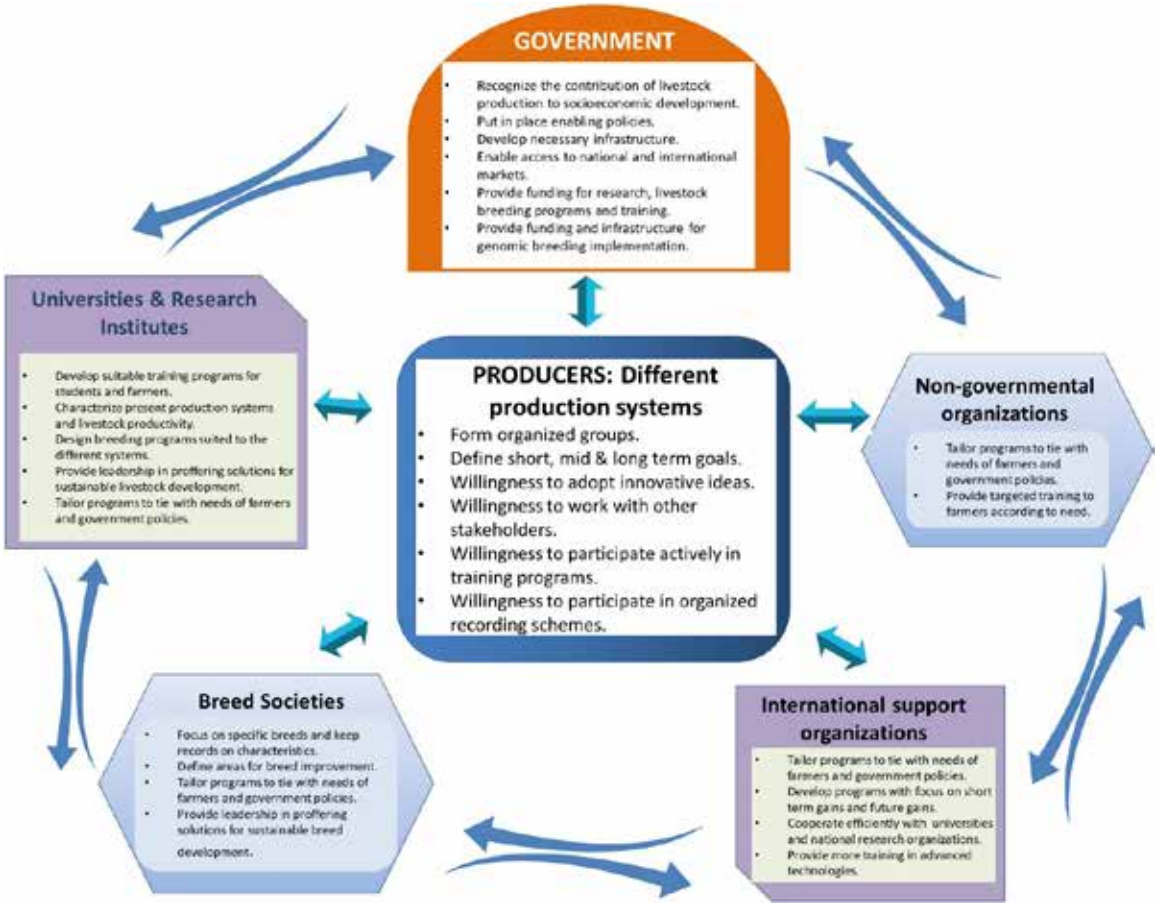
Figure 9. *Governance mechanism of the value chain for local poultry farmers' organisations*

Management should define the person(s) responsible for ensuring compliance with the hygiene requirements and should establish an acceptable system to demonstrate that the requirements are enforced.

Management should ensure that there is sufficient staff cover in place for periods when key staff are absent. Training records should be maintained for all personnel performing key tasks.

To have an organised sub-sector requires a conducive environment to grow for which policy support and intervention are necessary, mainly for disease surveillance, drug residue and drug/ vaccine quality control, standardization & quality control of poultry feed, eggs & meat, application of HACCP (Hazard Analysis and Critical Control Point) and Good Manufacturing Practices for compliance to WTO & CODEX norms and gradation, value addition, brand promotion and export boosting etc.

Some important regional, bilateral, multilateral and international programmes are now investing on the use of advanced technologies, like genomics to advance African poultry. It is the case for the Centre for Tropical Livestock Genetics and Health (CTLGH) and some farmers facing programmes like the African Chicken Genetic Gains (ACGG). For successful implementation of structured genomic breeding programs for African chicken populations, several factors deserve consideration as well as collective action and cooperation by all stakeholders (farmers, governments, research professionals, research organizations, universities, breed societies, private businesses, and support organizations) working together to achieve a common goal as illustrated in the figure below. As a farmer facing programme, ACGG work with poultry farmers association to have the sector transformation expected from the deployment of the tools developed by the CTLGH and other research institutions from Africa and overseas.



Source *: Ibeagha-Awemu et al., 2019*

Figure 10. *Model of collective action and cooperation by all stakeholders working together to achieve better productivity.*

CHAPTER II: PRODUCTION SYSTEMS, MANAGEMENT, CONSTRAINTS AND OPPORTUNITIES

Family poultry farming encompasses the wide variety of small-scale poultry production systems found in rural, urban and peri-urban areas of countries. There are four main categories of family poultry systems:

1. Small-scale extensive farming/Free range,
2. Semi-intensive farming,
3. Small-scale intensive farming.
4. Commercial intensive farming

In the African poultry sector, the relationship between poultry feed and feeding and health needs to be further investigated. In addition, the possibilities for improving bird's welfare, e.g. through more appropriate management (including human-animal relationship in farming), need to be further explored and improved.

2.1. Characteristics of the various production systems

a. Free range

- Chicken are dependent on local feed and water resources, in some areas, a feed supplements are provided to the birds
- Low level of inputs
- Chicken can move freely in the environment, but movement can be limited by crops and other barriers
- The composition and size of the herd are variable
- Generally, no shelter for chicken. However, in some cases, there are over-night shelters for birds
- Breeds adapted to the local environment
- Production generally intended for sale
- A large part of their diet comes from scavenging
- Most of the feed are available on site and sometimes there is selective feeding of hens and chicks

b. Semi-intensive

- Specialized exotic breeds
- Trade in eggs and live birds
- Growing demand for animal health services
- Purchase of specific chicken feeds
- Some investment in housing / infrastructure
- Feed and water for chicken generally available
- Specialized in the production of live birds/meat and/or eggs

c. Small-scale intensive

- Totally dependent on national markets to buy inputs and sell products
- Possible links with sub-regional markets
- The size of the flock and the farming techniques depend on the companies with which they deal
- Play a very important role in feeding urban and peri-urban populations

2.1.1. Poultry housing

Local chicken, given its zootechnical parameters, is not profitable when produced in absolute confinement. Feed expenses will dramatically increase operating costs. For local chicken, it is important that the birds are at certain times of the day outside the chicken-house in search of natural feeds.

Figure 11. *Illustration of a modern battery poultry house*

a. Importance of the poultry house

- The chicken building has a very important role because it contributes more than 50% to the success of poultry farming.
- The poultry house should offer comfort and consequent protection to birds against predators (hawks, cats, snakes etc.) and bad weather (cold, wind, rain, sun ...)
- The existence of the poultry house reduces the transmission of diseases by vectors and facilitates better distribution of feed and products. It also makes the collection of eggs, droppings and others easier

b. Choice of the site for poultry-house

- The site must be accessible;
- The site must be near a water point (source, well, borehole or running water);
- The site must be located approximately 50 m from the homes;
- The site must be ventilated to allow easy circulation of air;
- The site must not be too rough.

c. *Essential features of housing design and its management*

- Be rain-proof
- Be strategically located to avoid wind draughts
- Have smooth surface walls to eliminate hiding spots for mites and other pests
- Periodically spraying the poultry unit with insecticide and disinfectants
- Periodically removing the dropping/cleaning the poultry house regularly
- Have good ventilation and in hotter areas at least 2 sides should be partly poultry wire mesh
- Preferably have cemented floor for ease of cleaning and disinfecting
- Be rat-proof
- Using plenty of litter after cleaning the poultry house
- Should accommodate the optimum number of birds
- Separating chicks from old birds

d. *How to set the egg-laying house*

Table 8. Few features of egg-laying house

Chip litter or chopped straw	

Grating + wire mesh, raised 40 to 80 cm above the litter, carrying the drinkers	
Number and size of nesting nests adapted to the species are placed in the center or on the periphery of the building to allow manual collection 3 to 5 times a day	 
A quarantine building can be constructed from local materials (round hut) and placed at a suitable distance from the poultry house. This is to prevent spread of diseases from sick or new coming animals	 

e. *Materials and equipment*

- Plan a road surrounded by a fence and strewn with trees providing shade for the animals and piles of gravel (0.5 m² / chicken)
- Feeders: linear wooden or xyphoid plastic or galvanized sheet to be placed inside the building (01 linear feeder of 01 meter / 10 hens);

- Manual and automatic xyphoid waterers for the poultry house or under the trees of the course
- Radiant heaters
- Nesting boxes generally made of wood: place them in a dimly lit corner of the building (01 nesting room / 03 hens);
- Perches: Provide wooden perches with a height of 1.20m and a length of 02 meters inside the building (01 perch / 10 chicken);
- Litter in wood shavings or chopped straw.
- Transport cages for live chicken
- Incubator

f. Some modern farmhouse innovations

- Automated public access control system with automatic showers, concrete flooring between houses to reduce vegetation, pad cooling with easy cleaning and disinfecting even when birds are present
- Chain-feeder technology promotes efficient feed distribution by accurately measuring feed and providing uniform nutrition for birds.
- Fluid LED light level control, flicker free lighting system, with multiple light level settings.
- Air Quality Monitor is designed to sample the air within the building every two minutes and display the following air quality information CO2 / Ammonia /Humidity / Temperature.
- Water system designed to keep water uncontaminated by preventing dirt, feces and other pollutants from entering the automatic drinking system.
- Innovative waste management methods: Manure belt systems in egg production. Pelleting of dried manure further stabilizes the material, reducing dust. Some countries are using Black soldier fly (BSF) larvae as an alternative system for manure treatment.
- Remote Access Livestock Monitoring: this Livestock Monitoring System allows poultry farmers the ability to view their broiler sheds internally from their smartphones, tablets and personal computers, in great detail they can view feed and drinker lines, hoppers, bird spread, all without the need to enter the houses as regularly as they normally would.

g. Care at start-up

- Maintain the ambient temperature of around 28°C for a week, then lower it by one degree each week until reaching 26°C;

- During this phase, the chicks are fed with finely ground corn kernels, they receive a supplement rich in proteins (for example, meals from maggots, earthworms, termites, etc.);
- Animal health monitoring at all ages will be provided by a veterinarian.

Table 9. Ambient temperature according to chicken age and corresponding plumage evolution

Age	Ambient temperature	Plumage Evolution
0 to 3 days	31 to 33°C	Down
3 to 7 days	31 to 32°C	Down + wings
7 to 14 days	29 to 31°C	Down + wings
14 to 21 days	28 to 29°C	wings + back
21 to 28 days	24 to 28°C	wings + back + Wishbone

Table 10. Density of chick in brooding pens

Age	Number of chickens per m²	Building Surface
1st week (1 to 7 days)	40	Start-up circle = 1/4 surface
2nd week (8th to 14th day)	30	1/3 surface
3rd week (15th to 21st day)	20	1/2 surface
4th week (22nd to 28th day)	15	2/3 surface
From 28th day	10	Whole room surface

Table 11. Density and material standards at the reception of the chicks according to the number

Number of chicks	100	200	300	400	500	600	700	800	900	1000
Diameter of the Starting circle	1.8 m	2.5 m	3.1 m	3.6 m	4 m	4.4 m	4.7 m	5 m	5.3 m	5.0 m
Surface (m²)	2.5	5	7.5	10	12.5	15	17.5	20	22.5	25
Length of Plywood used	5.7 m	7.8 m	9.7 m	11.3 m	12.6 m	13.8 m	14.7 m	15.7 m	16.7 m	17.6 m
Density (No. of Chicks per m²)	40	40	40	40	40	40	40	40	40	40
Number of drinkers	2	4	6	8	10	12	14	16	18	20
Number of Feeders	2	4	6	8	10	12	14	16	18	20

2.1.2. Feeds and feeding systems

In the family poultry sector, the feeding system must be based on a sustainable strategy which consists of training and educating farmers on available feed resources. The feeding systems must be flexible enough to meet the climatic conditions of different regions, so as to incorporate cereals, agricultural by-products, household food scraps and premixes of vitamins and minerals, or different sources of vitamins or minerals in the food system. The continuous training of small poultry farmers on the different types and quality of commercial feeds is important. Training on industrial feed and available feeds locally (produced or mixed on the farm), on the collection of this type of feed (supply), the mixing of the different ingredients (formulation and composition of the ration) and on chicken feed (purchase, storage and supply), is also encouraged.

Free range chickens find their food in the environment. The scavenged feed is however, rarely adequate for their needs as is their access to water. Chicks are more vulnerable as they compete with adult birds for food. Many birds die young for lack of food and exposure to diseases.

The scavenging residual feed base

- Household waste
- worms, snails, and insects
- Crops and their by-products
- By-products of local industries
- cultivated or wild grass seeds, grasses and fodder shrubs
- Aquatic plants such as lemna, azolla or *Ipomoea aquatica*

a. Feed ingredients and characteristics

- Feed represents the major cost of poultry production, constituting up to 70% of the total. Of the total feed cost, about 95 percent is used to meet energy and protein requirements, about 3 to 4 percent for major mineral, trace mineral and vitamin requirements, and 1 to 2 percent for various feed additives.
- The predominant carbohydrate source used in poultry feeds worldwide is maize. The traditional plant protein source used for

feed manufacture is soybean, which is the preferred source for poultry feed and is fed as a meal. In Africa, feed supplements like probiotics, vitamins, minerals, amino acids, mould inhibitors, enzymes, preservatives, coccidiostats, antioxidants and others. are mostly imported.

Free-range system

In the free-range system, poultry feeding depends on edible items like maggots, earthworms, ticks, insects, household waste, among others. There are concerns about the potentially dangerous effects of using pesticides, whose residues in the environment may find themselves in poultry products, and could constitute a biohazard for human health. The integration of free-range poultry production with rice cultivation, market gardening, fish farming, cattle rearing or pig production also contributes to diversifying feed sources.

Semi-intensive system

In the semi-intensive system, most of the nutrients for the birds come from rations prepared on the farm or from balanced commercial feeds. Feeds available during scavenging include insects, worms and plants. Access to a balanced ration limited to certain periods of the day, as concentrates or basic food are provided at different times of the day and associated with periods of containment and freedom respectively. The production level of chicken is not as high as that of chicken raised in an intensive system. Birds also benefit from the sunshine, fresh air and can exercise. Regular access to an outdoor course provides nutrients such as: phytic phosphorus, vitamin D, protein from insects and worms, fiber from plants

It is necessary to integrate into the ration in the most profitable way possible: grains, agricultural by-products, household waste; premixes of vitamins and minerals

b. Feed and water

The young chicks remain confined in the pen. They must receive a full ration of water and formulated feed to cover their requirements. Fresh and clean water should be provided in drinking troughs inside chicken pens. Chicks should always have free access to water. In general, the feed resources available on the poultry runs contributes less than 30% of the total daily nutritional

requirements of poultry.

Only proper nutrition can guarantee a high level of production and profitability. Hence the need to ensure that the daily amounts of food that birds need at different stages of their lives are available and that birds have access to food and water at all times. Complete feed must be produced in relation to the feeding requirement of the following categories: - chicks - growing birds - pullets - laying hens - cockerels - roosters.

That requires :

- *Ad libitum* balanced feed
- Only one species of poultry should be raised
- Dilution of nutrients is not recommended except in an emergency
- The use of animal tissue and by-products in food is strongly discouraged
- Feeding in intensive systems relies only on compound feeds
- It is important to maintain a balance between the different types of nutrients
- A precise ratio must be maintained between the energy content and the protein content
- An optimal proportion must be maintained between proteins (and their amino acids) and between minerals
- An improper calcium / phosphorus ratio can cause bone problems
- Compound foods must contain the recommended amount of nutrients with a very small margin of error vitamins
- Improper feeding or watering systems are the two major challenges of intensive production systems.

c. *Feed formulation*

- Farmers can mix their own feeds using the carbohydrate and protein sources available in their area.
- Feeds can include green vegetal products and fruits such as pawpaw.
- Only palatable green feeds should be given to birds. Do not feed poisonous plants

Table 12. Nutrient requirements layer breeder of different age groups

(Age in weeks)	Chick (0-8)	Grower (9-15)	Pre-layer (16-18)	Layer Phase-1 (19-34)	Layer Phase-2 (35-72)
Protein (%)	20.00	17.00	17.00	19.00	17.50
M.E. (Kcal/kg)	2750	2550	2550	2550	2500
Linolenic acid (%)	1.40	0.10	1.20	1.40	1.20
Lysine (%)	1.10	0.80	0.80	0.88	0.75
Methionine (%)	0.50	0.40	0.45	0.50	0.40
Methionine + Cystine (%)	0.75	0.60	0.65	0.73	0.62
Calcium (%)	1.10	1.10	2.50	3.80	4.00
Available Phosphorus	0.45	0.45	0.45	0.45	0.42
Sodium (%)	0.20	0.18	0.20	0.20	0.20
Vitamin A (IU/kg)	20,000	16,000	20,000	20,000	20,000
Vitamin D (IU/kg)	4,000	3,200	4,000	4,000	4,000
Vitamin E (mg/kg)	60	40	60	60	60
Vitamin K (mg/kg)	4.00	3.20	4.00	4.00	4.00
Riboflavin (mg/kg)	20	50	20	20	-

Table 13. Example of feed formulation

Feed Composition	Starter feed for broiler/layer	Broiler finisher feed	Pullet feed	Layer feed
Corn	59.5	60	57	45
Soya meal 49%	32.5	28.35	21	22.45
wheat bran	1.2	5.55	9.2	0
Palm kernel meal	0	0	0	15
Palm oil	2	2.5	1.5	5
Bone meal	3.3	2.6	1.3	1.2
Oyster shel	0	0	8.9	10.35

Salt	0.2	0	0	0
Premix 1%	1	1	1	1
Total	100	100	100	100

d. Cutting-edge technology in poultry nutrition

Single-cell protein products: These are elements such as algae, bacteria and yeasts showing promise as components of poultry feeds/diets.

Transgenic feeds: Technology has made it feasible to produce transgenic feeds with high protein and amino acid contents (for example, quality protein maize (QPM) which has higher levels of lysine and tryptophan, when compared with common maize), low anti-nutritional factors (for example, Canola meals with low erucic acid, tannins, and glycosinolates) and with high vitamin activity (for example, yellow sorghum with high beta-carotene activity), among others.

The synbiotics: these are probiotics and prebiotics been considered as suitable substitutes of antibiotics, which are slowly being phased out, especially the gut-acting ones. Micro-organism have been selected and optimized by classical biotechnological methods to produce limiting amino acids in fermentation process in large quantities for the feed industry.

Trace mineral proteinates: Production of trace mineral proteinates (organic minerals) utilizing yeast (*Saccharomyces cerevisae*) has become feasible in augmenting availability of various trace minerals including zinc, manganese, chromium, selenium, copper, etc.

Dried Distillers Grain Solubles (***DDGS)*** which is left over after corn is turned into ethanol and other such alternatives can help alleviate stagnant growth of maize.

2.1.3. Poultry health and disease management

Strengthening surveillance, prevention and control of avian diseases (Newcastle disease, chicken pox, parasitic diseases and others) will make a significant contribution to poverty reduction, food security and the detection and control of zoonoses, such as that

highly pathogenic avian influenza.

a. Vaccination

Effective control of diseases such as Newcastle Disease (MNC) and smallpox is facilitated by:

i. the availability and accessibility of appropriate vaccines (i.e. thermotolerant, single-dose format);
ii. raising farmers' awareness of the importance of vaccinating their flocks;
iii. the existence of sustainable supply mechanisms, including the presence of well-trained community vaccinators and the possibility of cost recovery;
iv. compliance with a vaccination schedule adapted to local production conditions

The choice of vaccine must comply with the criteria of efficacy, thermotolerance, ease of use, transportability, availability and affordability. To be effective, vaccination programs must be combined with appropriate biosecurity measures and practices to strengthen the immune system of birds (eg good nutrition and control of mycotoxins in cereals).

e. *Biosecurity*

Biosecurity is "putting up barriers to reduce the risk of the introduction and spread of pathogens" (FAO, 2008b). The risks and requirements in terms of biosecurity vary according to the production system. It concerns both live poultry farms as well as their transport and the market and consists of measures of good farming practices. These measures must be achievable, practical, sustainable and proportionate:

i. Create a physical barrier to the entrance to the farm for people and objects
ii. Provide sources of clean water and food
iii. Housing chicken in a structure that prevents them from being in contact with wild birds and rodents
iv. Use "all full-all empty" management systems
v. Farm workers must not keep birds at home
vi. Change clothes and shoes before entering and leaving the farm
vii. Quarantine newly introduced or returning birds

viii. Perform compartmentalization and zoning for sick birds
ix. Thoroughly clean and disinfect buildings

j. Control of parasites and diseases

Routine prevention forms the first line of protection against disease after good poultry farming practices. Control of diseases include the following:

Table 13. Methods to control parasites an diseases

Vaccination	Vaccination can prevent many poultry diseases. This could be targeting the following pathologies: • avian encephalomyelitis • chicken anaemia • egg drop syndrome 76 (EDS 76) • fowl cholera • fowl pox • infectious bronchitis • infectious bursal disease • infectious coryza • infectious laryngotracheitis • Marek's disease • Newcastle disease. For breeders of poultry, when vaccinating: • always follow the instructions on the label, including storage conditions • use disposable syringes and needles • discard all unused vaccines, syringes and needles in a proper manner • be clean, but never use detergents or disinfectants near vaccination equipment. • Do not disinfect skin before vaccinating with fowl pox or Marek's HVT vaccine, as this will kill the vaccine virus.
Parasite control	chicken on floor and access to outdoor areas have greater exposure to internal and external parasites. in such conditions, it is important to have an appropriate prevention program in place to minimize physical stress and keep birds in good. parasites should be controlled by: • regularly inspecting birds for external parasites • spraying or dusting birds thoroughly with an approved insecticide if lice or mites are suspected - spray the shed, perches and nests thoroughly, making sure the insecticide gets into crevices

	• cleaning sheds and rotating ranges to prevent worms • regularly checking fecal material for any sign of worms • always checking the label on worming treatments for withholding periods as some are not suitable for production birds • consulting a veterinarian.
Identifying and treating sick birds	Regularly observe birds for any signs of ill health or problems within the flock such as feather pecking. Remove sick chickens and other poultry from the main flock and obtain a diagnosis from a qualified person. Give the correct treatment once you identify the disease or problem. Keep ill birds quarantined from the flock until completely recovered.
Separating multi-age flocks	keep age groups separate - have an all-in and all-out system for each age group to allow for a complete clean and disinfection of facilities and equipment between batches always start work with younger poultry and finish with the oldest. practicing routine biosecurity procedures between flocks and staff working with them

d. food safety

Eggs and poultry meat should be free of salmonella and other zoonotic germs, and mycotoxins, etc. therefore, production conditions must integrate hygiene and biosecurity measures and be subject to inspection by a technician, veterinarian

e. *Cutting-edge technology in poultry health*

Recent technological advancements make it easier to diagnose and treat poultry diseases and illnesses, resulting in improved flock health. There are technology development for diagnosis tools, management, control and prophylaxis of diseases; training, infrastructure and information sharing for responding to emerging diseases; combating outbreaks of avian influenza and strengthening Sanitary & Phyto-Sanitary measures to deal with exotic agents; development of effective and convenient biosecurity; establishment of Compartments / Disease Free Zones etc.

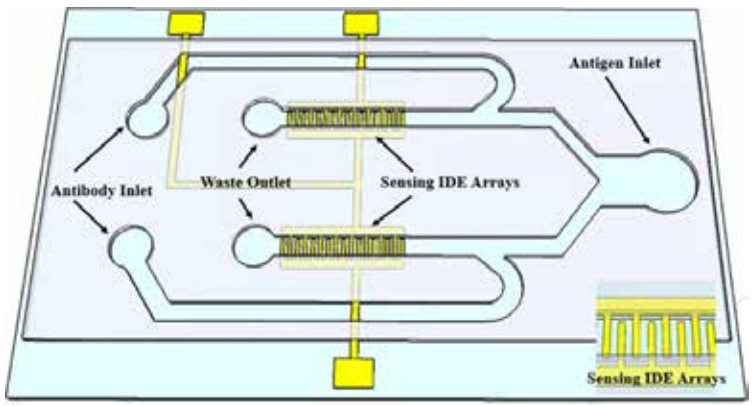
Many other innovation tools consider effective use and application of new technologies in participatory epidemiology, GIS techniques etc. to help effective need-based input and service delivery.

Mazen Animal Health Edible Vaccines enable chicken producers to dose room-temperature stable vaccine in the feed for both mucosal (in the gut) and systemic (intracellular) protection against coccidiosis. The technology platform inserts genes for specific antigens into corn plants to create the vaccines.

TyraTech Phytogenic Blends for Coccidiosis Control chemically block receptors specific to parasites and physically disrupt the parasite cuticle. The blends are composed of GRAS-listed terpenes that naturally occur in food plants known to be safe as food flavorants. Using a proprietary encapsulation technology, the formulation will be active in the intestine of the chicken.

The Virlock Technologies device LLC is able to selectively can trap avian flu viruses for early detection and concentrate viruses by their size.

Faster salmonella detection: A team of researchers at the University of Missouri (MU) and Lincoln University has developed a portable and easy-to-use sensor that can detect salmonella and *E. coli* in raw and ready-to-eat poultry products. (https://www.thepoultrysite.com/articles/the-latest-poultry-tech-round-up).



https://www.thepoultrysite.com/articles/the-latest-poultry-tech-round-up

Figure 12. *Sensing IDE array for faster salmonella detection*

The newly developed sensor uses antibodies and chemical polymers specific to each of the bacteria, to give a positive or negative reading and determine the sample concentration, according to the researchers. It can detect as few as seven cells per millilitre in less than an hour without the need for enrichment culture for raw poultry. It takes about seven hours for ready-to-eat products. The sensor currently works for three serotypes of salmonella and *E coli* O157:H7. The researchers are also configuring it for listeria and campylobacter.

A new way to control necrotic enteritis

Necrotic enteritis is a major health, welfare and performance disease of broilers. Without technologies to control *Clostridia perfringens*, the causal agent of the disease, producers are struggling to raise healthy birds and produce safe food. The challenge is now becoming acute with the withdrawal of antibiotics from livestock production.

General Probiotics Inc. covers the agile research and development of live biotherapeutics using synthetic biology and artificial intelligence. The results of animal trials demonstrate the effectiveness and safety of this technology (https://www.wattagnet.com/articles/40854-poultry-health-innovations-poised-to-disrupt-the-industry).

f. Women vaccinators and extension agents

Women vaccinators contribute to the success of disease control programs; in addition, the involvement of women improves the condition of women in their homes, their contributions to the livelihood of the home and their condition in the community.

2.1.4. Flock management

a. Management of Chicks

- Before chicks arrive at home; make sure that; A brooder is in place, Paraffin lamps/electric bulbs/charcoal stove is available, Litter for the floor is available, 1m^2 will accommodate 20 chicks up to 4 weeks old.
- Temperature control: 35°C for day-old chicks, 24-27°C for 1 week. Reduce heat to….. as they grow especially at night.

Debeaking

i. Both males and females are debeaked at 10-14 days of age and again at 12-14 weeks of age.
ii. For females, leave 2mm beak from the nostrils, whereas for males, cut half of the beak between nostrils and tip of the beak.
iii. Both upper and lower beaks are cut off straight. Give vitamin K in water one day before debeaking and electrolytes for 2 or 3 days from the day of debeaking. Increasing vitamin K in the diet will shorten blood clotting time and prevent bleeding, as well as reducing the mortality of chicks. Dosing quantity is 0.5 mg / kg according to body weight.

Figure 13. *Chicken debeaking*

Uniformity

i. Flock uniformity is a major goal to be achieved in breeding flock management for peak egg production, less number of culls and more uniform sized chicks.
ii. From 4 weeks of age, group the chicks according to body weight.
iii. The weak chicks should be provided with extra care for them to attain uniformity.
iv. At any stage, the flock must have at least 80% uniformity.

Table 14. Production standards for breeding stock

Trait	Standards
No. of cocks/ 100 hens/pullets in deep litter or slats	10
No. of cockerels/ 100 females/pullets in cages	3
Feed/ bird up to start of egg production (kg)	6.0
Feed/ hen/ day during laying period (g)	110
Feed/ cock/ day during breeding period (g)	100-105
Period of hatching egg production (week)	24-72
Total no. of hatching egg/ hen (dam)	260
Total no. of straight run (unsexed) chicks/ day	230
Total no. of pullet chick/ dam	110
Total no. of saleable chicks/ dam	105 (female)
Average body weight of day-old chicks (g)	35
Average body weight of male at maturing age (kg)	1.6
Average body weight of female at maturity age (kg)	1.25
Average body weight of male at culling age (kg)	2.0
Average body weight of female at culling age(kg)	1.5
Average mortality during growing period (%)	5
Average mortality during laying period (%)	8

Table 15. Parent stock performance potential

Traits	Male	Female
Body weight (g) at 4 weeks of age	300	250
Body weight (g) at 8 weeks of age	725	580
Body weight (g) at 12 weeks of age	1100	850
Body weight (g) at 16 weeks of age	1350	1100
Body weight (g) at 20 weeks of age	1550	1300

Body weight (g) at 40 weeks of age	2000	1600
Body weight (g) at 72 weeks of age	2300	1700
Flock uniformity (%)	>80	>80
Feed intake (kg) 0-8 weeks	3.0	2.5
Feed intake (kg) 9-20 weeks	4.5	4.0
Feed intake (kg) 0-20 weeks	7.5	6.5
Feed intake (kg) 20-72 weeks	38.0	40.0
Layer feed/ hatching egg (g)	145	
Total feed/ hatching egg (g)	188	
Mean livability (%) 0-20 weeks	94	
Mean livability (%) 21-72 weeks	92	
Mean mortality (%) 0-72 weeks	14%	
Hen housed egg number (20-72 weeks of age)	280	
% Total hatchability	90	
Saleable pullet chicks/ hen housed	110	

Management of feeding systems

i. The feeds given to layer parents will be more or less similar to that of commercial layers in respect of major nutrients.
ii. But the breeder feeds, notably the breeder hen feed is enriched with micronutrients like trace minerals and vitamins to obtain high fertility and hatchability rates at peak egg production.
iii. Moreover, the breeder feeds must be free from all mycotoxins, because mycotoxins will not only affect the egg production and health status of the birds but also fertility and hatchability.
iv. A starter diet is about 24% protein, grower diet 20% protein, and finisher diet 18% protein (1). Layer diets generally have about 16% protein. Special diets are available for broilers, pullets, layers, and breeders. Whole grains can also be provided as scratch grains
v. Reproduction management

Management of Layers

i. Allow for good air circulation in laying house for the control of gas levels (see table below). Air inlet velocities of 600 to 1,000 feet per minute (fpm) are recommended
ii. Layer needs on average 120 g of feed per day
iii. Distribute feed troughs and water troughs evenly (one basin/50 birds)
iv. Provide grit at 20 weeks
v. Laying nests must be kept in dark places, collect eggs 3 times a day, allow a nest/5 hens
vi. Provide soft clean litter
vii. Store eggs with the small end down
viii. Clean dirty eggs with steel wool/coarse leaves (never wash them with water)
ix. Add locally available and palatable plant materials to the diet and whenever possible vitamins to water
x. Debeaking at the onset of lay
xi. Culling when egg production drops below 40%

Table 16. Common gas levels in poultry houses

Gas	Symbol	Lethal	Desirable
Carbon Dioxide	CO_2	Above 30%	Below 1%
Methane	CH_4	Above 5%	Below 1%
Ammonia	NH_3	Above 500ppm	Below 40ppm
Hydrogen Sulfide	H_2S	Above 500ppm	Below 40ppm
Oxygen	O_2	Below 6%	Above 16%

How to programme/synchronize egg laying and incubation in local poultry

i. Assume a farmer has 14 local hens and 2 indigenous cocks
ii. Give each bird own nest when they start to lay. Place dry grass on top.
iii. Boil one egg from each bird and put it in nest as a landmark for each hen. Mark the egg. As long as the boiled egg will never

hatch, it will keep the hen in the next, incubating fertile eggs

iv. Remove the eggs that were laid on the day they are laid. Write dates on them using pencil and store them together on trays with broad end facing up.

v. Leave boiled egg in nest.

Vaccination, Health and biosecurity program management

i. Vaccination plays a very big role in disease protection for any kind of poultry breeds. Therefore it is important to vaccinate local poultry against some common poultry diseases like Gumboro and Newcastle.

ii. The vaccination programme is similar to that of commercial layers.

iii. The vaccination programme may vary depending on location and other factors including prevalence of diseases in the area.

iv. The only difference will be, inactivated (killed) vaccines are given, for diseases like Newcastle Disease (N.D.), Infectious Bursal Disease (I.B.D.), Infectious Bronchitis (I.B.), Respiratory Enteric Orphan (REO) disease and *Mycoplasma gallisepticum* (MG), before the onset of egg production.

v. For N.D., I.B.D. and I.B. vaccines are repeated at 45 weeks of age in problematic areas, to increase the maternal acquired immunity in the chicks. Fowl cholera vaccine must be given at about 10 weeks of age in endemic areas.

vi. Moreover, the flock must be tested for Mycoplasma and Salmonella at around 16 weeks of age, to eliminate the positive reactors.

vii. Deworming will be done every month or once in 6 weeks in deep litter system and once in two months in case of cage and slat reared breeders.

viii. LaSota (strain of NC vaccine) vaccination will be invariably followed after deworming.

Below is a simple vaccination program that is recommended to effectively safeguard improved local poultry.

Table 17. Simple vaccination program recommended for improved local poultry.

AGE	Vaccine
One day Old	Mareks
2 Weeks Old	Gumboro
3 Weeks Old	Newcastle
6 Weeks Old	Fowl Pox
8 Weeks Old	Fowl Typhoid
19 Weeks Old	Deworming

It is also very important to understand that these vaccinations alone may not help to eliminate the occurrence of these diseases. There are other factors that must be considered. These in include the hygiene of the feeding and drinking equipment, ventilation of poultry structures, quality of feeds, vitamins and minerals and others.

2.2. Constraints to a sustainable local poultry value chain development

These include

1. Production related constraints: inadequate access to improved breeds, Access and affordability of feed, Disease control, predation, supply of other inputs,
2. Lack of knowledge and skills for genetics and breeding. Farmers most of the time have a vague idea of the genetic material they are keeping.
3. Inadequate capital at all levels and marketing: lack of funds to start any sector of the value chain as a business.
4. Marketing, commercialisation, and socio economics. The marketing and commercialisation system is not clearly established.
5. Farmers organization and production skills. Most or the producers are not organised into cooperatives and lack technical skills.
6. Poor stakeholder management: the various categories of the value chain stakeholders are disconnected.
7. Family poultry is not clearly understood and not always seen as an investment opportunity, hence the Lack of entrepreneurship in that domain.

Chapter III: PRODUCTION ECONOMICS AND MARKETING OF POULTRY PRODUCTS

Whatever the production system, the availability of some inputs is necessary. This need for factors of production is essential with semi-intensive and intensive systems which require investment and working capital, and the creation of a breeding account. Profitability depends on the best valuation of the factors of production and the good mastery of commercial opportunities in the value chain. Production should assess whether the losses avoided are greater than the costs incurred following the improvement of the 'production tool.

All production systems must be linked to consumer needs and therefore answer the following questions:

1. What to produce?
2. For whom to produce?
3. When to produce?
4. How to produce?

The answers to these questions determines the management method to satisfy the clientele and the necessary management skills. Given the socio-cultural importance of family poultry farming, the availability of eggs or chicks constitutes an important marketing element.

Thus, engagement platforms such as WhatsApp groups of breeders and other stakeholders along the value chain are important.

3.1. Small-scale poultry project design

Family poultry projects should consider production systems and market opportunities and aim at improving the system in terms of productivity, provided that the additional benefits are greater than the additional costs of improvement (change)

3.2. Microfinance and credit access

The changes in terms of improving family poultry farming involve an increase in the use of production inputs, and an increase in

market sales. This requires an increase in the use of advanced technologies, including a need for financing which can through use of credit. The systems most likely to support production are microfinance institutions which sometimes, despite the high interest rates, show a certain flexibility on the loan conditions and a certain proximity to the farmer.

3.3. Poultry farmers associations

1. The development of producer networks has the following objectives:
2. Consolidate knowledge and coordinate the development of family poultry farming;
3. Serve as a forum to exchange ideas, methods, resources and performances obtained on farms;
4. Document the results and disseminate the information;
5. Coordinate training and human resource development; and
6. Identify opportunities for research and development, cooperation and funding

Advantages

- Better bargaining power for group purchasing of inputs,
- Better bargaining power for group purchases of breeding birds, materials and equipment
- Organization of vaccination campaigns against poultry diseases
- Installation of storage and distribution facilities for livestock inputs
- Sharing of information
- Capacity building for poultry farmers
- Organization of distribution networks for livestock products
- Reduction of competition between members
- Harmonization of prices of produce
- Community breeding, genetic improvement and dissemination of avian genetic resources programmes

To achieve success and sustainability, the training of breeders' associations must however be combined with a value chain approach, above all an interactive connection with research.

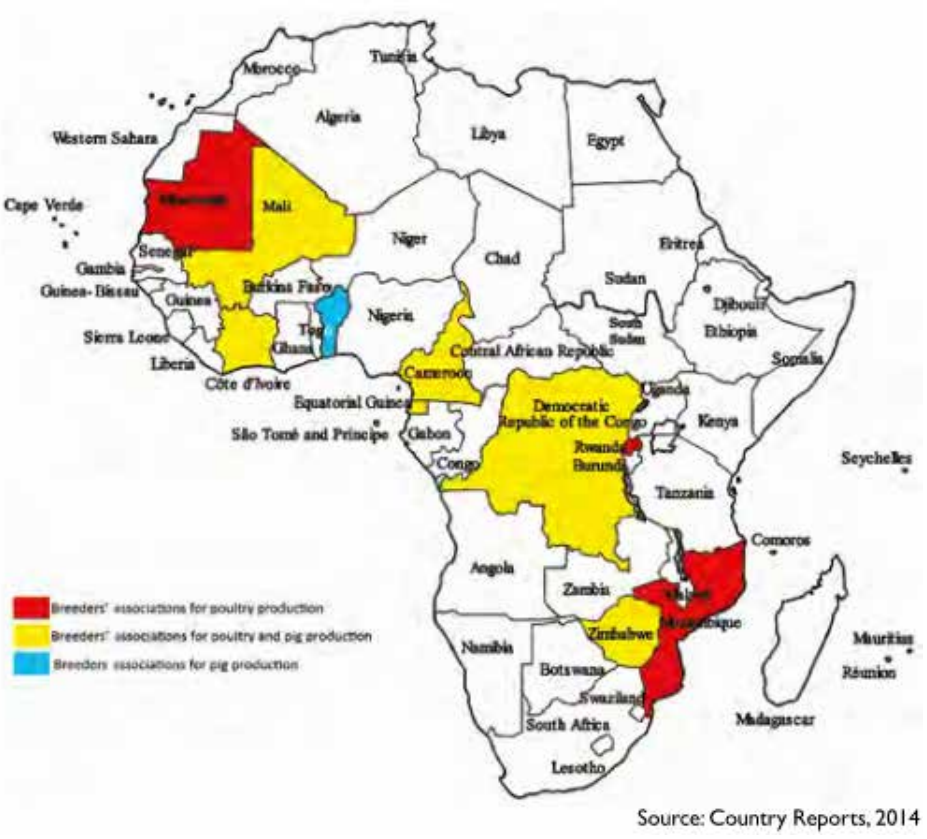


Figure 14. *African countries with established national livestock breeders 'associations*

3.4. Local poultry business plan

Local poultry farming is a very profitable business, and many people are making money in developing countries by raising backyard poultry. However, to build a successful, sustainable local poultry farming business, one requires sufficient knowledge of how to efficiently raise poultry, good management skills, and a good poultry farming business plan.

Few things one needs to consider when planning for the local poultry business:

Land, housing and equipment: that will depend on the size of one's poultry project. When choosing the location for a poultry business, one has to balance the need for proximity to the market, with the cost of land, labour costs, security, and a good water supply. When planning to construct a free-range poultry house, one has to select a site which is well-drained with plenty of natural air movement. The right poultry housing should have proper ventilation and lighting. Ventilation is necessary so that adequate air exchange can take place. Lighting stimulates hens to lay eggs. To produce eggs year-round, one needs to install adequate lighting in the facility. One should have equipment including good poultry feeders, drinkers, lighting system and nest boxes.

Day old chicks: The success of poultry business will partly depend on the quality of day-old chicks which one buy. After getting experience, one could a system to hatch their own chicks, which will reduce expenses and need to buy day old chicks. There are many different breeds of poultry, and the right breed to choose will depend on one's needs.

Feed, nutrition and health: Lack of feed or water will reduce resistance to diseases and parasites, and subsequently increase flock mortality. Supplementary feeds should be offered in the morning and evening when the free-range poultry come back for the night. Clean water should be provided in shady areas during the day to avoid heat stress. Proper vaccines and medications are needed to prevent diseases and promote growth of free range and backyard poultry

Management and labour: The number of farm workers needed will depend on the size of the free range and backyard poultry project. If one is running a small business e.g. 100 birds/cycle, family members may provide enough labour to take care of the poultry. However, if one is rearing 2000 birds per cycle, full time employees will be required to manage the free-range poultry. There is need for good technical knowledge of free-range poultry rearing techniques for success in the business. Good management skills are necessary.

Capital: The amount of capital required for a free-range poultry farming business depends on the scale of the project. Sources of capital include bank loans, and equity investors. Start small and grow business over time. Free range poultry are very profitable, so if profits are reinvested the business can quickly grow. A good free-range poultry and eggs production business plan to guide

the business is a pre-requisite.

Market for meat and eggs: The market for free range poultry is large and increasing, as more people are moving towards organic and healthier foods. Many people prefer organic free-range poultry meat, as compared to broiler poultry meat. This is because free range poultry are highly nutritious, delicious, organic, and healthier. Thus, the demand for free range organic poultry meat continues to rise. Free range poultry have a higher price than broiler poultry, as they are considered superior. One can supply free-range poultry meat and eggs to individual households, butchers, schools, restaurants, companies, supermarkets, organizations, events, abattoirs etc. Free-range poultry can be sold as live birds or slaughtered and dressed. As the business grows, one could export the free-range organic products.

Supermarkets and restaurant chains are expanding in Africa to tap into changing market interests among Africa rising middle class.

Source: *Rabobank 2020*
Figure 15. *Internationalization of poultry grocery distribution in Africa*

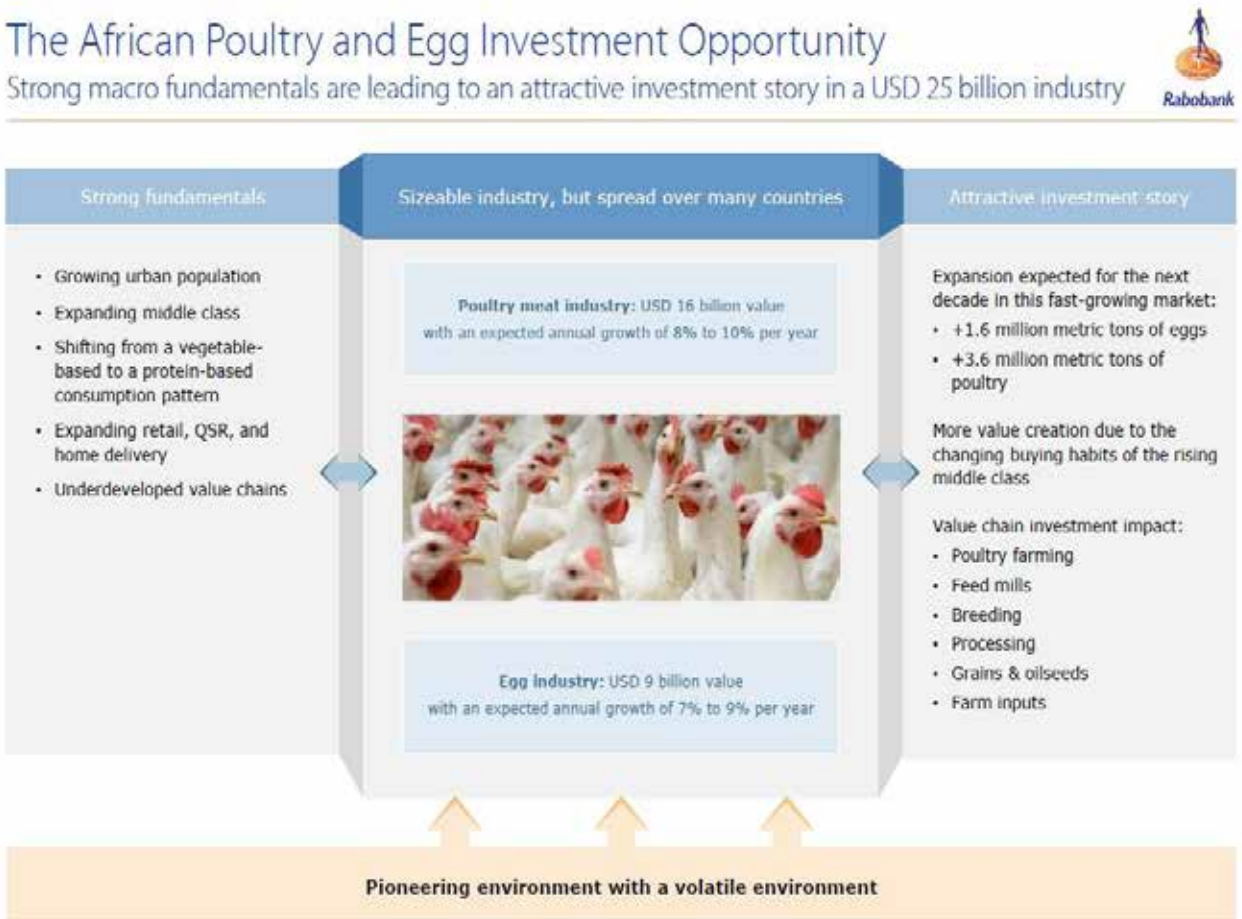
The free-range poultry farming business plan can be used for many purposes including:

1. Raising capital from investors/friends/relatives.
2. Applying for a bank loan.
3. Start-up guide to launch free-range poultry farming business.
4. As a project/business proposal.
5. Assessing profitability of the free-range poultry business.

6. Finding a business partner.
7. Assessing the initial start-up costs to estimate how much to save.
8. Manual for current business owners to help in business and strategy formulation.

Poultry farming business plan should include, but not limited to:

1. Marketing Strategy
2. Financial Statements (monthly cash flow projections, income statements, cash flow statements, balance sheets, break even analysis, payback period analysis, start-up costs, financial graphs, revenue and expenses, Bank Loan Amortization)
3. Risk Analysis
4. Industry Analysis
5. Market Analysis
6. SWOT & PEST Analysis
7. Operational Requirements (Including technical aspects of how to keep and rear the poultry, feed requirements etc.)
8. Operational Strategy
9. Why some people in the poultry business fail, to avoid their mistakes
10. Ways to raise capital to start the poultry business



Source: Rabobank 2020

Figure 16. *The African poultry meat and egg investment opportunity*

CHAPTER IV: PRODUCTION TECHNOLOGIES

There are two distinct approaches to family poultry development: a conservative approach (to preserve existing practices) and a progressive approach (for the introduction of new practices), the success of which depends on taking into account the following elements:

1. Poultry development interventions must be adapted to socio-economic, cultural and logistical conditions.
2. An appropriate development strategy must be drawn up according to the characteristics of the poultry systems.
3. The probability of success of the interventions is higher if the constraints which characterize a specific family poultry farming system are approached in a global and integrated manner.
4. If the intervention is divided into several stages, experience in the field shows that priority must be given to improving health, food and housing conditions, before trying to improve the race.
5. Practical training, exchange visits between poultry farmers, and follow-up sessions are all effective ways to build capacity
6. The choice of development strategy must be based largely on the local context and access to markets and services (for example, vaccination, health, credit)

Family poultry farming can be developed according to the systems:

1. by improving producer management skills for local poultry
2. by identifying commercial opportunities for poultry products
3. by identifying the actors of change and the marketing of agricultural production
4. by introducing simple technologies, adapted and accepted by producers
5. by maintaining vaccination and animal health through public-private partnerships
6. advising agricultural extension workers and teaching them new participatory learning skills: moving from the role of traditional trainer to that of change facilitator
7. by supporting farmers' organizations and facilitating their participation in the provision of services and inputs to farming communities
8. by promoting family poultry farming to decision-makers and political leaders locally and nationally for their support

4.1. Selection

Genetic improvement projects must, depending on the systems, take into account the perceptions and priorities of breeders. They will focus on:

1. breeds with productivity, adaptability and resistance to diseases;
2. breeds with low input costs and improved productivity (especially in semi-intensive systems)
3. establishment of a selection structure
4. establishment of a multiplication center - creation of distribution networks to support vulnerable farmers taking into account the situation in the country.

4.2. Feed resources and feeding

Integration of family poultry farming with other production systems, such as forestry, arboriculture, annual crops, large livestock, fishing, etc. presents nutritional opportunities

Integrating family poultry with fruit and vegetable cultivation offers more nutritional opportunities, since poultry droppings are used for composting, while earthworm production provides protein for poultry.

Small poultry farmers with extensive roaming poultry farms generally have little experience and knowledge in industrial feeding, but those with semi-intensive or intensive small-scale farms are better informed about commercial feeds and try to buy the right kind of feed to feed their poultry.

However, farmers can buy low quality feed to keep their poultry from wasting away during times of scarcity in villages, and in peri-urban areas where there are no alternatives to industrial feed.

The raw materials for the formulation of commercial foods are products / by-products of animal and vegetable origin and agro-industrial products / by-products of local or imported origin.

4.3. Poultry health

Organization of poultry farmers in health defense groups
Systematization of biosecurity on farms
Planning and organization of vaccination campaigns against poultry diseases
Training and Communication on the risks of diseases

4.4. Sex ratio management in flocks

Maintaining fertility throughout the production period requires a balanced female to active male ratio. Higher than recommended mating ratios can lead to issues with over-mating, as well as reduced flock fertility, egg numbers and animal welfare. Therefore, a planned reduction programme should be used to avoid high mating ratios and maintain optimal fertility during lay.

To avoid high mating ratios:

1. Review mating ratios weekly
2. Where necessary, establish a well-planned male-reduction programme
3. Use recommended mating ratios as a guide only, and adjust them to local circumstances and flock condition.

Table 18. Sex ration

Days	weeks	Number of good quality males / 100 females
154-168	22-24	9.50 – 10.00
168-210	24-30	90.00 – 10.00
210-245	30-35	8.50 – 9.75
245-280	35-40	8.00 – 9.50
280-350	40-50	7.50 – 9.25
350 to depletion	50 to depletion	7.00 – 9.00

Remove males if:

1. Alertness and activity has declined
2. Body weight is appropriate
3. Legs and feet are not straight or show signs of bent toes or footpad abrasions
4. Body condition is not as expected
5. Comb and wattles are not an intense red colour and the beak is not uniform
6. Males exhibit no feather loss around the shoulders or thighs
7. Vent is pale in colour with no signs of feather wear
8. Females show visible damage or excessive feather loss.

4.5. Separate/restricted feeding and quality check

Separate-sex feeding

- Feeding separate male and female birds, a practice called separate-sex feeding.
- Since male broiler poultry grow faster, they often are reared separately from the females until they are moved into the breeder house.
- There will be more uniformity among males and among females in the flock.

- Separation of the birds also allows producers to feed diets that more closely meet the nutritional needs of the male and female birds.
- Therefore, sex separate feeding of breeder hens and cocks will be followed.
- Females will be fed a 18% protein and 3.0 to 3.5% calcium feed while the cocks with 13-14% protein and 1-1.5% calcium feed with higher levels (40mg/kg) of vitamin E; on other aspects, both the feeds are comparable. The breeder males must be fed with a low protein diet because high protein diet will affect sperm quality as well as semen volume.
- Male and female feeds are offered in separate feed hoppers in slat and deep litter system. In cage system, sex separate feeding can be followed with 100% accuracy since they are reared in different cages.

Restricted feeding

- Method of feeding where time, duration and amount of feed are limited.
- Adolescent birds, when given the opportunity, will eat until they become obese.
- Restricted feeding is necessary if the birds are going to be used as breeder stock.
- The obesity severely limits the numbers of eggs laid and the fertility of eggs.

There are different methods of feed restriction:

- Physical Feed Restriction
- Skip-a-day Feeding
- Lighting Programs
- Diet Dilution
- Use of Low Protein or Low Energy Diet

Benefits of Feed Restriction

- Delay Sexual Maturity
- Increase egg size
- Uniform egg size

- Lower layer house mortality
- Increase profit
- Improved feed conversion
- Decreased Ascites (abnormal buildup of fluid in the abdomen)
- Decreased Sudden Death Syndrome
- Decreased Leg Disorders

4.6. Eggs incubation and Brooding technologies

a. Foster mothers. Hens are known to adopt other eggs and chicks and care for them as if they were their own.
b. Cooperative incubation and brooding. Farmers can bring together eggs of chicken from various hens for grouped incubation and brooding.

4.7. Use of feed additives and supplements

a. Antibiotic growth promoters
b. Antioxidant
c. Anti-stress
d. Enzymes
e. Eubiotics
f. Fortified omega-3 egg
g. Immunomodulators
h. Mycotoxin binders
i. Nucleic acid
j. Organic acids
k. Phytobiotics
l. Prebiotics
m. Probiotics
n. Synbiotics

CHAPTER V: BREEDING AND REPRODUCTION TECHNOLOGIES

5.1. Choice of breeders and Reproduction Management

The breeders must be chosen in good farms or multiplication centers where feeding, health monitoring are well applied and take into account the following criteria:

1. age (not too old)
2. the health status (healthy).
3. ridges and barbs: thick, dark red, soft, warm, large;
4. large and deep eyes;
5. the short, heavy bill, without deformation;
6. the long, straight breastbone, inclined downwards;
7. supple skin;
8. the hardiness of the breed or strain
9. the GMQ growth speed between 30g –40g -50g;
10. colour (according to request);

5.2. Reproduction management

1. Breeding of the rooster at 6 months of age and cull at 3 years of age
2. Breeding of the hen at 6 months and culling at 18 months
3. Avoid inbreeding by changing roosters regularly
4. Provide 1 rooster / 6-10 hens;
5. Mating takes place in the course reserved for breeders and / or in the breeding room;
6. The laying begins from 6 months (about 01 egg every two days);
7. Put near the nest a drinker and a manger (a hen can hatch 12 to 15 eggs for 21 days);
8. Incubation can be artificial, using a mini incubator set between 38 and 39°C. In this case, the eggs must be turned twice times a day;

9. candle the eggs on the 8th and 18th days;
10. After hatching, allow the chicks to dry, then transfer them to the preheated chick-house;
11. 06 weeks later, transfer them to the fattening henhouse.

5.3. Pyramidal organization of Poultry Breeding programme

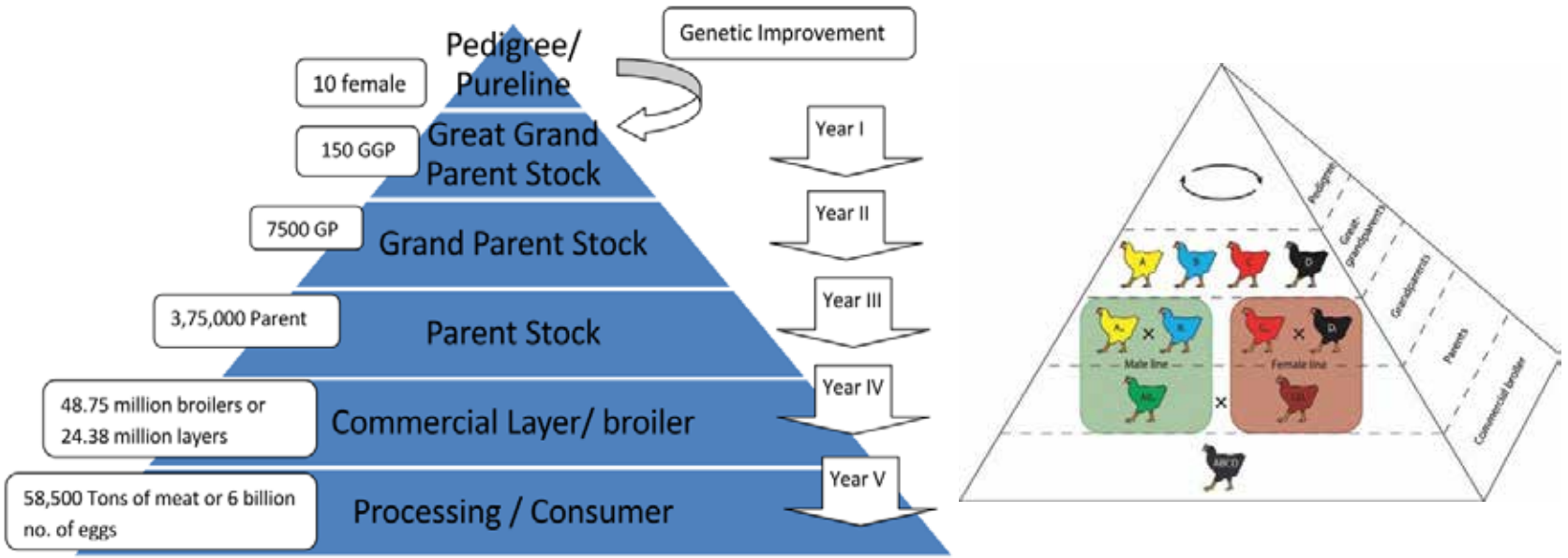


Figure 20. *Pyramidal organizations of Poultry Breeding programme*

A typical modern broiler poultry breeding programme represented as a pyramid where each level represents a generation. The great-grandparent line/pure lines on the top of the production line are where desired traits are selected across four lines. Within the pedigree segment are the specific male and female lines, with the males typically selected for heritable growth and production traits and the female lines selected for early growth and conformation (Anthony, 1998). The commercial broiler (fifth generation)

is derived from the cross of a male and female parent line.

5.4. Breeder Management

1. The layer breeder management is more or less similar to the management of commercial layers.
2. Since the parent stocks are costly and their hatching eggs and pullet chicks fetch higher income, more care has to be taken on parent stock, to generate more profits.
3. Moreover, in parent stock management, the management of male breeding stock and the hatchery are additional activities, to be carried out more carefully.

Rearing systems and space requirements

1. The layer parent stock can be reared successfully on deep litter, slats, slat cum litter or in breeder cages.
2. The floor space requirements will be 1860 cm^2 in deep litter, 1400 cm^2 on slat/wire floor and 450 cm^2 in cages for females and 700 cm^2 in breeder cages for male breeders.

5.5. Males and Artificial Insemination

1. Males are reared separately from 0-21 weeks of age.
2. Start with 12% males in case of natural mating and 8% in case of artificial insemination.
3. At the beginning of the breeding season (22 weeks), introduce 8 males per 100 females.
4. Replace weak, lame and sick males promptly. In case of A.I. maintain at least 5% males which can yield about 0.5 ml neat semen per ejaculate with not less than 60% motility.
5. Inseminate females once in 5 days, with 0.03 – 0.05 ml of neat semen; within 30 minutes after collection.

There are some cutting-edge technologies applicable to African poultry breeding. Biotechnological and immunological tools must be adopted in combination with breeding methods to develop robust stocks having higher production level like

1. Quantitative Traits Loci (QTL) through genome wide scan. This is a region of DNA which is associated with a particular phenotypic trait

2. microarray analysis for elucidating biological pathways (a series of interactions among molecules in a cell that leads to a certain product or a change in a cell)
3. identifying the genes involved processes that are vital for an organism to live, and that shape its capacities for interacting with its environment,
4. identifying useful genes or part of genes affecting phenotype.
5. The genetic modifications like transgenesis process of introducing an exogenous or modified gene (transgene) into a recipient organism of the same or different species from which the gene is derived), knocking down/silencing a gene and RNA interference (RNAi, biological process in which RNA molecules inhibit gene expression or translation, by neutralizing targeted mRNA molecules), and many other genetic technologies hold immense potential.
6. Breeds/ strains having high immune competence will be another priority area for research due to adaptability of future stocks to changing farming systems and climate.
7. For smallholder systems, creep-upgrading or nucleus crossbreeding, community-based breeding programs and strategies to generate sustained replacement stocks in systems where crossbreds are the best option may be explored further.

5.8. Artificial Insemination

This is the most widely used reproductive technology in the livestock industry. Its adoption in poultry has increased in popularity for research and commercial purposes.

1. Artificial Insemination (AI) is an important tool to improve the reproductive performance of birds especially broiler breeders and turkey where fertility is low due to heavy body weight.
2. Even though AI is well developed technique in cattle, is not so well developed in poultry because no standard technique is available to store poultry semen for a long period.
3. The techniques available at present permits to collect semen and use it for insemination immediately with or without dilution using semen diluents at 1:2 ratio. Semen collected from one cock is sufficient for inseminating 5 to 10 hens depending upon the semen volume and sperm concentration.
4. At farms, where AI is practiced the males are kept separately in individual cages where sufficient space is available for movement of the birds.

5. There should be a particular team of workers to associate collection and insemination of semen.
6. Frequent changes of personnel in the team may affect the normal behaviour of birds.
7. Rough handling should be avoided, if not it may develop fear reaction, which affects the semen volume during ejaculation.

Characteristics of poultry semen

- Usually cock start producing semen from the age of 16 weeks but the fertilizing capacity of the semen is low.
- So the cocks from 22 or 24 weeks of age are used for semen collection.
- The natural colour of poultry semen is white or pearly white.
- Heavy breed male can produce 0.75 to 1 ml semen and light breed male can produce 0.4 to 0.6 ml of semen.
- A male can be used thrice in a week for semen collection with a gap of one day.
- Although everyday semen collection will not change the fertilizing capacity but the volume of semen will be low.
- Semen consists of spermatozoa and seminal plasma.
- Fowl semen is generally highly concentrated (3 to 8 billion spermatozoa per ml for broiler fowl).
- This is due to the presence of limited amount of seminal plasma since the accessory reproductive organs are absent in avian species.
- The seminal plasma is derived from the testes and excurrent ducts.
- At the time of ejaculation, a lymph-like fluid (also known as transparent fluid) of cloacal origin may be added to the semen in varying amounts. The addition of transparent fluid to semen at the time of ejaculation act as an activating medium for the previously non-motile spermatozoa, thus ensuring their transport from the site of deposition to the sites of sperm storage tubules in the utero-vaginal junction of the hen's oviduct.

5.6.1. Why AI in poultry?

As the selection for faster growth rates is intensified, fertility in males is likely to decline due to the negative relationship between growth and fertility. Application of AI in such scenarios is cost effective in broiler breeding management. It allows:

1. Incompatible individuals to mate
2. Progeny test and specific male's reproduction

3. Increase female's mating rate
4. Increase male's utility
5. better use of the cage feeding system in hatchery operations.
6. one male of high genetic merit for a particular trait of interest to serve more females, therefore increases the number of offspring per cock.
7. Adjust insemination frequency.
8. Increase inseminated ratio.
9. Early selection of cock.
10. Research and development on frozen semen

Artificial insemination in poultry requires one to understand the basic anatomy and physiology of the hen's and the cock's reproductive tract. In addition to this one must be technically competent with the semen collection and deposition procedures in order to achieve effectiveness in producing fertilized eggs.

5.6.2. Equipment

1. A 1 cc plastic syringe, a medicine dropper, and a glass eye cup
2. More intricate equipment such as temperature-controlled collectors for the semen, injections guns and collection aspirators can be used in commercial poultry breeders.
3. Small glass funnel with stem plugged with wax.
4. Inseminating syringe
5. Wide mouthed glass vial.
6. Small pyrex semen cup
7. Large flask to hold water at 180° C to 200°C range for short time holding of semen.

Figure 21. *Poultry Artificial Insemination Gun*

5.6.2. Selection requirement of male and female poultry used in the insemination process

1. Maturity, no physical defects, and healthy.
2. Sexually active, tame and free from external parasites.
3. Hen's squatting behaviour.

The Male* Procedure *for semen collection

The abdominal massage technique involves massaging the cloacal region to achieve normal penis engorgement with blood. This is followed by a 'cloacal stroke', a squeezing of the region surrounding the sides of the cloaca to express the semen. Little additional semen can be expressed after two cloacal strokes; additional cloacal strokes may cause damage to the phallic and cloacal regions and contribute to semen contamination

1. The first step in AI program is manual collection (milking) of the semen
2. For semen collection, a team of two members are generally involved, one for restraining the male and the other for collecting semen.
3. The bird is held in a horizontal position by a person at a height convenient to the operator who is attempting to collect the semen.

4. To collect semen the operator should place the thumb and index finger of the left hand on either side of the cloaca and massage gently.
5. By his right hand the operator should hold a collecting funnel and with the thumb and index finger massage the soft part of abdomen below the pelvic bones.
6. Massage should be rapid and continuous until the cock protrudes the papilla from the cloaca.
7. Once the papilla is fully protruded, the previously positioned thumb and index finger of the left hand are used to squeeze out the semen in to the collecting funnel.
8. Collect the semen from the extension of copulation organ with a small tube or any cup-like container.
9. Avoid contamination of semen with faeces and feather.
10. About 0.5 mL can be collected.
11. If the semen flow is too slow, it can be increased with a small milking action.
12. Poultry semen beg begin to lose fertilizing ability when stored >1 hr.
13. Liquid cold (4°C) storage of poultry semen can be used to transport semen and maintain spermatozoa viability for ~6-12 hr.

Figure 22. *demonstration of semen collection*

5.6.5. Semen evaluation at the time of collection

1. Normal colour of the semen in pearly white or cream coloured.
2. Yellow semen and semen contaminated with blood, urates, faeces or other debris should be avoided.
3. Do not allow semen to contact water.
4. If debris or contaminants are observed in pooled semen, carefully aspirate contaminates from the sample before mixing with additional diluent with the semen
5. Place the diluted semen in a cooler or refrigerator (3 to 12°C) to cool down.

5.6.6. Sperm concentration

The most popular techniques for determining sperm concentration are the packed cell volume (PCV; also referred to as a spermatocrit) and optical density (OD; photometry).

Table 19. Semen volume and sperm concentration in different species of poultry

Species	Volume (ml)	Sperm concentration (million per ml)	Need of sperm concentration per insemination (million)
Broiler chicken	0.7	3500	150 to 200
Layer chicken	0.5	4000	150 to 200

5.6.7. Sperm viability

'viable' sperm simply implies that such sperm possess an intact plasmalemma and are assumed to be functional.

Plasma membrane integrity is frequently determined using either a dead-cell or a live-cell stain alone or simultaneously. Both eosin and propidium iodide are popular dead-cell stains while calcein AM and SYBR-14 are frequently used live-cell stains

Figure 23. The left panel shows a nigrosin eosin preparation of turkey sperm with nearly 100% viable sperm (unstained) white nuclei and midpieces. The sperm head is clearly visible as the white arcing segment; the acrosome and midpiece are difficult to differentiate from the nucleus. The upper right panel reveals a normal sperm and a second sperm with an abnormally curved and swollen midpiece. Observed in the lower right panel is a nonviable sperm stained with eosin throughout the nucleus and midpiece. Barely visible at the anterior end of the nucleus is the unstained, conical shaped acrosome.

5.6.8. Sperm motility and mobility

Sperm motility can be progressive (forward direction) or non-progressive (random movement or oscillations) movement. The sperm mobility assay has gained popularity as a measure of an individual male's ability to produce highly mobile sperm [mobility defines the ability of sperm to move progressively against a viscous medium (Accudenz) at 41°C] that are more likely to fertilize an ovum than males producing less mobile sperm.

5.6.9. Insemination Procedure

1. Bird is held by the legs with the left hand down and tail tucked back and against the operator chest.
2. The thumb of the right hand is placed against the upper lip of the vent then with a rounding motion press the abdomen muscle.
3. Do not squeeze with fingers but apply pressure evenly with the palm of the hand.
4. When the oviduct is everted, the second operator inserts the syringe into oviduct as far as it is going inside without exerting

pressure.

5. The insemination apparatus is introduced into the vagina about 1 inch and semen is deposited at the junction of vagina and uterus.
6. For insemination, pressure is applied to the left side of the abdomen around the vent.
7. This causes the cloaca to evert and the oviduct to protrude so that a syringe or plastic straw can be inserted ~1 in. (2.5 cm) into the oviduct and the appropriate amount of semen delivered.
8. In order to prevent injury, the female should not have any hard-shelled eggs in the lower area of her oviduct.
9. The presence of such an egg would hinder the journey of the sperm to the ova.
10. For maximal fertility, inseminations may be started before the initial oviposition.
11. As the semen is expelled by the inseminator, pressure around the vent is released, which assists the hen in retaining sperm in the vagina or the oviduct.
12. In native poultry, inseminating 0.02-0.03 mL and 8~10×107 spermatozoa of pooled semen is required.
13. AI can be done at intervals of 7 days.
14. In summer time, inseminating at intervals of 5 days and 0.04 mL semen are suggested.
15. When fertility declines, it may be justified to inseminate more frequently or use more cells per insemination dose.

Figure 24. *demonstration of insemination*

1. All equipment used for insemination should be thoroughly cleaned and dry before use.
2. Insemination must be carried out when majority of the birds completed laying since a hard-shelled egg in the lower end of the oviduct obstructs insemination and lowers fertility.
3. In practice, inseminating poultry after 3 pm obtained better results.
4. In turkey flocks much better results are obtained if insemination is done after 5 pm.
5. It is difficult to inseminate non-laying hens.
6. Usually insemination is done when the flock reaches 25% egg production.
7. Hens are inseminated twice during first week. Then at weekly intervals.

5.6.10. Dose and frequency of insemination

1. Chicken: 0.05 ml, once in a week
2. Turkey: 0.025 ml once in every 2 weeks

3. Ducks: 0.03 ml once in every 5 days
4. Goose: 0.05 ml for every 7 days.
5. It has been observed that the males produce more semen of good quality during morning and females produce more fertile eggs when inseminated around 9 p.m.

Duration of fertility

1. Goose: 66 days
2. Duck: 8-9 days
3. chicken: 12 days
4. Turkey: 22 days

In practice to maintain semen quality:

1. Periodically collect semen.
2. For each batch, collect 5 cocks' semen and then inseminate 75 hens

With AI programs, it is often desirable to determine the fertility status of a flock before the next weekly insemination. There are several options available: breaking-out fresh eggs and examining the germinal disk to differentiate a fertilized from an unfertilized or early dead embryo; setting normal but culled eggs (checked, hairline cracked, or dirty eggs) in a spare incubator for 24-36hr before breaking-out; counting sperm in the outer PL; and counting sperm holes in the inner PL.

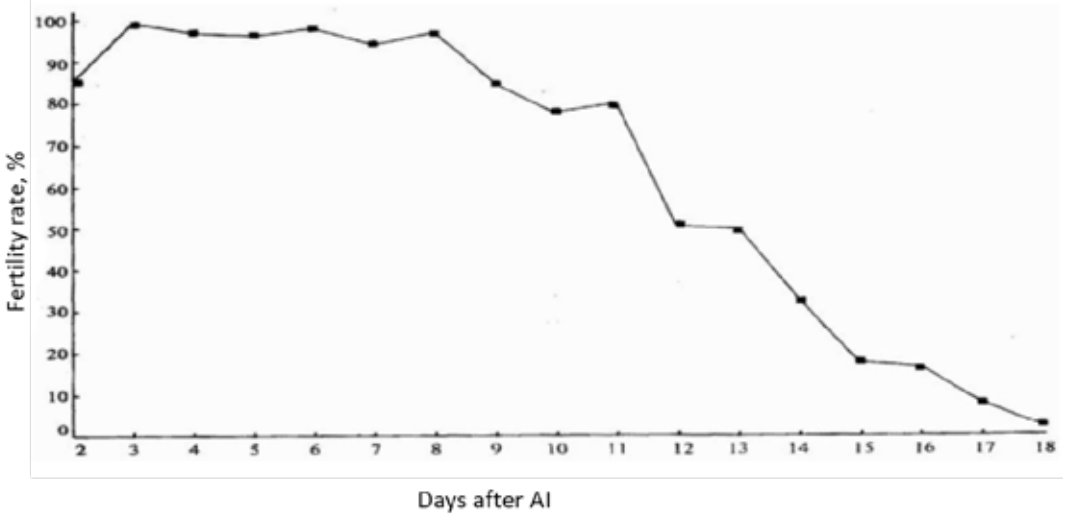


Figure 25. *Duration of fertility and fertility rate after single AI of hen*

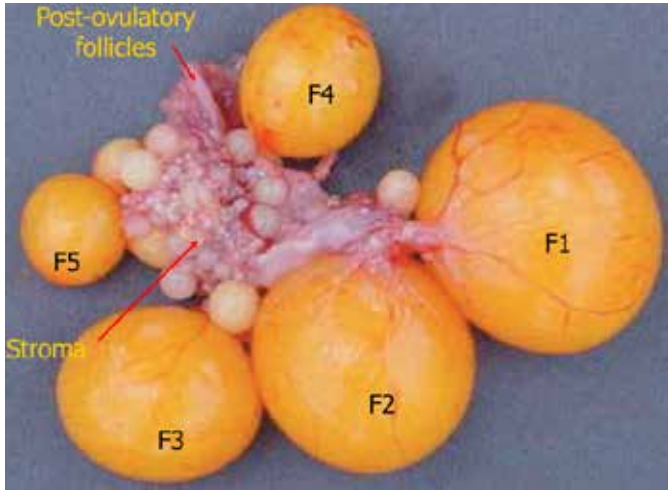


Figure 26. *The ovary of laying hen*

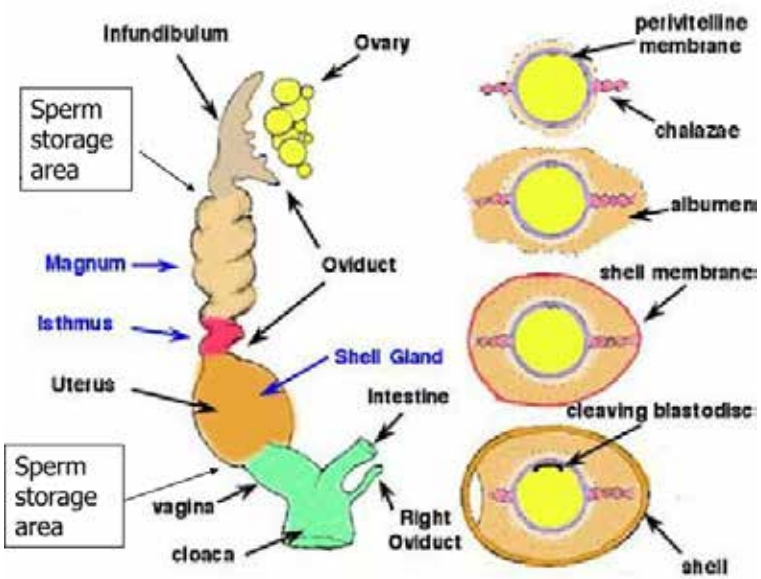


Figure 27. *Ovary and oviduct of bird*

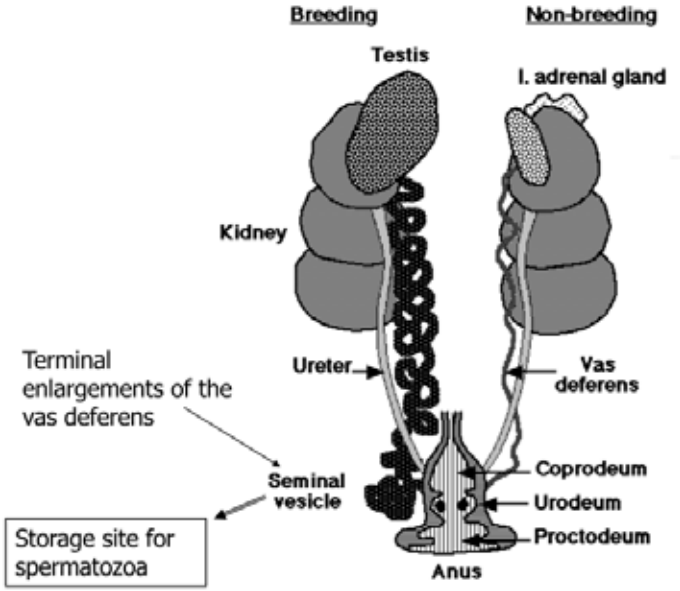


Figure 28. *Avian Testes*

5.7. Fertile Eggs

The nucleus of the female cell is a small white or light-coloured speck about the size of a pin head that is located on the top side of the yolk. Here the microscopic male sperm cell finds lodgement and the cells are united to form the embryo. A fertilised egg is characterised by a white ring 3-4 millimetres in size on the yolk surface (germ cell), whereas an infertile egg is characterised by a single white speck of about 2-3 mm diameter.

Hatching egg collection and care

- In slat or deep litter system, keep nest boxes at the rate of one hole for 4 to 5 hens at 18-20 weeks of age. Close the nest holes during nighttime, to discourage broodiness and soiling of nest material.
- Introduce males around 22 weeks of age at 8 cocks/ 100 hens or as per the recommendation of the principal breeder.
- Collect hatching eggs when they reach at least 48-50g weight or from 25 weeks of age whichever is later.

- Collect eggs at hourly interval during forenoon and once in 2 hours in the afternoon in deep litter and wire floor sheds. In cages collect eggs 2 or 3 times a day.
- Separate clean, soiled dirty, broken, misshapen and abnormal eggs soon after collection.
- Save clean eggs with sound shell, shape and size for hatching, without any cleaning.
- Dry clean soiled eggs with the help of a sandpaper, dry cloth or cotton and also save them for hatching.
- Do not practices wet cleaning of eggs. Discard other eggs which can be sold for consumption.
- Fumigate hatching eggs with formaldehyde (H_2CO, formalin, formol) and store in an egg storeroom, until 6 hours before setting. A minimum concentration of 600 mg formaldehyde per m3 (i.e. 10 g paraformaldehyde or 45 ml of 40% formalin and 30 g $KMnO_4$) at 21˚C is necessary.
- Do not store hatching eggs for more than a week. In case of cage system, netlon or rubber mat is placed over the cage floor to prevent hair cracks (checks) in hatching eggs. Otherwise, plastic coated steel mesh is used as cage bottom.

Fertile eggs should be clean and dry and stored between 12-15°C at a relative humidity of 75% with the small end down.

Eggs should be turned by 90 degrees at least once to twice daily. Optimal hatchability is achieved in fresh eggs less than 10 days old, but reasonable hatchability can be obtained in eggs up to 14 days of age. Fertile eggs should maintain a relatively constant weight with minimal weight loss during storage. Temperatures above 25°C can initiate cellular replication of the germ cell on the yolk of the fertile egg and will increase embryonic mortality and reduce hatchability. Temperatures below 10°C can inactivate the germ cell.

5.8. Eggs incubation technologies

5.8.1. Hatchery operation and sanitation

1. The eggs are set according to the demand or order for pullet chicks.
2. Depending upon the size of the hatchery, the eggs are set 1 to 6 times a week. Set 250 eggs for every 100 pullet chicks required.
3. The remaining hatching eggs may be either sold as hatching eggs for other needy hatcheries or sold for table purpose.

4. The cockerel chicks produced may be either sold for specialized cockerel market or destroyed and recycled in feed as "male chick meal", replacing fish meal.
5. Discard weak female chicks also, weighing less than 32 grams.
6. Unlike the old design, the modern hatcheries locate the tray cleaning room etc., at least 30 m away from the main hatchery, on sanitation grounds.

Several parameters are susceptible of affecting the incubation performances

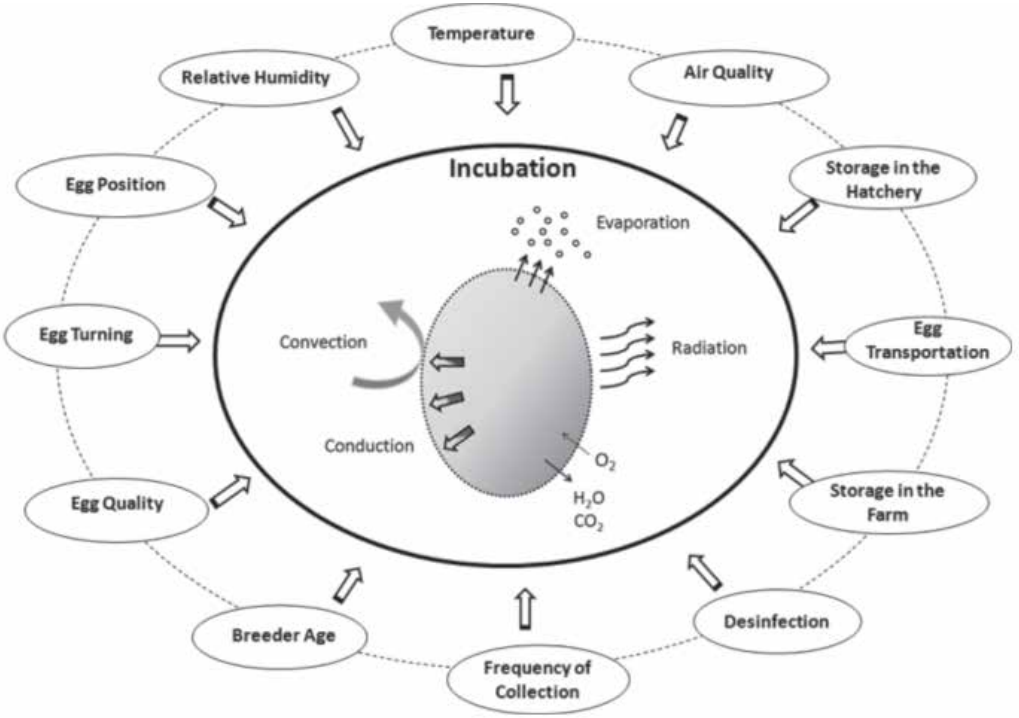


Figure 29: *Physical exchanges of the eggs with the environment during incubation (heat transfer, water loss and gases exchanges) depend of the egg characteristics (size, composition, form, and eggshell thickness, porosity and heat and water vapor conductance), embryo metabolism rate and physical incubation conditions, but also of the pre-incubation conditions.*

The four main essentials of incubation of good quality fertile eggs are:

1. Correct and even temperature controlled by a thermometer or thermocouple
2. Correct humidity controlled by ventilation rate and water application
3. Correct oxygen and carbon dioxide concentrations controlled by ventilation
4. Turning of the fertile eggs by approximately 90 degrees several times per day by manual or automatic means.

These parameters can be easily achieved and maintained if the incubator manufacturer's operating instructions are carefully adhered to.

5.8.2. Incubation by mother hens

1. Usually one hen starts incubating by staying overnight on boiled egg
2. Leave this hen on the boiled egg for 10 days while it is waiting for other birds
3. After the 10 days, give all the birds that would have started incubating (within the 10 days) 17 selected but recently laid eggs
4. Leave out the birds that refuse to incubate
5. If one want to eat or sell, eat/sell those which were laid first (old ones).
6. Avoid giving the following eggs to birds for incubation: very small, round eggs, very dirty, cracked eggs, extremely pointed eggs, very big eggs, very old eggs.
7. When done this way, all birds will hatch on the same day. An egg takes 21 days, 6 hrs to hatch.

Eggs can also be collected and taken to a hatchery instead of incubation by mother hens.

5.8.3. Incubation Temperature Range and Variation

The temperature requirements for incubation are described in Table 1 (below) and most incubators have a temperature variation of 0.2-0.4°C for effective incubation and subsequently a high hatchability rate.

Embryo tolerance to temperatures more than 1°C above or below the recommended temperature (Table 1) is low, and temperatures outside this range will result is significant embryonic mortality. Embryos are much more susceptible to temperature variation in the early and late phases of incubation.

Table 20. Incubation Temperature Range and Variation

	Poultry	Turkey	Duck	Muscovy Duck	Goose	Pheasant	Guinea Fowl	Quail
Incubation Period days	21	28	28	35	28	23-28	28	23-24
Incubation Temperature (°C)	37.6	37.4	37.5	37.5	37.4	37.6	37.6	37.6
Wet Bulb Temperature (°C)	29.4-30.5	28.3-29.4	28.8-30	28.8-30	30-31.1	30-31.1	28.3-29.4	28.8-30
Relative Humidity (%)	56-62	51-56	53-60	53-60	60-65	60-65	51-56	53-60
No of Daily Turning	18	25	25	31	25	21	25	21
Incubation Temperature last 3 days (°C)	37.4	37.2	37.3	37.3	37.2	37.4	37.4	37.4
Wet Bulb Temperature last 3 Days (°C)	32.2-34.4	32.2-34.4	32.2-34.4	32.2-34.4	32.2-34.4	33.3-35	32.2-34.4	32.2-34.4
Relative Humidity last 3 days (%)	70-83	70-83	70-83	70-83	70-83	76-90	70-83	70-83

For still air incubators add approximately 1°C to the operating temperatures recommended in table 1. This is because the thermometer in still air incubators is normally located at the top of the incubator and there is a marked temperature gradient from the top of the incubator to the bottom.

5.8.4. Incubation Relative Humidity Range and Variation

The maintenance of consistent relative humidity is more difficult during incubation and can only be constantly maintained by ventilation rate, using adjustable ventilation apertures and by surface water and water sprays during incubation. The tolerance of the embryo to different ranges of humidity are greater than temperature, but there are negative consequences observed with humidity below 40% and above 90%. Good hatchability is achieved when relative humidity is maintained at approximately 50-65%

until the last 3 days of incubation, at which point it should be increased to between 70-90%.

5.8.5. Ventilation and Carbon Dioxide/Oxygen Concentration

Embryonic growth is optimized at an air concentration of carbon dioxide of 0.4% and embryonic growth is depressed, and mortality increased with carbon dioxide concentrations above 1%. The normal atmosphere contains 21% oxygen and 0.04% carbon dioxide. The hatched chick is most susceptible to oxygen deviation (compared to the pipped chick and the embryo in the intact egg), which implies that ventilation rate and carbon dioxide concentration is most critical in the late phase of incubation.

5.8.6. Egg Turning and Rotation

Egg rotation or turning is required to ensure that the embryo developing on the yolk does not adhere to the shell membrane. This phenomenon of adherence to the shell membrane commonly occurs during fertile egg storage and during early incubation (generally the first week). The turning process allows the embryo to revolve and slide in the inner white and provides access to additional nutrients for embryonic development. Egg turning should be undertaken 3-6 times per day and an uneven number of rotations are better so that the eggs are not in the same position for a longer period. Most incubators rotate the eggs by approximately 90 degrees.

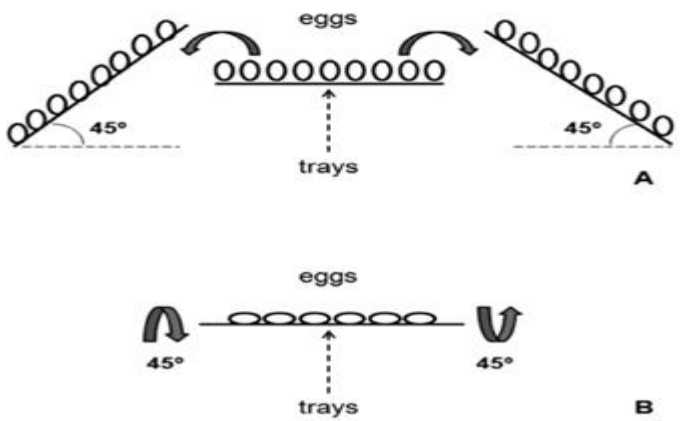


Figure 30: *Egg turning in vertical (A) and horizontal (B) incubators*

5.8.7. Candling of Incubated Fertile Eggs

After 5-8 days of incubation the eggs should be examined using a candling light to examine the embryo for blood vessel development ('spider web-like') and a dark spot. Infertile eggs are obviously clear with no evidence of blood and early embryonic death is noted by the presence of a blood ring surrounding the yolk. Infertile and early dead embryos are removed at this stage. Candling can also be undertaken at 18 days of age, where the embryo is clearly visible with a distinct dividing line between the embryo and the air cell.

In large commercial incubators candling is not normally undertaken and there is a high reliance on fertility and egg hygiene to maintain viable embryos.

Weight Loss during IncubationEggs that contain a growing embryo will progressively dry-out throughout incubation. This results in an overall weight loss of the egg and this progressive weight loss can be objectively monitored to improve incubation success. The data below (Figure 1.) is a good guide. Weight loss patterns should be monitored and the ideal weight loss (13%) achieved if possible.

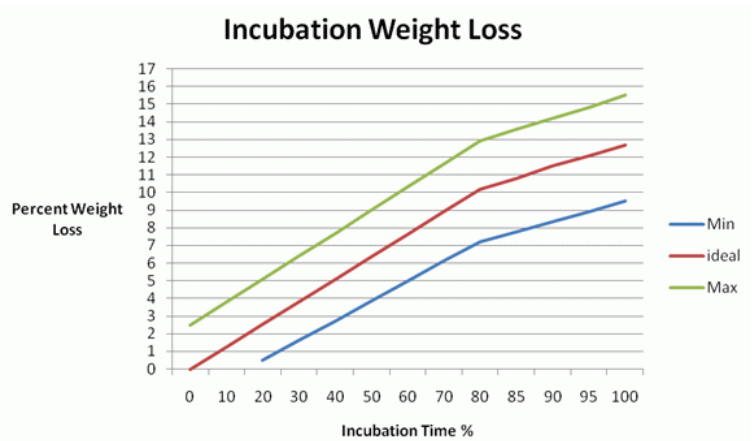


Figure 31*: Percentage of weight loss during incubation period with ideal weight loss and tolerances illustrated with maximum and minimum values.*

Figure 32: *Newly hatched chicks in incubator*

5.9. Possible causes of hatching problems

Table 21. *Causes of hatching problems in poultry*

Observation	Possible cause(s)
Eggs exploding	Dirty eggs Improperly cleaned eggs Dirty incubator

No embryonic development	Infertile egg Rough handling of eggs Incubation temperature too high Incubation temperature too low Eggs stored too long Eggs stored improperly Breeders stressed Too many hens per rooster Old or unhealthy hens or males Inbreeding Disease
Blood ring Early dead	Early dead Old eggs Incubation temperature too high Incubation temperature too low Electric power failure Eggs not turned Inbreeding Infection Poor nutrition of breeders
Air cell too small	Humidity too high
Air cell too large	Humidity too low
Chicks hatch early, dry chicks, bloody navels, chicks too small	Small eggs Temperature too high Humidity too low
Chicks hatch late	Large eggs Old eggs Temperature too low Humidity too high

Chicks dead after pipping	Eggs not turned first 2 weeks Thin-shelled eggs Temperature too low during incubation Temperature too high during incubation Humidity too low during incubation Humidity too high during incubation Infection disease
Unhealed navel Mushy chicks	Temperature too low during incubation Wide temperature variation in incubator Humidity too high during incubation Poor ventilation
Malformed legs and toes	Improper temperature during incubation Improper humidity during incubation Legs also may be harmed by hatching or holding chicks
Weak chicks	Temperature too high or low Old eggs Poor ventilation
Gasping chicks	Disease: Bronchitis or Newcastle disease
Malpositions	Temperature too high or low Turning inadequate Large end of egg not up when set Old or poorly handled eggs Poor breeder nutrition

5.10. Incubation ***technologies***

Incubation technologies have evolved a lot.

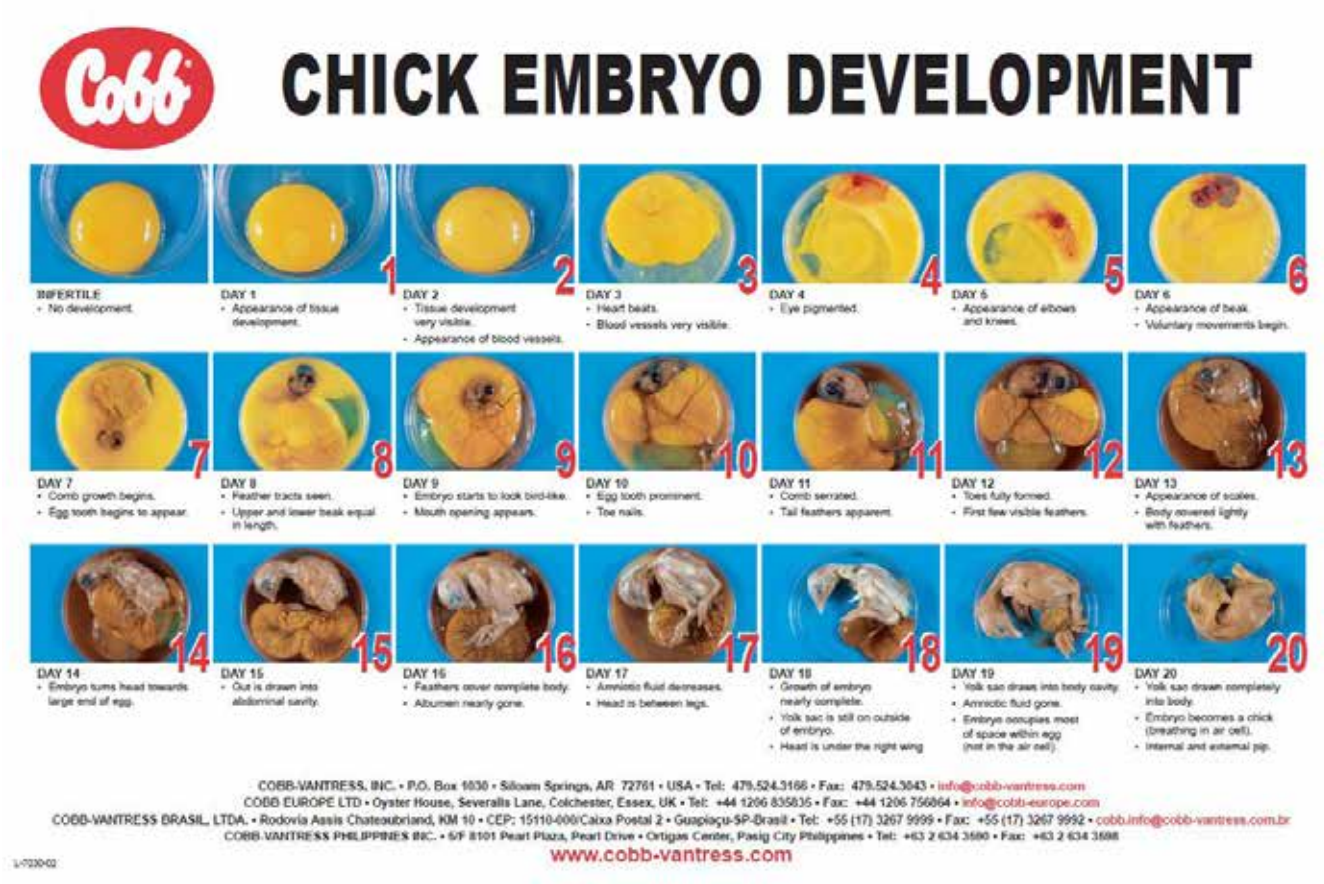
Table 22. Evolution of incubation technologies

Foster mother incubation	
Kerosene-Powered Poultry Egg Incubator	

Homemade plastic container incubator	 https://www.youtube.com/watch?v=yUojPVhYcA0
	

	
Solar energy powered automatic egg incubator	

Table. Chick embryo development



5.11. Tips for keeping the roosters virile

A necessity to the egg raising process is a virile rooster. It should be fertile for the successful hatching of chicks in order to raise future generations of egg layers or meat birds without purchasing those individuals.

Figure 33.*A healthy reproductive family*

5.11.1. Squad Rotation

It is important to rotate and rest top performing roosters to avoid over-using them. The ratio of hens to rooster needs to be realistic, which is typically about 12-10 hens per rooster. Although the rooster might to mate with all hens present, there may simply be too many for him to mate with each hen in turn, or he may play favorites, mating mostly with those he prefers.

5.11.2. Early Retirement

It is also possible that a rooster could be faced with infertility due to age. It may appear that he is doing his part to ensure egg

fertilization when in fact he is just going through the motions which results in egg waste. It will then be necessary to retire that rooster should one wish to continue raising chicks.

5.11.3. Candling to check fertility of rooster

A quick and easy way to check the ability of one's rooster to continually fertilize his hens is through candling. This method has been practiced for many years through the use of specialized lights held up to the egg. The goal is to locate the embryo to confirm a life is growing inside.

In some cases, instead of being able to the see the actual embryo, the egg will instead appear opaque, which is another sign of a successful mating. If the egg is not fertilized, the yolk will appear to float free and have a more uniform coloration.

After mating, fertilized eggs will be laid as soon as two days and hens can go on to lay fertilized eggs for up to three weeks from that very same mating. In the event that one wishes to pair a certain rooster and hen, it will be necessary to keep that hen free of rooster exposure for three weeks in order for her to lay eggs from the future pairing desired. Then, once that mating is complete, one should equip with the proper light and candle resulting eggs for confirmation of a successful mating. Though candling can be a tough skill to master, once one has some experience, it is sure to save disappointment down the road as well as egg waste at the same time.

5.11.4. Do not get bogged down

Keep poultry run in good order which will help poultry and roosters. Keep chick run well drained especially in winter. Boggy areas or puddles should be avoided. Poultry like drinking from puddles which might be contaminated by droppings. Add sand or grit to prevent standing water and if it is a big area dig it over. Hard wood chippings work as ground litter in wet conditions. Do not use 'bark chippings' these may encourage fungi.

5.11.5. Windbreaks – Create a sheltered area

Shelter from the elements, other than coop is essential. A piece of corrugated roofing leant against a fence or wall facing towards

the prevailing wind or take a couple of legs off an old table will create a freestanding shelter. This has the added benefit of reducing the amount of muck been brought back into the coop.

5.11.6. Moving Coop

If one is lucky enough to have the space. Move coop to a drier area in winter.

5.11.7. Poultry Vitamins

Multivitamins for poultry come in many different types, from the pleasant smelling "Poultry Spice" powder which can be mixed in with the feed (use cod liver oil to get the powder to stick to the food if one uses a dry feed), to the rather smelly "seaweed tonics" that can be added to the drinking water. Poultry keepers have different preferences, however most are agreed that these natural vitamins and minerals definitely give the birds a boost both during the moult and throughout the winter.

5.12. Semen Sexing

Sperm sexing depends on the difference in the amount of DNA in X and Y sperm. X sperm have 2.8-7.5% more DNA than Y sperm depending on the species. The X chromosome is bigger than the Y chromosome. Fluorescent dyes which bind to the DNA are used to differentiate the amount of DNA a cell has.

Sperm Sexing Procedure

1. Sperm are dyed with DNA dye. X bearing cells bind more dye than Y bearing cells.
2. Only one sperm is released in a drop.
3. A laser beam excites the dye and the sperm gives off light proportional to its DNA content
4. The drop is charged depending on the light intensity. (X sperm give off more light than Y sperm)
5. The drops pass through a pair of electrodes and the charged drops sorted into different tubes.
6. Inseminate females- deep uterine deposit

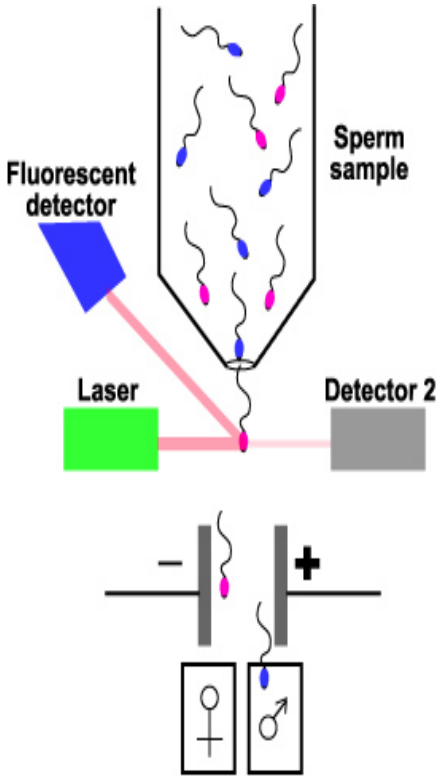


Figure 34. *Illustration of semen sexing*

Sexed semen for females' production

The sex of the offspring produced through artificial insemination can be controlled by the producer by the use of sexed semen.

1. Sexed semen is semen that has been prepared to produce all male or all female offspring
2. It is collected in the same manner as other semen used in artificial insemination.
3. Generally sexed semen will predict sex with approximately 90 percent accuracy.
4. The cost of sexed semen is normally about four times higher than the cost of unsexed semen.

5.13. Sexing chicks

There are three ways of sexing chicks:

1. Wing feathers: hens are often born with wing feathers or develop them in the first week of life. Roosters usually develop them after the first week. The 'pattern' of wing feathers is another indicator. Gently spread the chick's wings: if the feathers are of equal length, it is a male; if the feathers alternate between long and short, it is a female. Finally, females will often develop tail feathers before the males do.
2. Colour combinations: certain hybrid breeds will always hatch in specific colours, indicating gender. Some purebreds also exhibit gendered colouring early in life. Check the full article for a more detailed list.
3. Vent sexing: essentially feeling around for the reproductive organs. This is exactly as fiddly as it sounds, and not something we recommend for novice keepers. Vet will definitely have more luck!

Sexing grown chicks

Once chooks have completely developed, it is usually easy to tell the females from the males - this differentiation can very accurate through experience.

1. Crowing is a near-certain sign that it is a rooster. Most cockerels crow around 10-12 weeks old.
2. Large comb and wattle (the fleshy crests around the poultry's face).
3. Thick, powerful legs.
4. Saddle (and sickle) feathers - extremely long, pointed feathers covering the chooks bum.
5. Hackle feathers - neck feathers that are long and pointy. The bird's version of a lion's mane!
6. Upright posture - the males like to strut their stuff, and their 'cocky' walk is hard to miss!
7. Attitude - while some hens can be downright sassy, none can compare with a rowdy rooster.

5.14. Use of bio-stimulants

Prebiotics and synbiotics – in ovo delivery for improved lifespan condition in poultry

One of the precision livestock farming tools in poultry production is *in ovo* technology for modulating the conditions inside the egg through nutrients, vaccines and other bioactives. It allows depositing a certain amount of a carefully selected substance into a

specific site within an incubating egg.

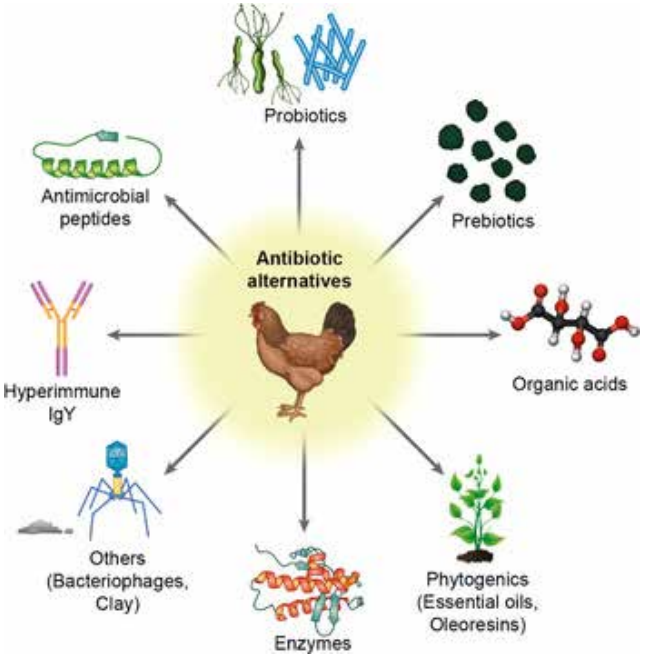


Figure 35. *Few example of biostumilants*

Concept *of early microbial programming in ovo*

Prebiotic or probiotic given on day 12 of egg incubation influences embryonic factors (microbiome, GALT development and function, gene expression, nutrient absorption) which are critical for future phenotype of the broiler poultry. Two critical perinatal moments are shown (hatch window and fasting post-hatching), when the newly hatched poultry is the most receptive to environmental stressors

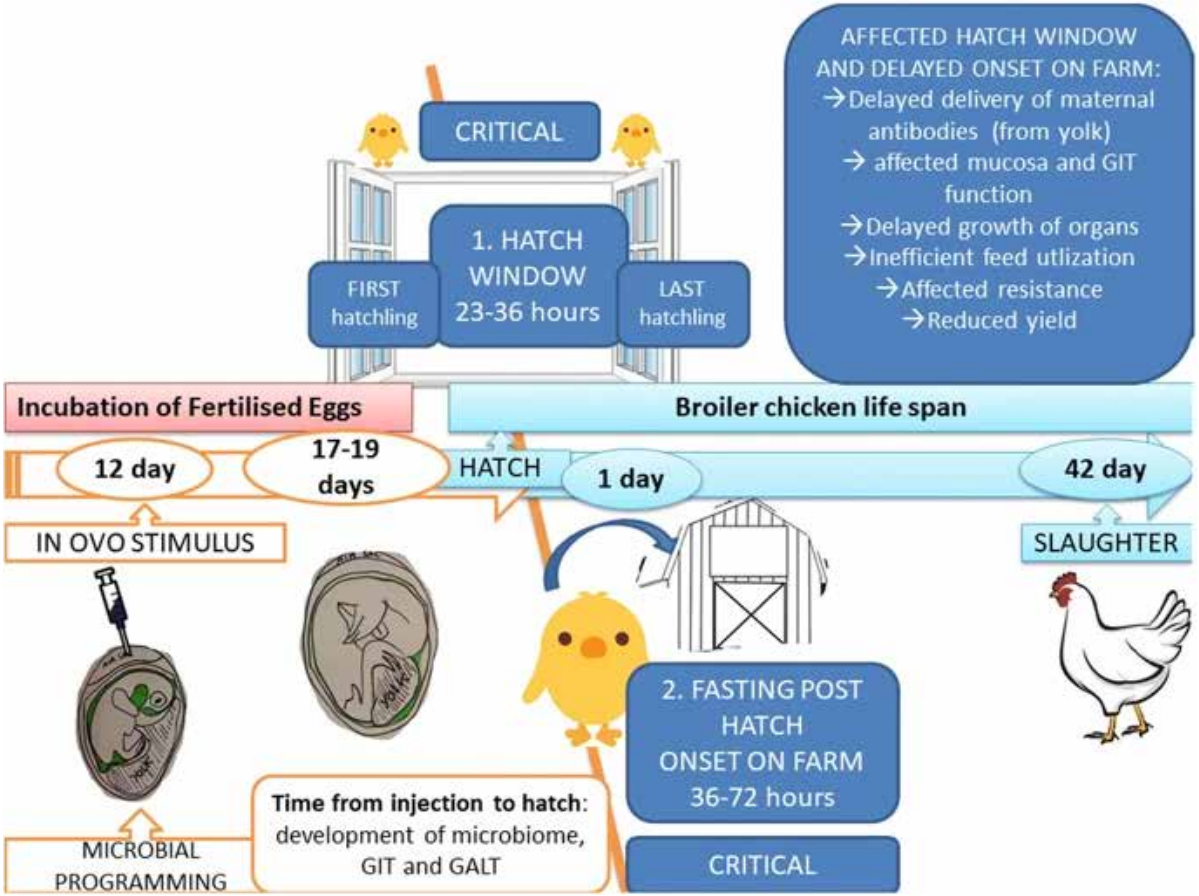


Figure 36. *In ovo microbial programming*

5.16. Short Periods of Incubation During Egg Storage (SPIDES) technique

The SPIDES technique is the application of short periods of incubation during egg storage to increase the hatchability. If hatching

eggs are stored for more than a week before being set in an incubator their hatchability begins to decline. When they are stored for longer than 14 days, the hatch loss can be substantial and is often hard to predict. Due to variable order patterns and sizes as well as seasonal fluctuations in demand it is not always possible to set all eggs within 7 days of lay. https://zootecnicainternational.com/poultry-facts/s-p-i-d-e-s-short-periods-incubation-egg-storage/ .

Prolonged egg storage affects both the dormant embryo and the incubation chamber (egg) that contains it. With increased storage the internal quality of the egg deteriorates, this affects both the albumen quality and vitelline membrane integrity. As a result of prolonged storage there will also be increased incidence of embryonic cell death.

Table 23. Effects of the SPIDES technique

Results for eggs stored for 11 and 12 days under normal storage conditions

	BROWN N BA21	GREY BA 21	BENEFITS
Treatment	Control	1x 6hr treatment	
Egg age	11-12 days	11-12 days	
Eggs set	462	465	
Live poults	380	391	
Hatch of set	82.30%	84.10%	+1.80%
Hatch of fertiles	84.40%	86.50%	+2.10%
Cull	0	0	0
Live pipped	13	8	-5
Dead pipped	3	3	0
Clear	12	13	1
23-28 days	9	7	-2
16-22 days	7	11	4
10-15 days	6	2	-4
3-9 days	19	20	1
0-2 days	13	10	-3
Un-hatched/Cull	82	74	-8

Suggested guidelines for the implementation of SPIDES

To date, the SPIDES technique has been found to give 2-4% better hatchability in eggs stored for 7-14 days and higher benefits when eggs were stored for over two weeks.

Table 24. effects of turning combine to heat treatment

The effect of turning in combination with heat treatment

TREATMENT	CONTROL	1X12 HRS TURNED	BENEFITS OVER CONTROL	1X 12 HRS NOT TURNED	BENEFITS OVER CONTROL
Egg age	15-17 days	15-17 days		15-17 days	
Eggs set	1116	1116		1116	
Live poults	769	879		910	
Hatch of set	68.91%	78.76%	9.85%	81.54%	12.63%
Hatch of fertiles	72.89%	83.32%	10.43%	85.45%	12.56%
Cull	1	3	2	3	2
Live pipped	45	35	-10	21	-24
Dead pipped	28	16	-12	20	-8
Clear	61	61	0	51	-10
23-28 days	20	16	-4	13	-7
16-22 days	31	24	-7	22	-9
10-15 days	24	21	-3	19	-5
3-9 days	63	27	-36	39	-24
0-2 days	68	30	-38	21	-44
Un-hatched/ Cull	3	0	-3	1	-2

- A single SPIDES treatment is sufficient to improve hatch in eggs stored from 15-17 days but needs to be given on or around 8-10 days.
- Hatch improvements can be greater if multiple (2 or 3) treatments are given depending upon how long the eggs are stored.
- Typically, no more than 7 days should be left between treatments.
- Where multiple treatments are applied there should be an equal amount of time left between treatments.
- SPIDES works in all incubator models and types tested so far, so long as the heating times are adjusted as necessary.
- The effective temperature range for SPIDES has been found to be between 32 and 38 degrees Celsius.
- It is not helpful to pre-define a heat treatment in terms of time – as this will vary with egg numbers and incubator type. What is important is that the eggs are warmed to just below incubation temperature and then cooled.
- Greater hatch improvements are likely to be seen with eggs that have been stored for more prolonged periods and have lost a lot of hatchability – the higher the hatch loss, the greater the improvement.
- SPIDES treatments give a tighter hatch window – less hatch delay from SPIDES treated stored eggs.
- Infertile eggs will not be affected.
- It is possible to overdo the heat treatments and kill embryos. Total treatment time above 32 degrees should ideally be kept below 13 hours.
- Poultry quality will generally be better after SPIDES treatment compared to untreated eggs.
- Setting too soon after heat treatment can have negative effects.

5.17. Gene editing technology

Improvements in genome editing technology in birds using primordial germ cells (PGCs) have made the development of innovative era genome-edited avian models possible, including specific poultry bioreactors, production of knock-in/out poultry, low-allergenicity eggs, and disease-resistance models.

Table 25. Important steps for the generation of genetically modified poultry.

Year	1987	1994	2004	2006	2013	2013	2015	2016	2017	2017
Contribution	Generation of the first genetically modified poultry using retroviral vectors	Generation of the first genetically modified poultry by DNA microinjection	Transgenic poultry using lentivirus carrying a transgene	Isolation and long-term culture of PGCs followed by transfection and generation of eGFP transgenic poultry	Targeted gene editing in PGCs and generation of the first gene knockout poultry	In vivo transfection of PGCs using Lipofectamine 2000 complexed with Tol2 transposon and transposase plasmids	Development of feeder and serum-free PGC cultures	CRISPR-mediated homology directed repair targeting the immunoglobulin heavy chain locus in PGCs.	TALEN-mediated gene targeting of PGCs	Restoration of male fertility by transplantation of genetically modified PGCs
Ref.	Salter et al., 1987	Love et al., 1994	McGrew et al., 2004	Van De Lavoir et al., 2006	Schusser et al., 2013a	Tyack et al., 2013	Whyte et al., 2015	Dimitrov et al., 2016	Taylor et al., 2017	Trefil et al., 2017

5.17.1. Methods to make a transgenic or edited poultry

- Primordial Germ Cells (PGCs)

1. Progenitors to ovum and sperm forming cells
2. Are accessible either outside or inside of the growing chick embryo

- PGCs OUTSIDE – highly skilled culture (not trivial)

1. Non-homologous recombination (van de Lavoir et al, 2006)
2. Gene targeting (Schusser et al, 2014)
3. Gene editing (Park et al, 2014)

***- PGCs INSIDE – accessing the germ cells* in vivo (in ovo)**

1. Integrating lentiviral systems (McGrew et al, 2004)
2. Direct Injection *in vivo* (Tyack et al, 2014)

- Sperm Transfection Assisted Gene Editing (STAGE)

1. Another approach which could speed up gene editing in poultry (Cooper et al, 2017)

5.17.2. Timeline approximations for application of the technologies

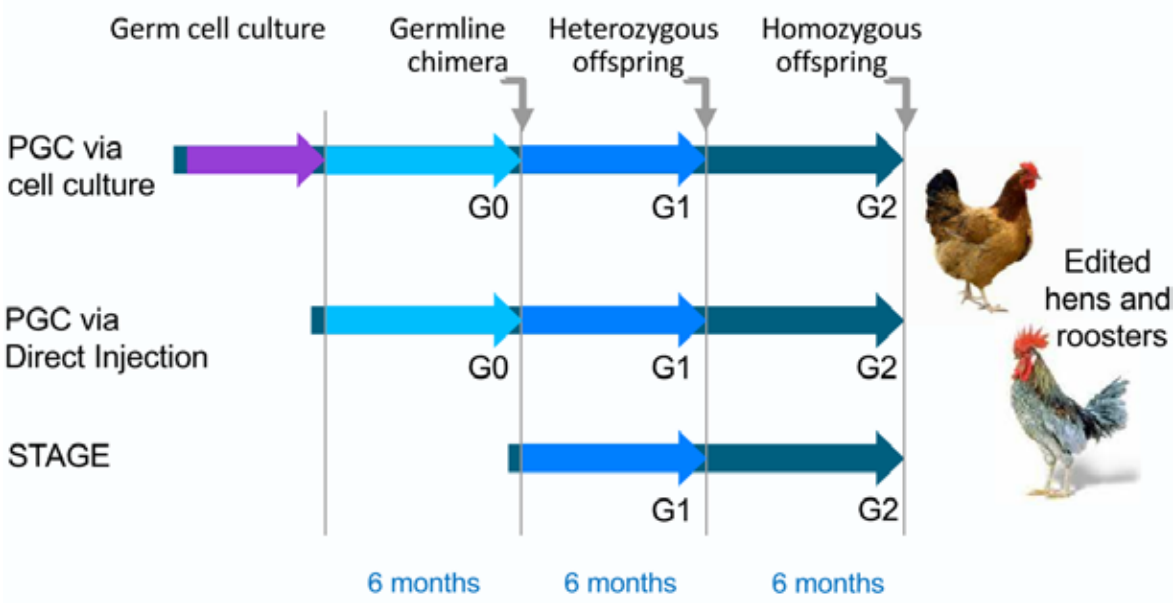


Figure 37. *Timeline approximations for the application of gene editing in chicken*

5.17.3. Applications of genome engineering

1. Improving eggs as a substrate for vaccine production
2. Allergen free eggs
3. Disease resilience
4. Sex selection

5. Improved growth

5.18. In ovo-sexing (hyperspectral imaging or by fluorescence spectroscopy)

In-ovo gender determination has the potential to bring an end to the unnecessary killing of billions of male chicks.
Implementing *in-ovo* sexing into the poultry industry results in a more animal-friendly and more sustainable production. More animal-friendly because the day-old male chicks no longer need to be culled, and more sustainable because less energy is used because only the female eggs need to be further incubated after sexing. The male eggs are sorted out and can be used for different purposes such as a high-value protein source. The following are the most well-known methods that are ready for practice or may be ready for use within a year.

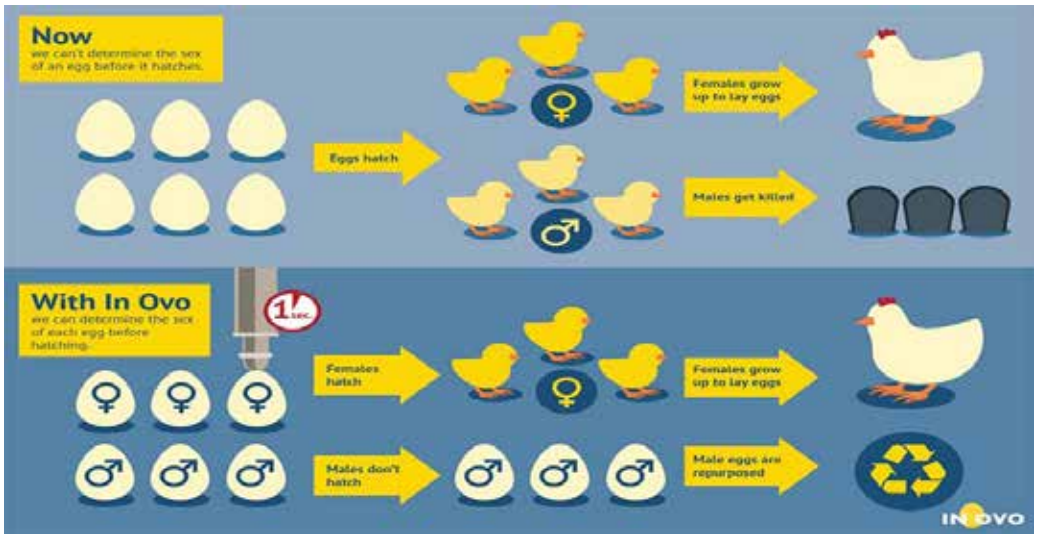


Figure 38. *in ovo sexing in poultry industry*

5.19. Bio-marker detection (Seleggt, In Ovo)

Seleggt measures a substance that is a 'biomarker' for the sex through a small hole in the eggshell on day 9 after fertilization. Mixed

with fluid from fertilized eggs, this marker changes to blue for a male and white for a female, with a 98.5% accuracy rate. As of May 2019, Seleggt sexed one egg per second (3,600 an hour) and thus enabled 30,000 'no-kill' female chicks to hatch in Germany every week.

5.20. PCR (Plantegg)

Plantegg utilizes a PCR method, through DNA to determine whether the hatching egg is male or female. Like *In Ovo* and Seleggt, this method determines the sex on day 9 of the incubation process. This method is expected to be ready for use by the end of 2020.

5.21. Spectroscopy (AAT, Projet Soo, Hypereye)

Agri Advanced Technologies (AAT) uses spectroscopy to determine the sex of the egg. The hatching egg is examined with by light beam, with a hyperspectral measuring technology the sex is determined based on the calculated light spectrum. This method works for brown hatching eggs and can take place from the 13th day of the hatching process.

Tronico employs a mix of spectroscopy and the use of biosensors with the target of achieving 90% accuracy *in ovo* sexing at 9 days of incubation.

Hypereye spectroscopic technology aims to achieve a 99% accuracy rate and to process 30,000–50,000 eggs per hour (8.3–13.9 eggs per second).

Alternative: male broilers

An alternative to preventing chick kills is fattening rooster poultry. Hens and roosters are separated in the hatchery as usual. The cocks then go to a broiler farm where they are fed and slaughtered when they reach their target weight.

5.22. Introgression of some major genes

One of the most effective ways of improving heat tolerance / temperature modulation is through the incorporation of single genes that reduce or modify feathering, such as those for naked neck (Na), frizzle (F) and scaleless (Sc), as well as the autosomal and sex-linked dwarfism genes, which reduce body size.

Table 26. Tropical relevant genes in local fowl (HORST, 1988)

Gene	Nature of Inheritance	Direct effect	Side effect
dw (dwarf)	Sex linked, recessive, multiple allelic	Reduction in body size 10-30%	Reduced metabolism, improved fitness and disease tolerance
Na (Naked neck)	Incomplete dominant	Loss of Neck feathers, Reduction of secondary feathers	Improved ability for convection, Improved adult fitness
F (Frizzle)	Incomplete dominant	Curling of feathers, reduced feathering	Improved ability for convection
h (Silky)	Recessive	Lack of hamuli on the barbules, delicate shaft, long barbs at the contour feathers	Improved ability for convection
K (Slow feathering)	Dominant, sex linked, multiple allelic	Delay of feathering	Reduced protein requirement, reduced fat deposition during juvenile life, increased heat loss during early growth, delayed immune response mechanism
Id (Non-Inhibitor of dermal melanin)	Recessive, sex linked, multiple allelic	Dermal melanin deposition on skin and shank	Improved ability for radiation from shank and skin
Fm (Fibromelenosis)	Dominant with Multifactorial modifiers	Melanin deposition on all over body, muscles and nerves, tendons, mesentery and blood vessel walls	Protection of skin against UV radiation, improved radiation from the skin, increased pack cell volume and plasma protein

CHAPTER VII: TECHNOLOGIES IN INPUTS AND SERVICES FOR POULTRY

The requirements for poultry farms and creating optimal conditions have fundamentally changed in the past couple of years. Without new technologies and modern approaches, high efficiency of farms cannot be guaranteed.

Precision poultry farming involves the use of sensors to collect data, followed by data analyses with the objective of enhancing the understanding of the system interactions, and developing control systems.

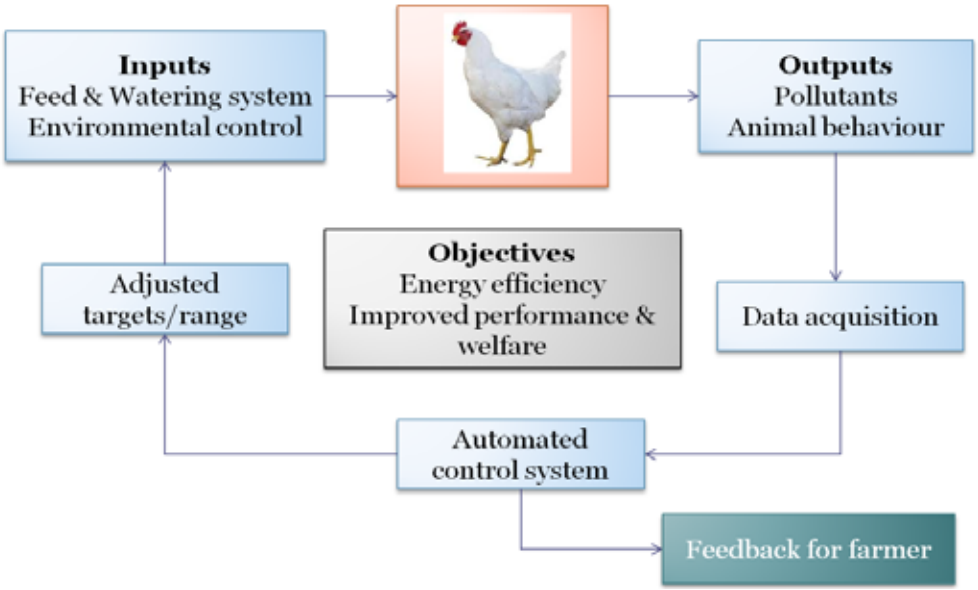


Figure 39. *Precision poultry farming model*

This allows real-time monitoring of birds' activities allowing the Precision Livestock Farming (PLF) system or smart systems farming to make changes to the poultry house equipment (including feeders, fans, heating system and sprinklers) based on the recorded information. This will result in improvements in animal health, animal welfare, quality

assurance at farm and chain level, and for improved risk analysis and risk management. Precision poultry Farming must satisfy the needs of both the farmer and the consumer to be commercially viable. For the farmer, increased profitability with minimal adverse environmental impact and high standard of animal welfare, while for the consumer, the food must be safe, nutritious and affordable.

6.1. Poultry feeding line: feed storage/silos with spiral conveyors

An essential part of high-production animal farms is also storage of feed and grain. This serves for feed production, storage of grain and components, and large-capacity grain or wet corn storages as the ideal tool to increase the effectivity of production on poultry farms.

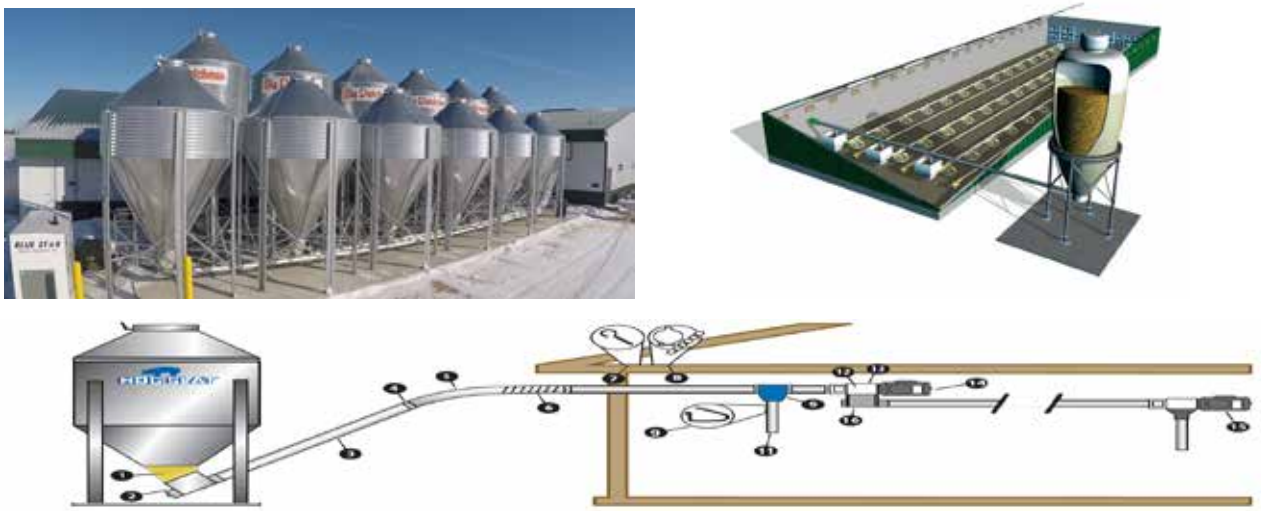


Figure 40. *poultry feeding line. 1. Clear boots; 2. Unloader kits; 3. Straight 3 m PVC pipe with socket; 4. PVC tube coupler; 5. 45° PVC elbow with socket; 6. "Grow-Flex" auger; 7. Cup hooks; 8. Chain and EMT clamp; 9. Wire pin; 10. Drop adaptors; 11. Drop tube; 12. Control unit; 13. Direct driver and tube anchor; 14. Direct drive power unit; 15. Extension unloader kits; 16. Drop cone;*




Figure 41. *locally made and adapted feeders*

6.2. Weighing systems for feed and animals

Monitoring bird weights is an important tool in modern poultry management. Especially in poultry growing, the exact determination of bird weights is a decisive factor for economic success.

Table 27. types of scale and advantages

Types	Main advantage
Versatile poultry scale consists of a load cell and a platform made of plastic material (or, as an option, stainless steel) 	Using the telescopic suspension, the platform can easily be adjusted in height and thus be adapted to the birds' age. The birds accept the scale well, resulting in plenty of weighings and therefore also in precise weight data. is suspended from the barn's ceiling. During the service period, the scale can easily be removed for cleaning while the weighing electronics remain installed close to the ceiling where they are protected against dirt.

Poultry scale for layers 	Due to its low weight of only 2 kg, Incas 2 is well-suited for use as a mobile poultry scale. The small distance between the floor and the load cell, which is shaped like a perch, ensures a high number of weighings and therefore precise weight determination.
Poultry scale for pullets and the AviMax broiler system 	is simply placed on the floor where its two feet hook into the flooring. Thanks to its compact design, the scale can also be used for mobile weighing.

Poultry scale for broiler breeders 	▪ automatic weight determination; ▪ a lower number of manual weighings reduces the workload and saves time; ▪ the period for weighing can be defined individually, for example before feeding or during the main laying phase; ▪ automatic differentiation between males and females during weighing.

Weighing computer as stand-alone solution 	All measured values can be saved directly in the weighing computer or transferred to a PC using a memory module. From here, the data can be analyzed in tables or graphs by means of the corresponding software (optional). An automatic comparison with a pre-defined set curve helps to detect deviations. Using the GSM version has the advantage that data are transferred daily to the PC via GSM modem (wireless) or to mobile phone by text message. The following data are recorded: ▪ daily average weight; ▪ number of weighings per day; ▪ daily weight gain; ▪ standard deviation (sd), coefficient of variation (%) – indicate the deviation of measured weights from the mean value; ▪ uniformity; ▪ automatic update of the average weight.

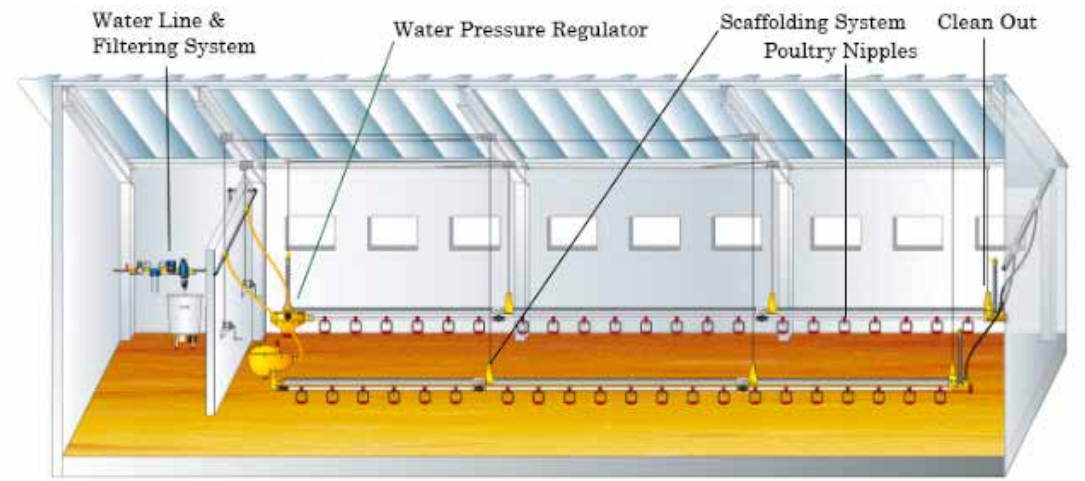
Manual mobile poultry scale 	Data are saved in pre-defined groups. A group may consist of an entire house, of a limited area with males, or of females only. The measured results can be transferred to a PC. The supplied software then shows statistics, histograms and growth curves for easy analysis. The data can also be compared with a set curve. A battery-powered printer is available as an option. This printer allows the producer to print measured results directly from FlexScale. The scope of delivery for FlexScale includes a simple weighing hook, the battery charger and the carrying case. Another, more comfortable weighing hook is available as an option, making manual weighing of the birds even easier. FlexScale is available in two versions: for up to 30 kg and for up to 50 kg of weight.

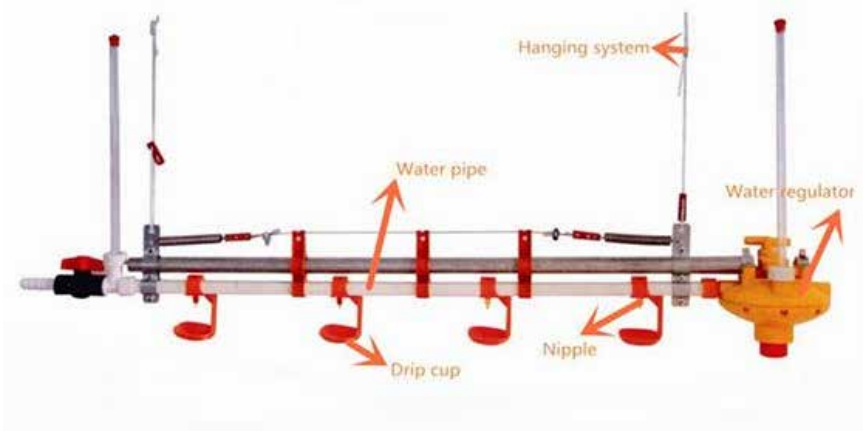
6.3. Watering lines

One of the basic needs of poultry is unlimited access to clean water. The following are factors and tasks that should be considered in a successful drinker line management programme.

- Well and pump capacity: The system should be able to provide enough water for bird consumption and to meet evaporative cooling system requirements on the hottest day of the year with market age birds.
- Level the drinker lines: Un-level drinker lines can lead to air locks and reduce drinking opportunities for birds.
- Minimize restrictions: Any valves that are used on the water panel should also be sized so they do not restrict water flow.
- Remove trapped air: Installing air vents/standpipes in conjunction with performing a high-pressure flush will remove trapped air from the water line. Air locks can restrict water availability.

- Perform regular flushing: This will remove residual contaminants and limit bacterial growth. Flushing the water line also provides cooler water to birds which may stimulate water consumption.
- Sanitize regularly: Using the correct sanitizer is important because sanitizers can be affected by water pH, hardness, mineral content and biofilms and other organic material. To ensure maximum product efficacy, information about the quality of the water being treated should be considered.
- Manage height according to bird age: As birds age, the line height should be adjusted so that pin is slightly above the birds head, requiring a slight upward angle to activate the pin. Birds should not have to strain to reach the pin
- Manage water pressure according to bird age: Pressure dictates how much water the bird gets when the drinker pin is activated. Pressure must be increased as the birds age to meet their water demand. If the litter is too damp, lower the pressure.
- Change water filters regularly: Filters must be changed when pressure drops to maximize drinker system operation.
- Conducted routine water tests: Consider testing water during periods of drought or high rainfall to ensure that water quality has not changed.
- Operate drinker system according the manufacturer's guidelines: All drinker manufacturers provide guidelines for their products and these should be followed to ensure optimal performance.





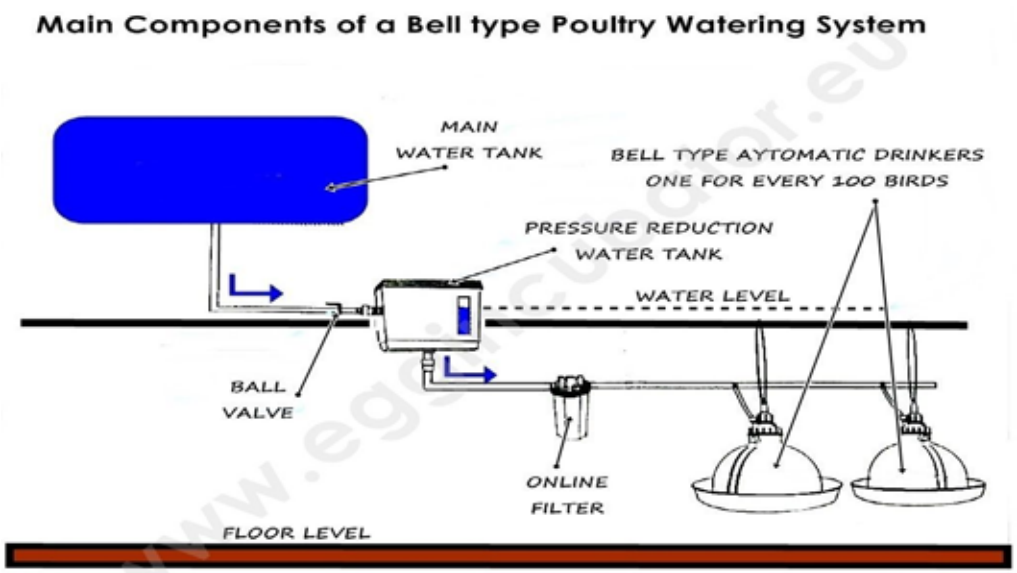


Figure 42. *A poultry watering line*

Nowadays it is possible and much economical to have locally made water lines well adapter to infrastructure need and to our tropical climatic conditions.

Figure 43. *Drinker and adapted drinking system*

6.4. Poultry ventilation and monitoring systems

Ventilation in a poultry house supplies fresh air that is essential to sustain life. It also helps reduce the extremes of temperature, humidity and air contamination to tolerable limits for confined poultry.

Legally there are certain air quality requirements that a ventilation system must be able to provide.

- Dust particles <1mg sq m>
- Humidity <84%>
- Ammonia <20ppm>
- Carbon dioxide <0.5%>

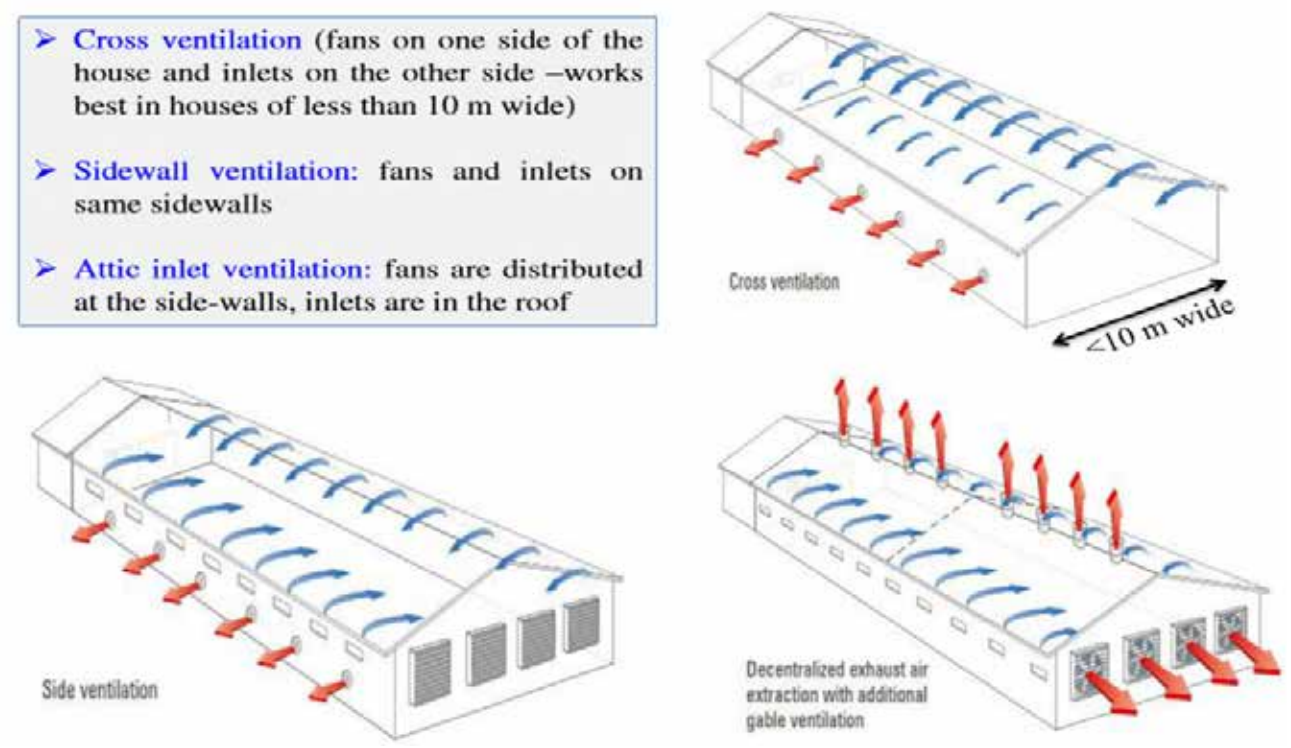


Figure 44. *Types of ventilation systems*

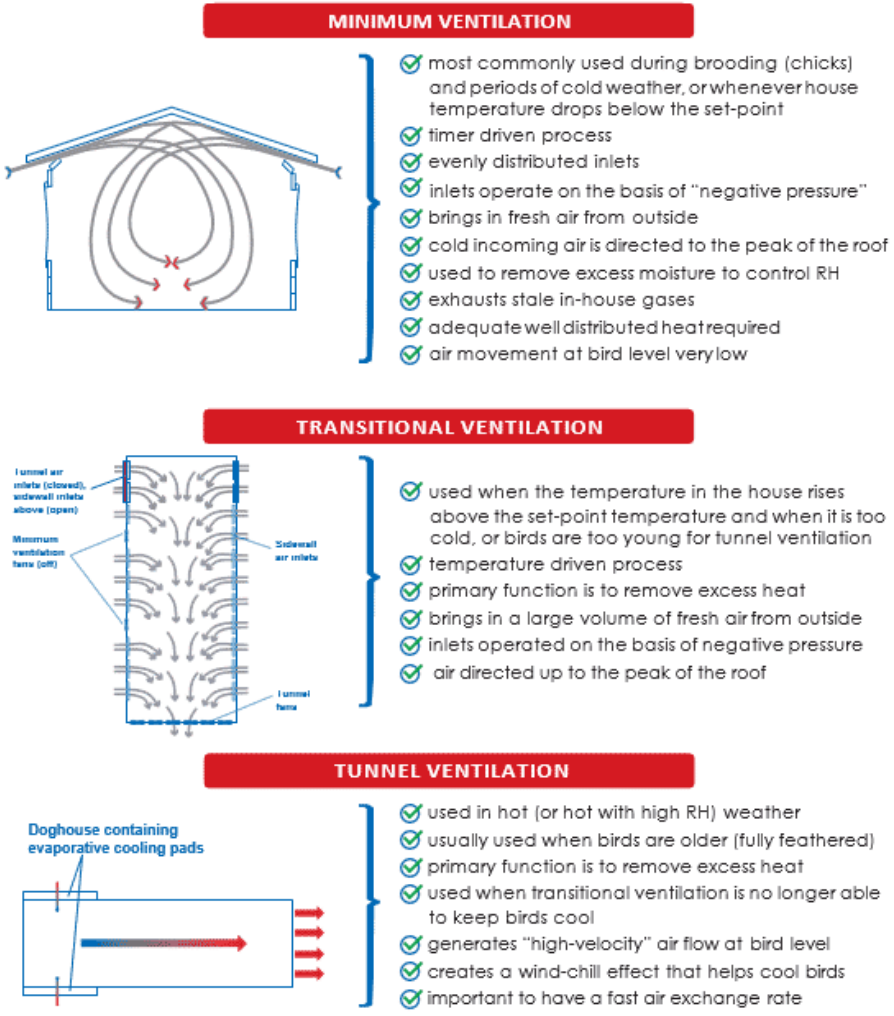


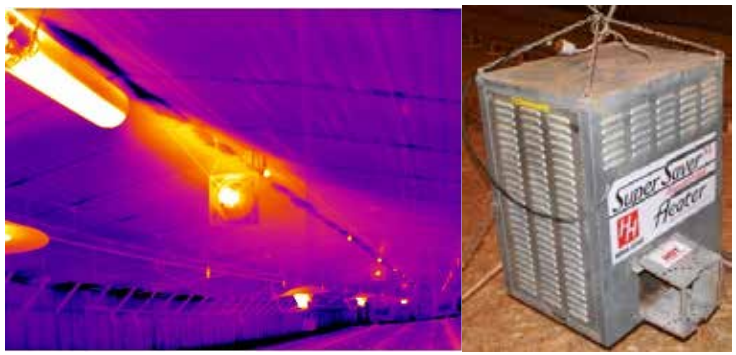
Figure 45. *efficiency characteristic of the ventilation system*

6.5. Cooling / Heating systems

There are three fundamental types of heat transfer:

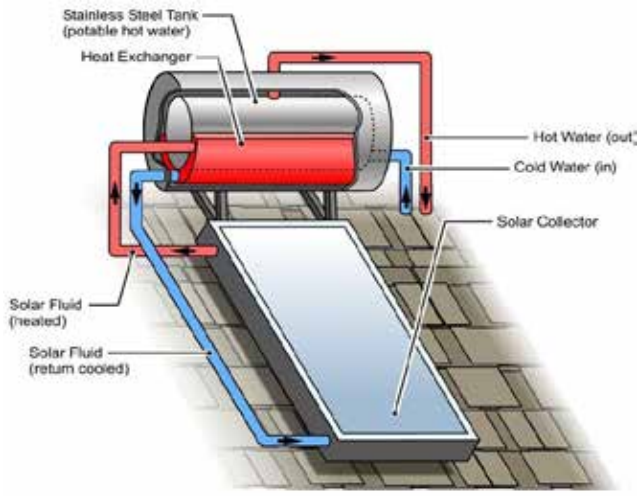
- **Conduction**: transfer of heat via physical contact.
- **Convection**: transfer of heat from one point to another via mixing of one portion of a fluid (liquid or gas) with another.
- **Radiation**: transfer of heat from one body to another not in contact with it by means of wave motion through space.

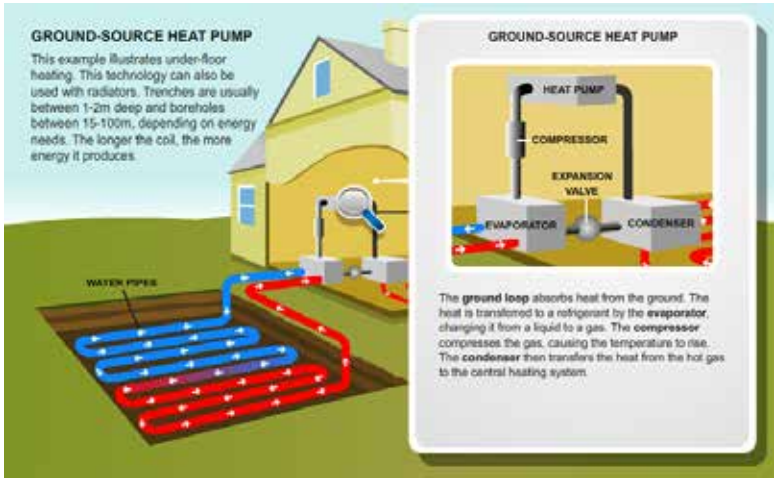
Table 28. Technology options for the control of poultry house temperatures

Forced-air furnaces or convective heaters: Indoor forced-air gas heater (left) and an infra-red image of a perforated heat distribution duct from an external gas heater with additional back-up radiative heaters (right)	
Radiant brooders	

Radiant tube heater burners The combustion chamber (burner or firebox) is the box at the end	
Reeves supply for house cooling	
Portable evaporative coolers	

Table 29. Alternative heating options

Solar hot water systems. These systems can be used in conjunction with gas- or electric-boost to generate hot water that can then be provided to convective heaters. Having a solar hot water system will reduce gas consumption; however, hot air distribution is still via convective means. Refer to supplementary paper, Solar hot water.	
Biomass. Biomass-fuelled heaters typically burn wood pellets or woodchips, delivered from a nearby hopper, in order to produce the required heat. These units pull air from the poultry shed, heat it, and return it to the shed via ductwork to eliminate short cycling. Drawbacks associated with this type of system include reliability of supply and ongoing maintenance.	

Ground or air-source heat pumps. Heat pumps are devices that transfer heat from a source to a sink in the opposite direction to that of spontaneous heat flow. An external energy source is used to achieve the transfer of thermal energy from source to sink. The most common type of air-source heat pump is similar to compressor-driven air-conditioning units, which transfer (pump) heat from air to air. There are also air-to-water air-source heat pumps, which deliver heat to water. Ground-source heat pumps transfer heat from the ground to the air or from ground to water.	
Underfloor heating. Underfloor heating systems rely on conduction, radiation and convection as their means of heat transfer. Underfloor heating systems are either electric systems (utilising underground electric heating elements) or hydronic systems (utilising underground pipes for heat transfer). Hydronic systems can provide both heating and cooling, but require an external boiler and cooling unit, respectively, to do so. The overall efficiency of hydronic systems can benefit from waste heat from other on-site services. These systems are often inadequate for providing all the poultry' heating requirements.	

6.6. Control and surveillance systems

A combination of wireless sensors and GPRS network can be used for controlling and monitoring environmental parameters in a poultry farm. Various environmental parameters like temperature, humidity, ammonia gas have a big role in operations of Poultry. Operator can get updates regarding the internal environmental situation of poultry farm by accessing the data using a web page.

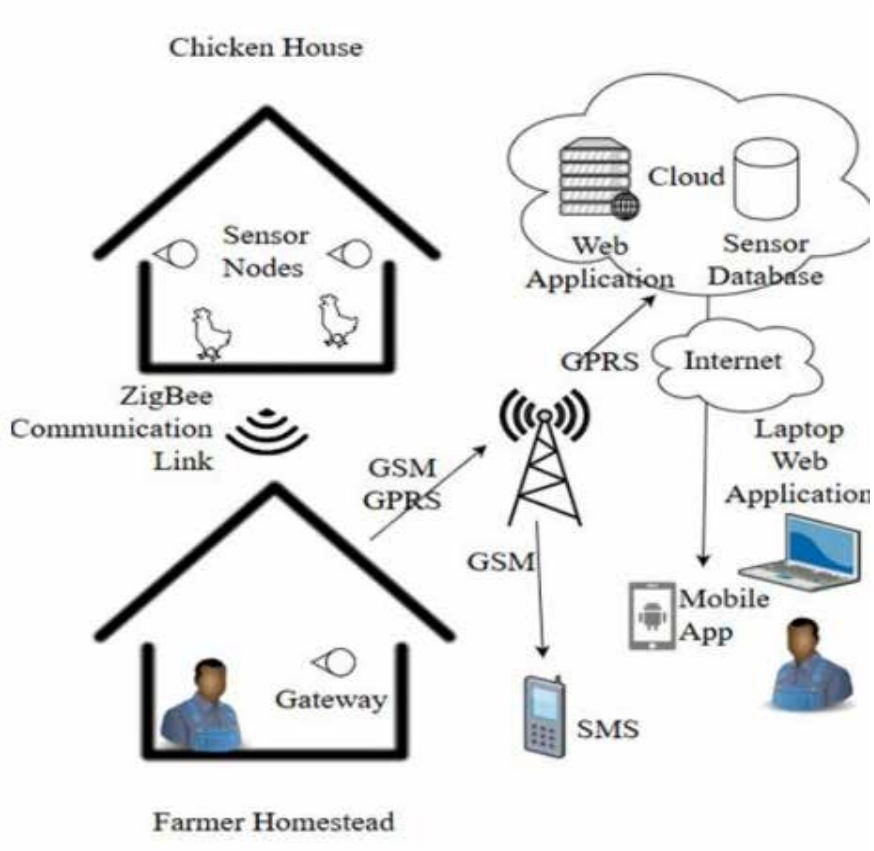


Figure 46. *poultry farm control and surveillance systems*

6.7. Lighting systems

It is important that poultry are given an appropriate resting period each day. Resting refers to the birds lying, sitting or standing. Light intensity should be less than 0.4 lux during this 'dark' period. During 'light periods' birds should be reared with an intensity of at least 20 lux and illuminating at least 80% of the useable area.

Table 30. Advantages and disadvantages of dim lighting regimes (0-10 lux)

Advantages	Disadvantages
• Reduced energy costs • Decreased activity/reduce energy output • Minimise skin scratching • Minimise aggression (turkeys)	• Young birds die of malnutrition (inability to see feeders and lack of activity) • Damage to eye lens (decreased corneal thickness)/possibility of blindness • Leg disorders • Reduced carcass and tender yield • Increased fearfulness in birds

6.8. Mobile apps for poultry production and extension services

Mobile communications technology has become the world's most common way of transmitting voice, data, and services, and the technology is developing at a fast pace.

Mobile phones:

1. Are owned by more people.
2. Provide delivery in an instant, more convenient way.
3. Can deliver personalized information to individual owners.
4. Are cheaper to deploy.
5. Provide other functions such as voice communication.

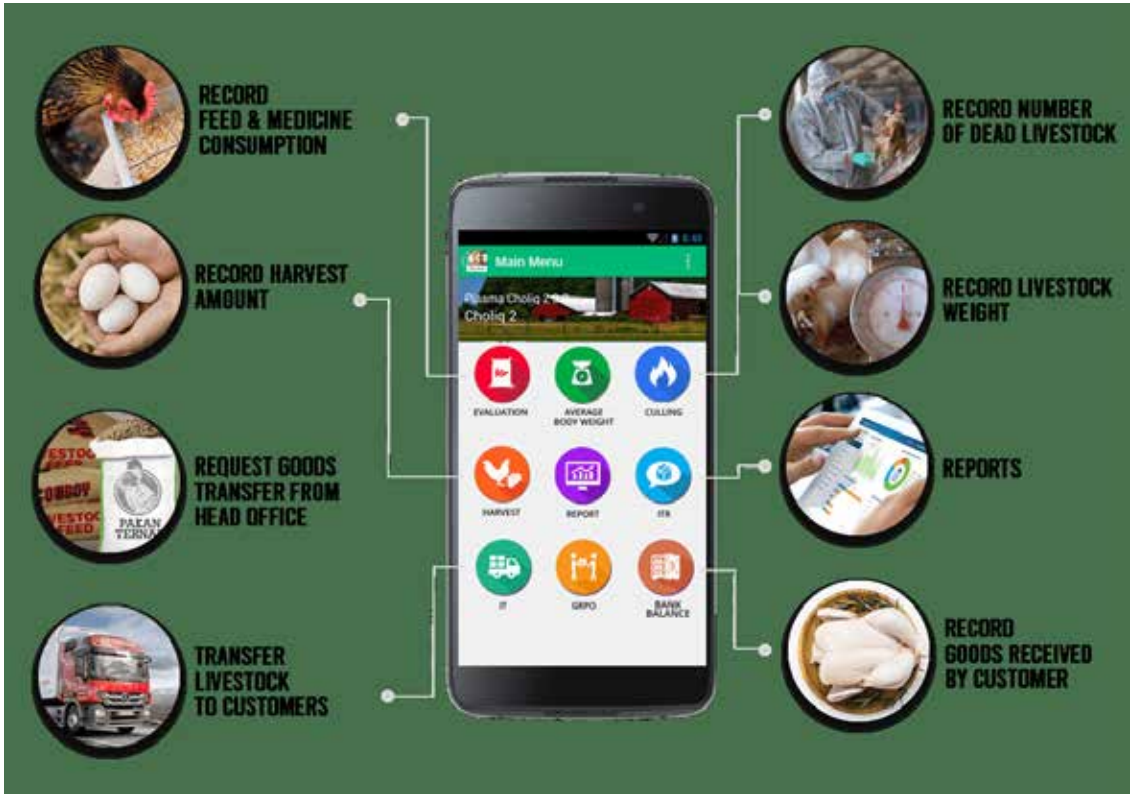


Figure 47. *Applications of mobile apps for poultry production and extension services*

The monitoring process in a farm (whether poultry, cow, duck, fish, etc.) is very important, so that the costs used can be accurately recorded for actual production costs to be obtained.

To produce maximum yield, the following points are very important to consider in livestock farming, such as:

- Location and condition of the cage
- chick selection

- Feeds and feeding
- How to maintain the flock
- Harvesting Process
- Analyze the efficiency of feed use
- Analyze the mortality rate of livestock
- Analyze the use of medicine on the performance of livestock
- Analyze animal weight
- Analyze livestock sales
- Analyze expanse expense (use of petty cash)

It is very important to be able to monitor the things mentioned above, especially those related to costs incurred.

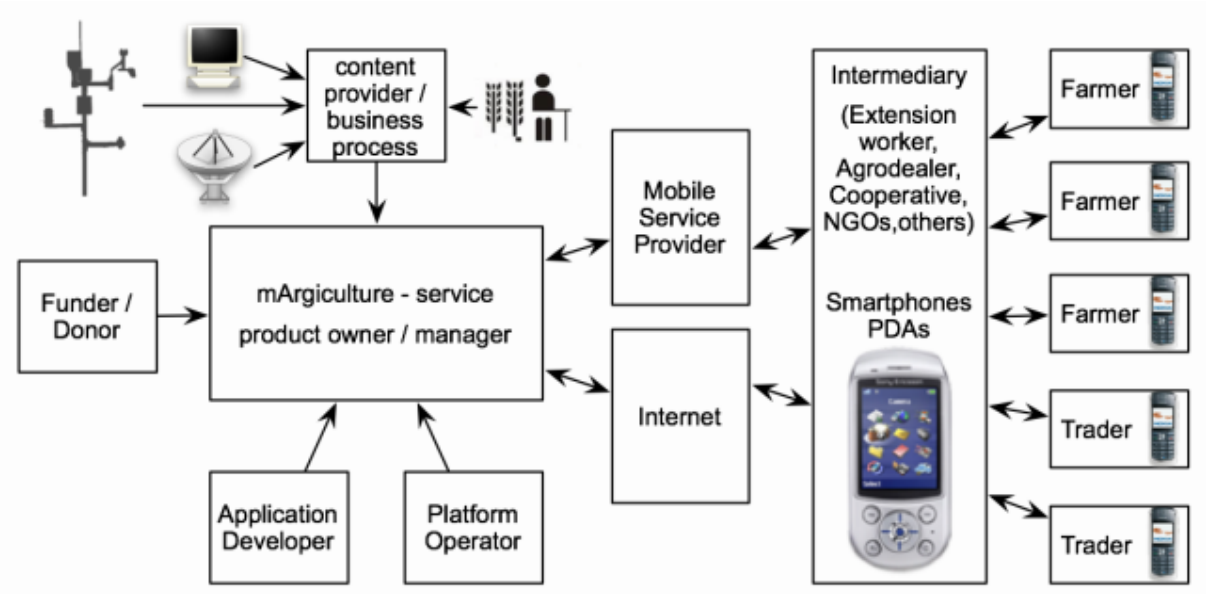


Figure 48. *smartphone monitoring of the poultry production*

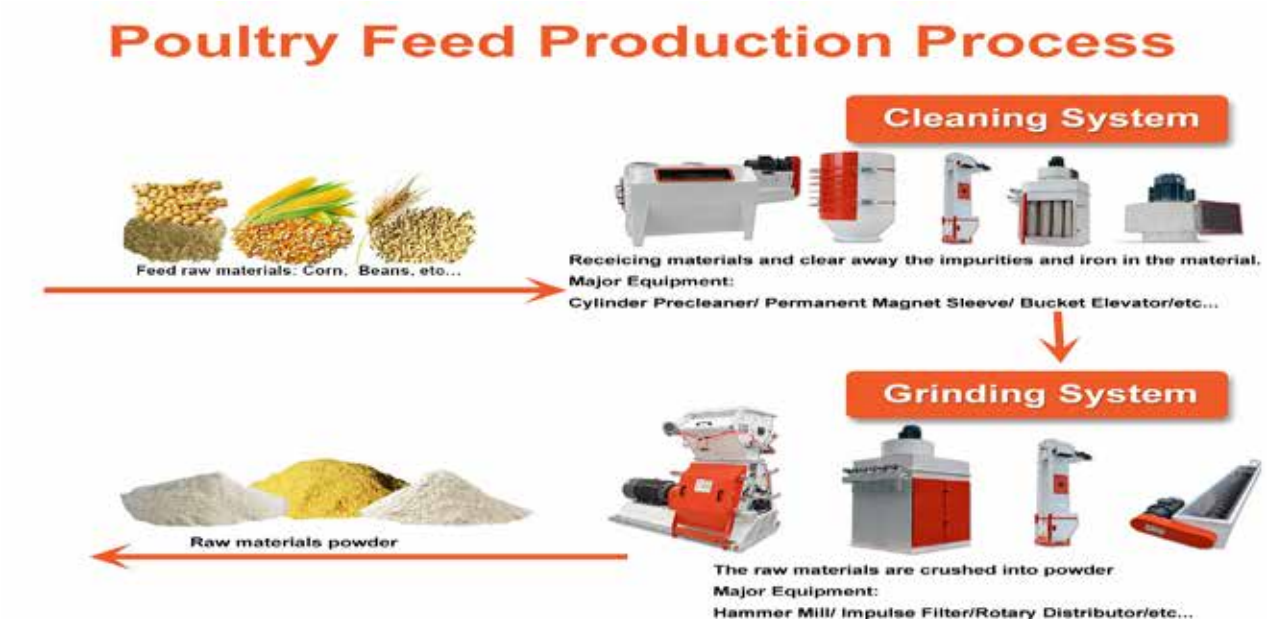
6.9. Poultry Feed manufacturing

- Feed Pellets Processing Technology

Raw Material → Feed Grinding → Feed Mixing → Feed Pelletizing → Pellet Cooling → Pellet Crushing → Screening & Grading → Pellet Packing

- ***Equipment Related to Complete Animal Feed Manufacturing Plant***

Feed Grinder → Feed Mixer → Feed Pellet Mill → Counterflow Cooler → Feed Pellets Crumbler → Feed Pellets Grading Sieve → Automatic Weighing and Packing Machine.




Batching & Mixing System
Feed Powder
To packing system
To make pellets if you need
Batching the powder feed raw materials according to the formula
Main Equipment:
Mixer/Batching Scale/Powder Screener/etc...
Pelletizing & Cooling & Screening System
final pellets
smaller pellets
Pressing the powder feed into pellets, cooling pellets,
and crumbling the pellets into smaller size if necessary
Major Equipment:
Pellet Machine/Vibrating Screener/Cooler/Crumbler/etc...

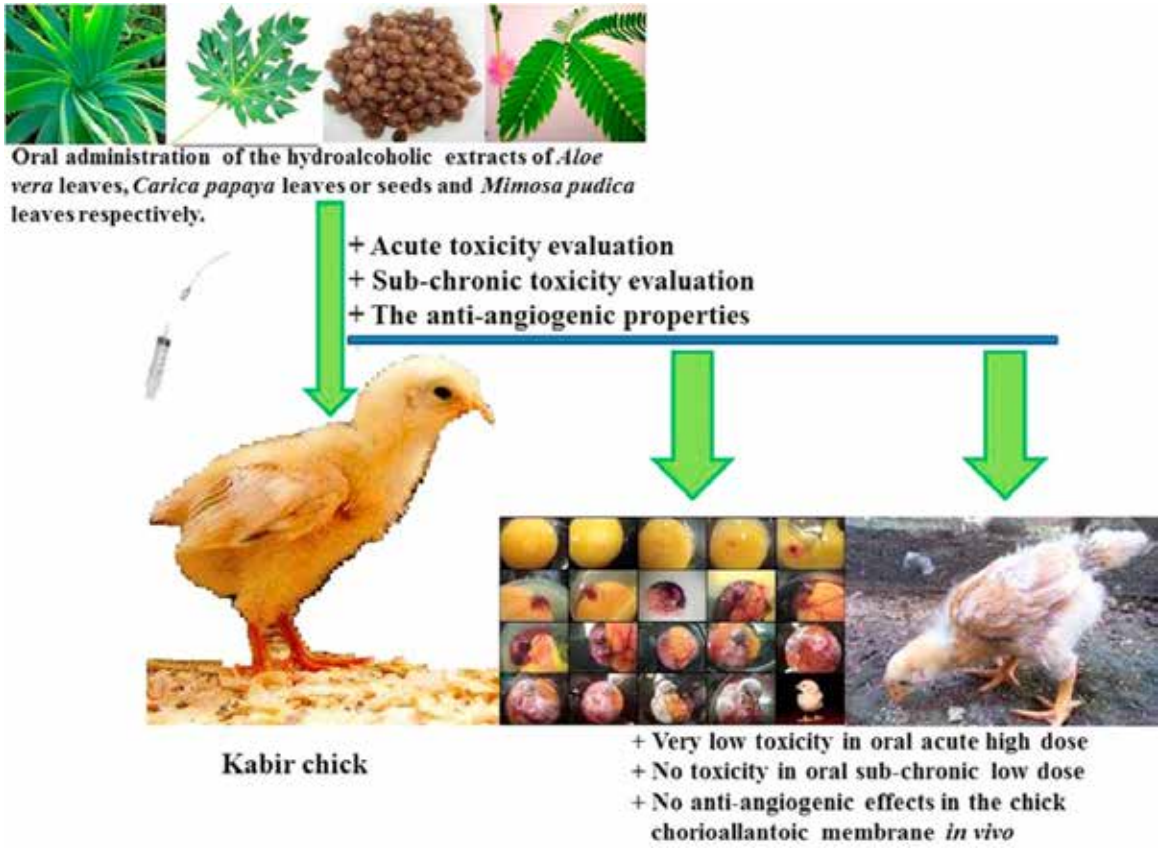

Packing System
pellets
pellets
Weighting and Packing the final products into bags,
Major Equipment:
Packing Machine/Sewing Machine/etc...

Figure 49. *Poultry feed processing*

Making feed from locally available materials and pelleting will help in reducing the cost and wastage.

6.10. Ethno-veterinary services in poultry production

Ethnoveterinary medicine is the way most livestock keepers in Cameroon and other countries treat animal health problems. Ethnovet practices are important because they are easily available, inexpensive and effective, especially in rural areas where veterinary services are absent, irregular and expensive. At this level, indigenous animal health interventions are used for emergency purposes.



Ndaleh Wozerou Nghonjuyi et al., 2016

Figure 50. *Example of ethnoveterinary research in poultry production in Cameroon*

6.11. Locally available equipment (feeders, drinkers, etc.)

Jua kali is a Kiswahili term that literally means "hot sun." But in Kenya, jua kali is an adopted word in the English language that denotes the entire informal sector of locally made goods and services. This include a lot of poultry equipment.

Feeders

Drinkers

Brooders

Figure 51. *Locally made poultry production equipment*

6.12. Collection/ cleaning, grading, packaging

Figure 52. *Egg Processing Line with Cleaning, Grading and packaging*

The process is as follows

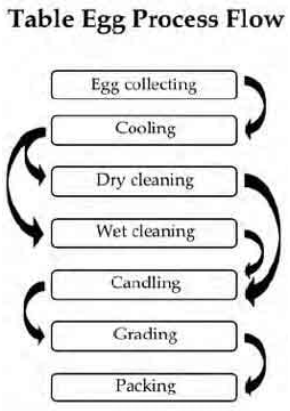


Figure 53. *egg process flow steps*

6.13. Other marketing and digital innovations technologies

Innovation in poultry product marketing will include:

1. App to develop poultry farmers database, disseminate technologies
2. Link farmers to service providers
3. Contract farming
4. E/mobile marketing
5. Social media marketing
6. Radio/tv/newspaper and other advert strategies
7. Branding (AOC)
8. Egg campaigns

CHAPTER VII: CRYOPRESERVATION/ CRYOCONSERVATION OF AFRICAN POULTRY GENETIC RESOURCES

7.1. Genetic diversity of local poultry

Poultry breeds make up the vast majority (63%) of total avian breeds, followed by ducks (11%), geese (9%) and turkeys (5%). Indigenous or local breeds make up most of the world's poultry genetic diversity. These local breeds are well adapted to extensive husbandry systems or backyard poultry production. The breeds are results of millennia of years of evolution and are therefore adapted to the local environment. Unfortunately, the African chicken diversity is declining. The decline in poultry genetic diversity and genetic variation are caused by the following factors:

1. Substitution of local breed adapted by exotic breeds
2. Uncontrolled crossbreeding
3. Increased local demand for poultry products forcing the need for fast growing and better laying animals

There is currently considerable concern regarding the number of poultry breeds that are either extinct or at risk of extinction.

7.2. Conservation of poultry genetic resources

The relevance of genetic diversity conservation in poultry production cannot be overemphasized because genes play a major role in formation of breeds and species. Genetic resources are the building blocks for poultry development.

Conservation enables farmers and breeders to respond to changing environmental conditions and to meet consumers demand. Conservation of genetic diversity helps to reduce the dependency on external inputs as the improvement of indigenous breeds is encouraged.

Conservation helps to preserve desirable traits and produce birds with high quality grades. It also encourages natural selection of only the fittest individuals which are better able to cope with diverse environmental challenges.

The maintenance of genetic diversity of poultry resources at adequate levels requires systematic scientific application of conservation biology principles. This entails the integration of population genetics and molecular biology.

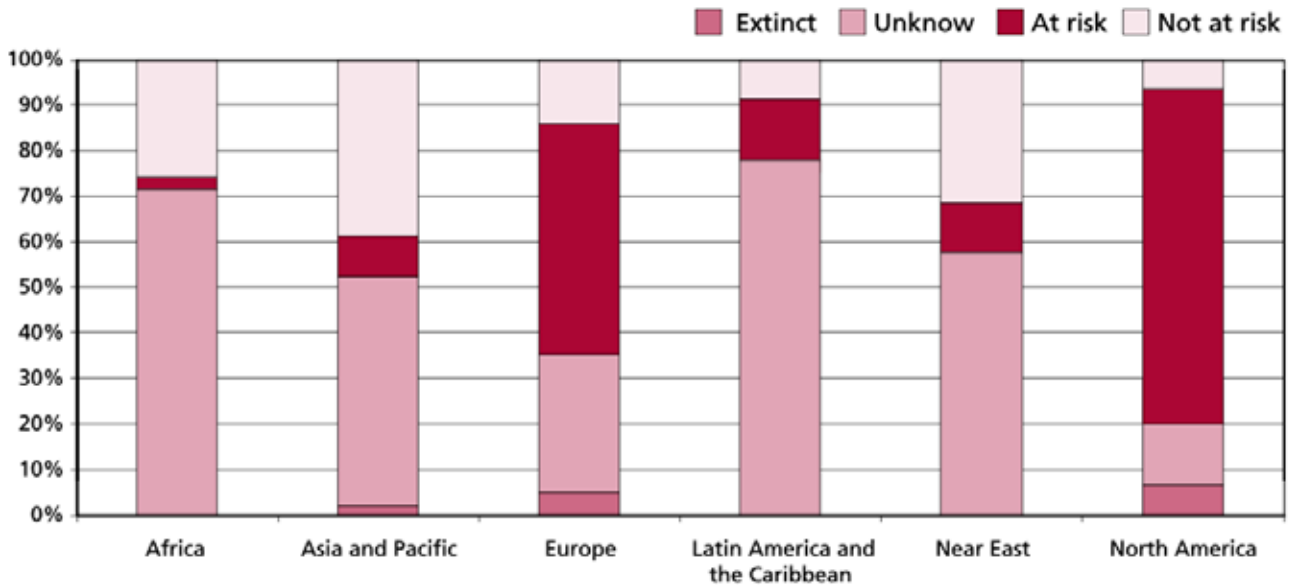


Figure 54: *risk status of local and regional poultry breeds, by region*

From the FAO database, it is estimated that about 25 percent of poultry breeds are included in conservation programmes, but there is no information about the nature or efficiency of these programmes.

An important step towards sustainable management of genetic resources is the establishment of conservation measures *in situ* as living populations or *ex situ* as cryopreserved material. The conservation methodologies are especially critical in Africa where losses of native genetic resources may have a dramatic impact on sustainable development of animal production.

7.3. Conservation in regional gene bank and database

Cryopreservation is an important complementary measure for the conservation of diversity in poultry as in other farm animal species.

The regional approach to organizing conservation of animal genetic resources across countries shows a clear advantage in that regional animal gene banks could play several key roles namely:

1. provide cryoconservation facilities for countries lacking national gene banks;
2. provide back-up storage for national gene banks (i.e. a second location f or security purposes); and
3. store material from trans-boundary breeds.

Regional animal gene banks could provide a uniform methodology for identification and evaluation of breeds to be preserved. They would also be ideal for the collection, freezing, shipping and storage of germplasm; and the long-term care, documentation and security of the samples.

The key steps required in a programme to establish regional animal gene banks across Africa will include:

1. Inventory and characterization of livestock populations with special attention to indigenous types
2. Identification of priorities and mobilization of resources in support of conservation
3. Support gene banking of threatened populations
4. Maintenance of gene banks
5. Evaluation and utilization of locally existing genotypes, including those imported from other countries
6. Collaboration with other national and international programmes.

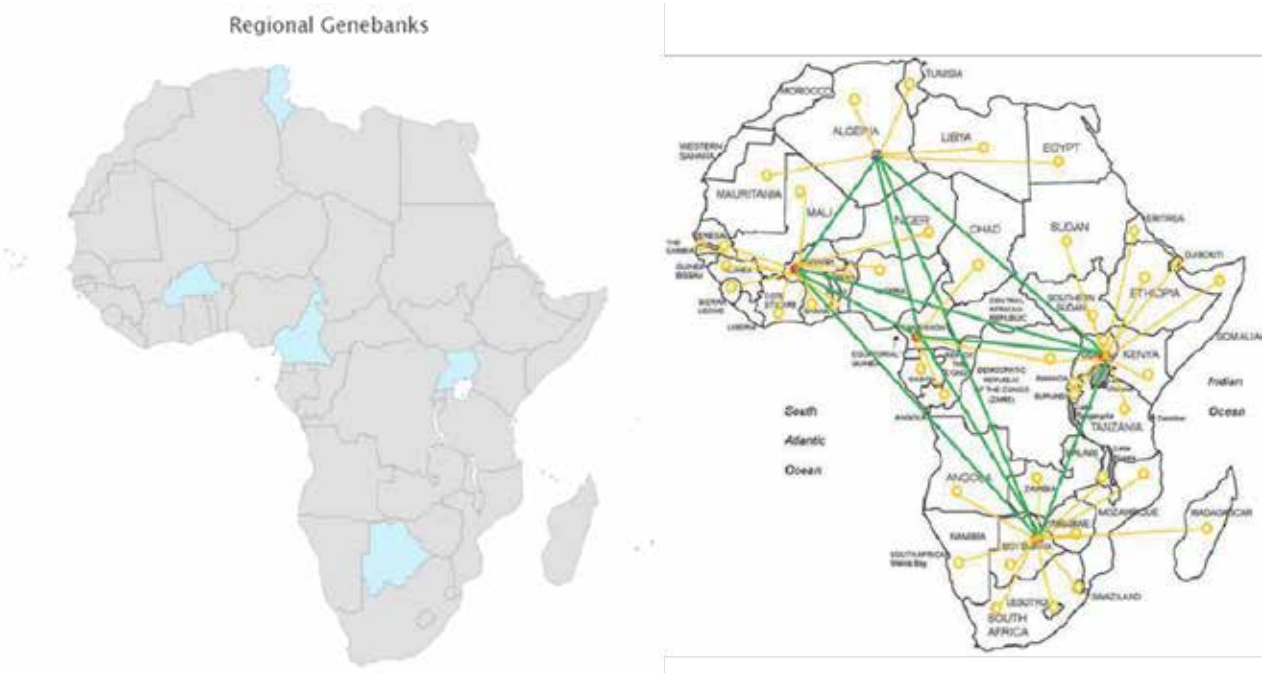


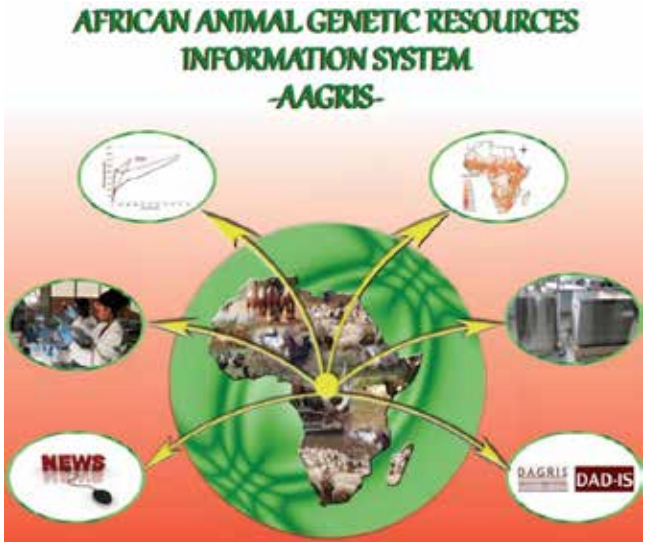
Figure 55. *Location of regional gene bank in African and networking with National conservation initiatives*

An important lesson from experiences with the plant genetic resources gene banks is that good documentation and good organization are critical. Otherwise, the task of accessing accumulated materials of which little is known regarding genetic characteristics or environmental background becomes formidable, and gene banks remain underutilized. Passport and pedigree information should be recorded at the time of collection by technicians from national institutions. Regional institutions play an important role in developing standard descriptions and enabling agreement on the minimal set of essential information recorded. Standard procedures will facilitate the use of gene banks over time.

Design and management of data banks should be done in harmony with gene banks to ensure that essential data are available. This implies that the same institutional infrastructure supports both data and gene banks. Data banks not associated with gene banks or active populations can contribute to historical studies but not much more

For the database, the African Animal Genetic Resources Information System (AAGRIS) is a "one-stop-shop" where a wide range of end-users can obtain relevant information, inform policy makers, raise awareness and promote best practices in the management of AnGR.

It is envisaged that AAGRIS will improve the accessibility and availability of information, data, tools and protocols and more importantly to capture policy makers' attention through availing primary indicators that will be crucial in decision-making and subsequent resource allocation.



https://award-demo.badili.co.ke/

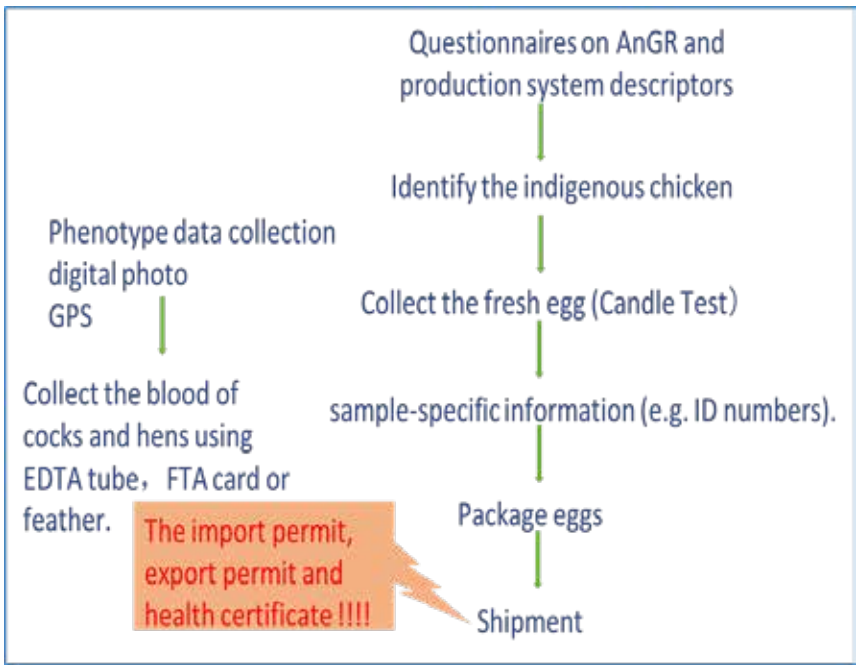
Figure 56. *African Animal Genetic resources information system - AAGRIS*

AAGRIS has **FIVE** main categories

1. Species and breeds
2. Inventory, monitoring and surveillance
3. Conservation and breed improvement programmes
4. Capacity development
5. AnGR Institutions

7.4. Collection of eggs from the field

Randomly select village chicken, according to the predominant phenotypes/ecotype kept with less introgression from exotic populations. The workflow for egg sampling for the purpose of cryoconservation is presented as follows.



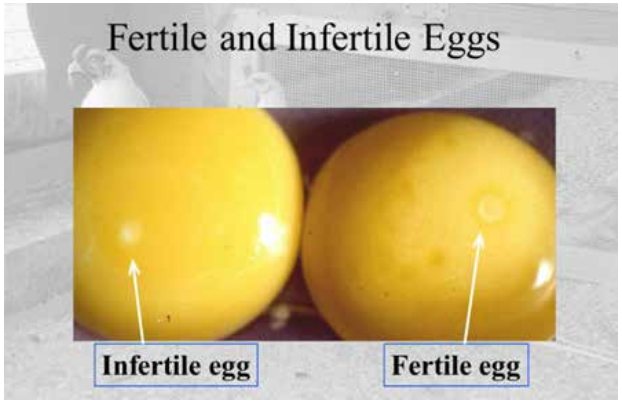
7.5. Primordial Germ cell (PGC) technology

a. The basic knowledge of Avian Primordial Germ Cells

Day by Day Poultry Embryonic Development:

- https://www.youtube.com/watch?v=PedajVADLGw
- https://www.youtube.com/watch?v=5mDNWJRxg-I

Fertilized eggs



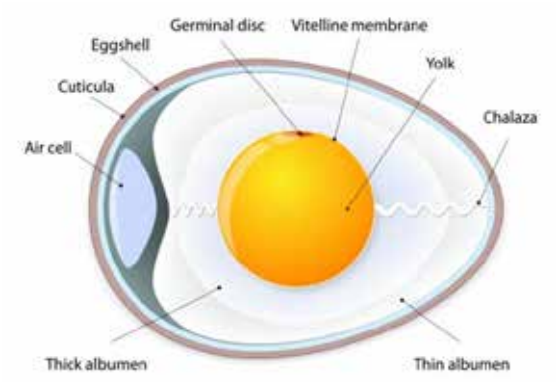


Figure 57. Fertilized eggs

Migration of PGCs in the chick embryo

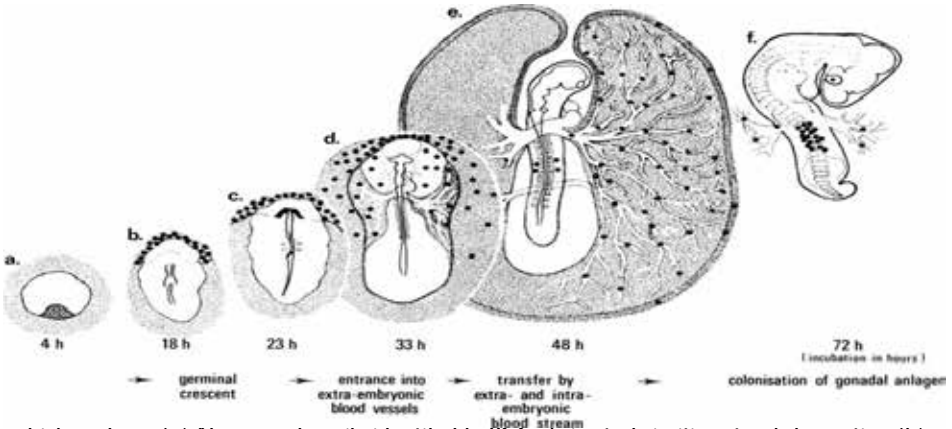


Figure 58. *Migration of PGCs in the chick embryo. (a) Absence of easily identifiable PGCs prior to primitive streak formation (b) and (c) accumulation of PGCs in the germinal crescent (d) penetration of the PGCs into blood islands (e) circulation of PGCs through the vascular system (f) colonization of the gonadal ridges.*

Isolation PGC cells form different stage of Embryo

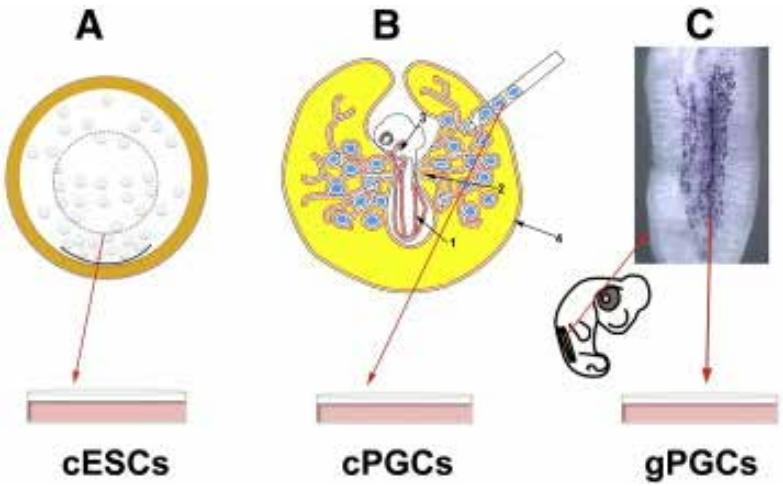


Figure 58. *Isolation PGC cells form different stage of Embryo*

Ready-to-use Protocols of biobanking of poultry genetic resources using cultured PGC

The Centre for Tropical Livestock Genetics and Health (CTLGH) has developed new and simplify protocols for poultry biobanking, which has already been piloted and proved efficient for deployment in Africa for effective chicken genetic resources cryoconservation and revival

Table 31. protocols developed for poultry generic resources cryoconservation.

Biobanking stage	Protocol title	Status
Project planning	Ethical approval documents, such as IACUC, material transfer agreement, Letter of Assurance	Finished /ILRI/Roslin
Target lines/breeds	Phenotypic characterization of poultry (economic traits, morphological features)	Finished /ILRI
	Example questionnaire to be filled during sampling (Breed questionnaire, Production environment descriptors)	Finished /ILRI
	Collection blood from poultry for evaluation genetic diversity	Finished /ILRI
	Collection and transport of fertilized eggs	Finished /ILRI
Isolation PGC	PGC derivation from Blood	SOP.MM.1.8 ver2 /Roslin
	PGC derivation from Blastodisc	SOP.MM.1.12/Roslin
	PGC derivation from poultry embryo gonad	SOP.MM.1.13/Roslin
	Characterization of PGC by using PAS staining, AP assay, immunofluorescence staining and Real-time PCR	Finished /ILRI
	Sexing of Poultry embryos	Finished /Roslin
Cryopreservation	Cryopreservation of PGCs serum-free	SOP.MM.1.5.4/Roslin
PGC revival	Injection of PGCs for producing chimeras	SOP.MM.1.10 ver 2 /Roslin
	Injection of PGC back to GM sterile poultry Embryos	In processing /Roslin

Isolation of PGCs from poultry embryo

The requirement of the facility, equipment, and reagents for isolation PCG cell lines from indigenous chick in Africa:

Facility:

- Category II Tissue Culture Laboratory
- Bio banking (Liquid nitrogen)
- Molecular biology lab (PCR, Gel)
- Poultry farm

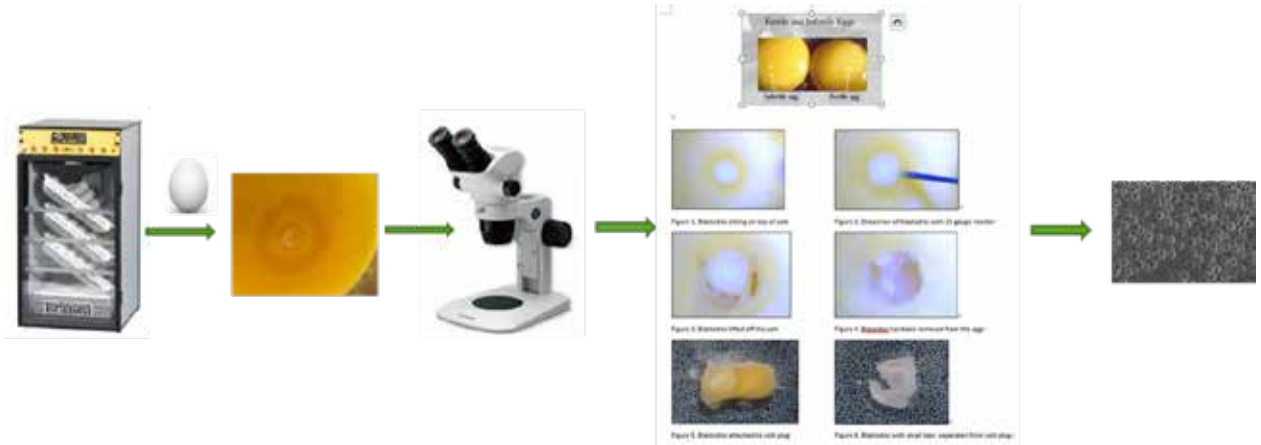
Table 32. consumable need for cryoconservation of poultry genetic resources

Item No	Item description	Preferred brand	Preferred Cat No.	Quantity
1	CO_2 Incubator	Thermo	Heracell™ VIOS 160i	1
2	Eppendorf Centrifuge	Eppendorf	5427 R	1
3	Egg incubator	Brinsea	OvaEasy 190 Advance Series II	2
4	Stereo microscope	Olympus	Olympus sz51	2
5	Stereo microscope	Nikon	Nikon SMZ1000	1
6	Inverted microscope	Nikon	ECLIPSE TS100	1
7	Touch light	-	Flashlight Tactical Touch Light	1
8	Shaking Water Bath	JULABO GmbH	Julabo Sw22	1
9	Analytical Balance	Sartorius	524S	1
10	Benchtop pH Meters	ThermoScientific	Orion™ Versa Star Pro™	1
11	Benchtop Autoclaves	ASTELL SCIENTIFIC	33 Litre Benchtop Autoclaves with Drying	1
12	Vortex Mixer	Jencons	Jencons PLS VX-100 Vortex Mixer	1
13	Biosafety Cabinets	Telstar	Bio II Advance	1
14	Clean Bench	ThermoScientific	Heraguard™ ECO Clean Bench	1
15	ACE® Light Source	SCHOTT	ACE® Light Source	1

16	Light Source- Halogen Lamps	150-Watt Halogen Lamps	A08120 A08130	1 1
17	Micropipette Puller	Sutter Instrument Company	P-1000	1
18	Aspirator tube assem-blies	Sigma	A5177-5EA	1
19	Veriti™ 96-Well Thermal Cycler	Thermo	4375786	1
20	Single channel pipettes	Thermo	4701070	1
21	Lab freezer -20°C	LGEX 3410 Index 23B/001	LieBher Mediline	1
22	Freezer -80°C	Innova U725G-86	New Brunswick	1
23	PCR operations UV cabinet	Grant-UVT-B-AR	Grant instruments	2

Isolation of PGCs from poultry embryo gonad

(a) Isolation of PGCs from poultry embryo Blastodisc



(b) Isolation of PGCs from poultry embryo blood

(C) Sexing of Poultry embryos（PGC）

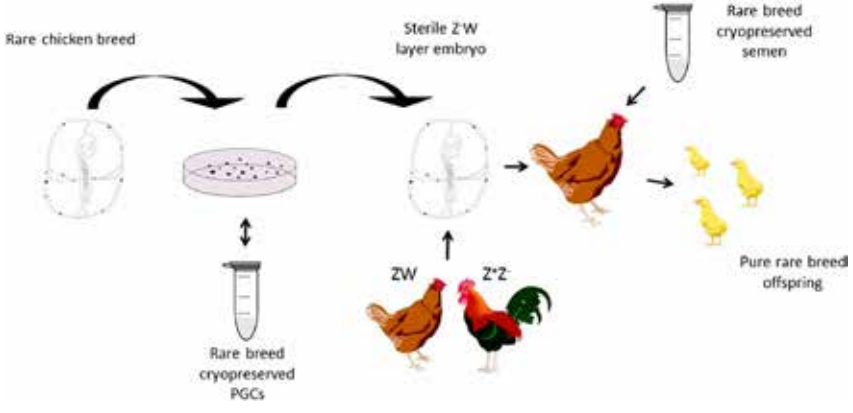
Figure 59. *Various process of isolation of PGCs and sexing of poultry embryo*

(d) Characterization of primordial germ cells

- Alkaline Phosphatase (AKP) and Periodic Acid–Schiff (PAS)
- Immunocytochemical staining and Flow cytometry,
- Expression analysis of germline-specific
- Pluripotency genes
- *Etc.*
- Cryopreservation of PGCs serum-free in liquid nitrogen

Figure 60. *Cryopreservation of PGCs serum-free in liquid nitrogen*

(a) Recovery of poultry population from cryoconserved PGC



Woodcock et a., 2019

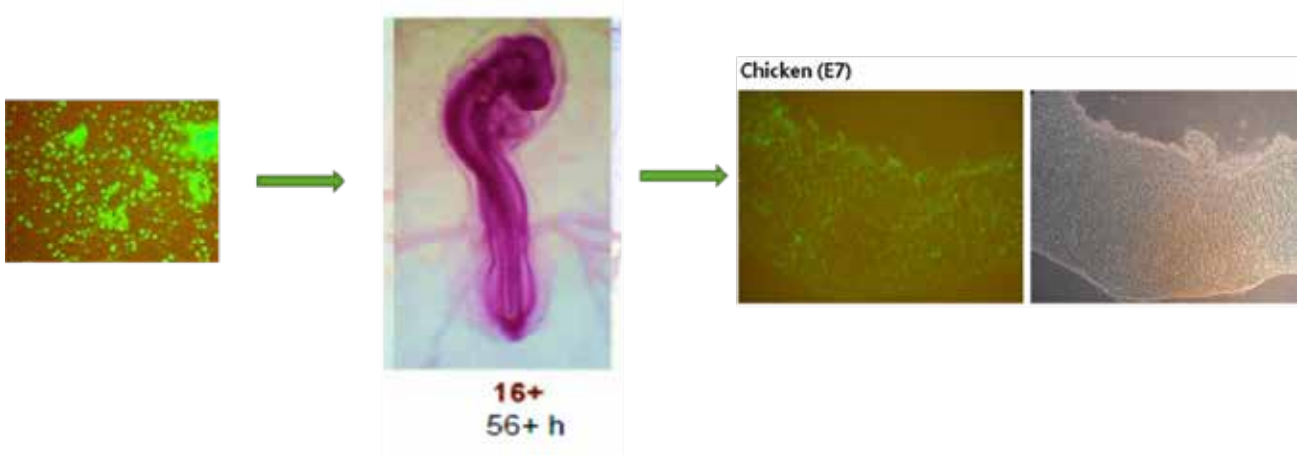


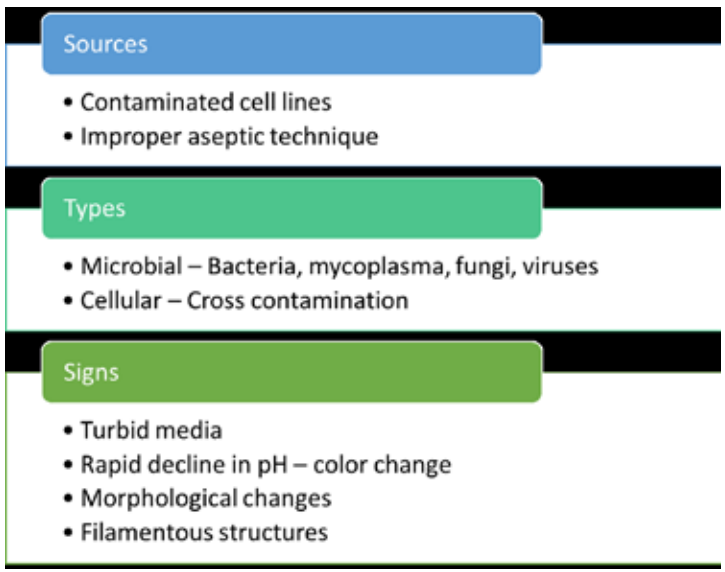
Figure 61. *Recovery of poultry population from cryo-conserved PGC*

Figure 62. *Indigenous chicks recovered from cryobanking and their surrogate mother.*

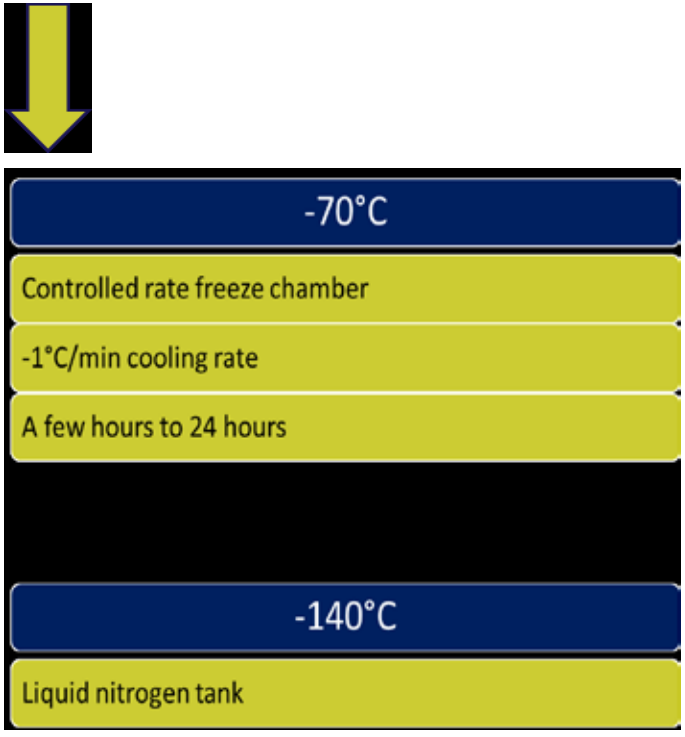
7.6. Cryopreservation procedure

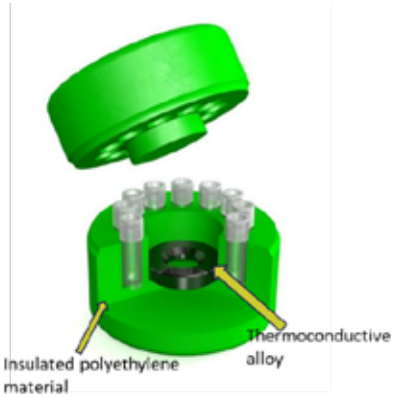
1. Check for contamination
2. Media preparation
3. Freezing cells in a controlled-rate chamber
4. Recovering cryopreserved cells
5. Post thawing considerations

The manipulator should avoid any sources of ccontamination. The origin of contamination is varied



Freezing Cells





- Reliable -1°C/min cooling rate
- 4 Hours in -70°C Freezer
- Comfortable to touch
- No alcohol use or maintenance

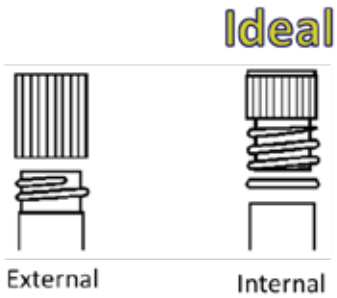
Vial Selection

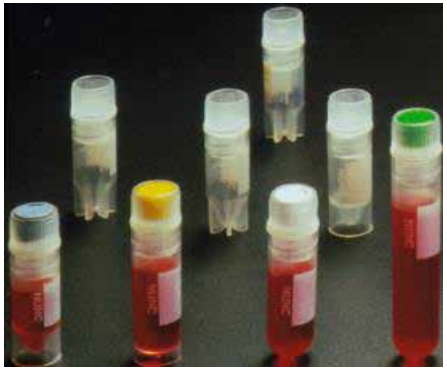
Several types of vials exist for storage at ultra-low and cryogenic temperatures

- Plastic vials
  - Internal thread
  - External thread
  - Straws
- Glass ampoules (heat sealed)

Considerations for vial type selection

- Storage temperature
- Liquid submersion
- Head space
- Effect on warming
- Material stresses





Low temperature storage

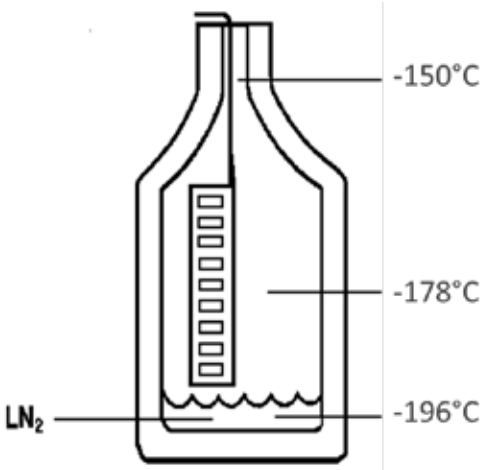
- Long-term storage should be below -140°C

  140°C for an indefinite length of time

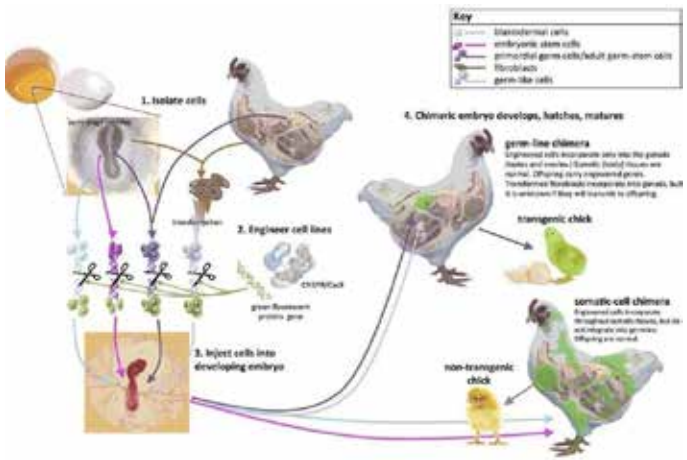
  80°C for less than 1 year

- Vials should be stored in a liquid nitrogen unit above the volume of liquid at the bottom of the tank

- This temperature should be between **-140°C** and **-180°C**



Creating transgenic poultry



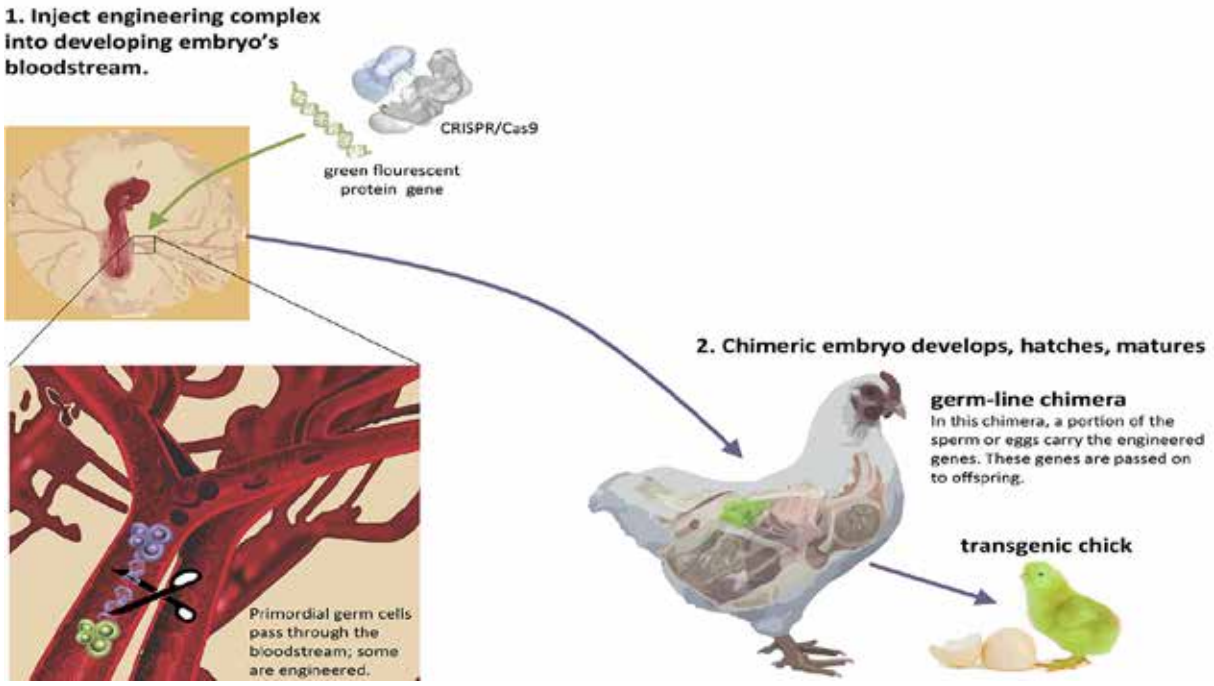


Figure 63. *Pathway to create transgenic chicken.*

CHAPTER VIII: VALUE ADDITION, PROCESSING AND BIOSECURITY IN LOCAL POULTRY VALUE CHAIN

8.1. Value addition and processing

This is still at a very nascent stage but both the quantity and value of the exported processed poultry products have increased during the last few years.

The wet market dominates with processed products accounting for only about 5 -6%. In case of eggs the processing is even lesser. Further, value-addition is miniscule or non-existent.

Advantages of Value Addition.

- Adding value to poultry especially to meat and eggs increases its life span
- Increasing value increases the convenience to consumers
- It mitigates losses that can be incurred while trying to sell such as meat rotting
- Value addition creates a more significant market opportunity and can easily satisfy the demand for products

When to Add Value

To have a competitive edge over business rivals, there is need to add value to poultry. It will benefit in reducing losses from poultry meat going bad and eggs breaking. Moreover, value addition will also reduce waste tremendously. One can make money from simple things including feathers and poultry waste.

State of the art Post-harvest technologies

Egg processing sector is still in infancy stage in Africa despite commendable production. Installation of about half-a-dozen egg processing units, rapid urbanization and industrialization and proliferating fast food parlours, etc. over the last decade have given some impetus to the growth of egg processing sector.

Many countries in Africa have begun exporting local poultry table eggs, egg powder and frozen egg products on a very limited scale in recent years.

At present, hardly 5% of eggs produced are processed into dehydrated/frozen products, primarily for export purpose or used in bakeries and other food and non-food industries.

Low-cost processing technologies have been developed for both cottage and large industries.

In Central Africa, Cameroon is leading in the wet market share compared to other markets. Live broilers are more than 95% of total consumer sales. Small birds 1.8-2.0 kg dressed weights are the norm. Skinless raw poultry products are preferred by many buyers

There is huge preference for freshly slaughtered poultry which is slaughtered in local meat shops or municipal slaughterhouses. The reasons behind this preference may be many. African consumer is price conscious.

Industry must come forward to create awareness about processed products. This will not only help in the improvement of production lines but will also promote consumption of healthy, safe, and hygienic meat products among African populations.
Preference for chilled poultry is said to be growing more rapidly than frozen, but both are a very small share of the total market.

What Poultry products can someone Add Value to?

- Eggs: Value is added to eggs by breaking them. The liquid then undergoes filtration, mixing, stabilization and is finally blended. After this, it is pasteurized to ensure that any pathogens are killed before being cooled into liquid form. After that, one can opt to dry it into powder form or freeze it. Egg powder can last up to four years. Furthermore, it is easy to use since all that is needed is to mix it with water. Bakers are increasingly embracing the use of powdered eggs in their trade.
- By-products: value can be added to poultry by-products such as feet and head by packaging and selling as pet food. Extra money can be made by drying poultry feathers. They are a good source of fibre and can be used to make pillows and cushions. Poultry excretions are a good source of manure. A good number of farmers prefer organic fertilizer from poultry farm. Dried poultry blood can be sold as feed for fish.

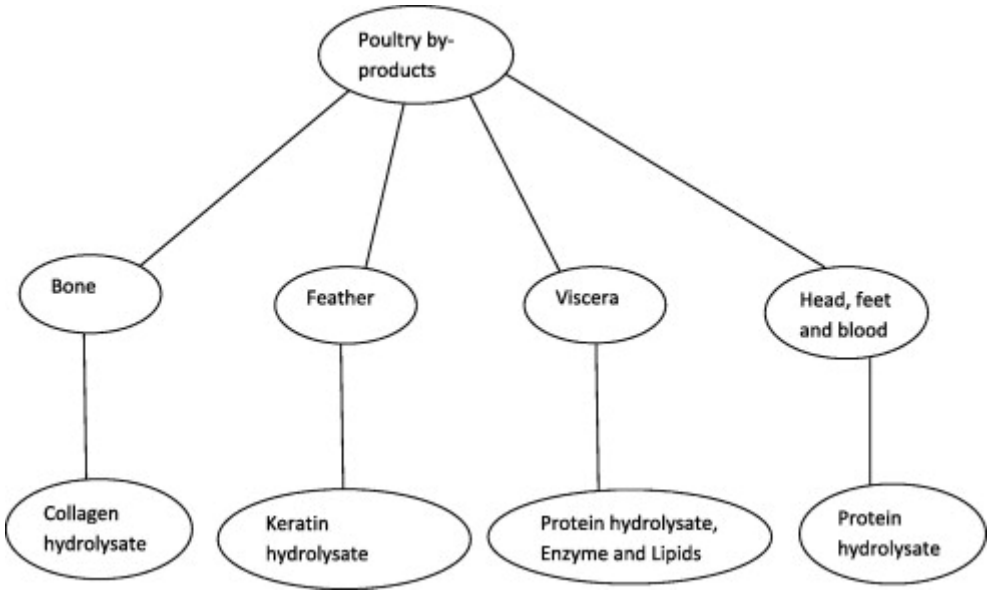


Figure 63. *poultry by-products and use.*

- Poultry Meat Parts: Customers should be given a wide range of choices. They can get poultry parts including gizzards, drumsticks, necks, thighs, wings, and breasts. These can be packed and sold as either fresh or frozen parts.

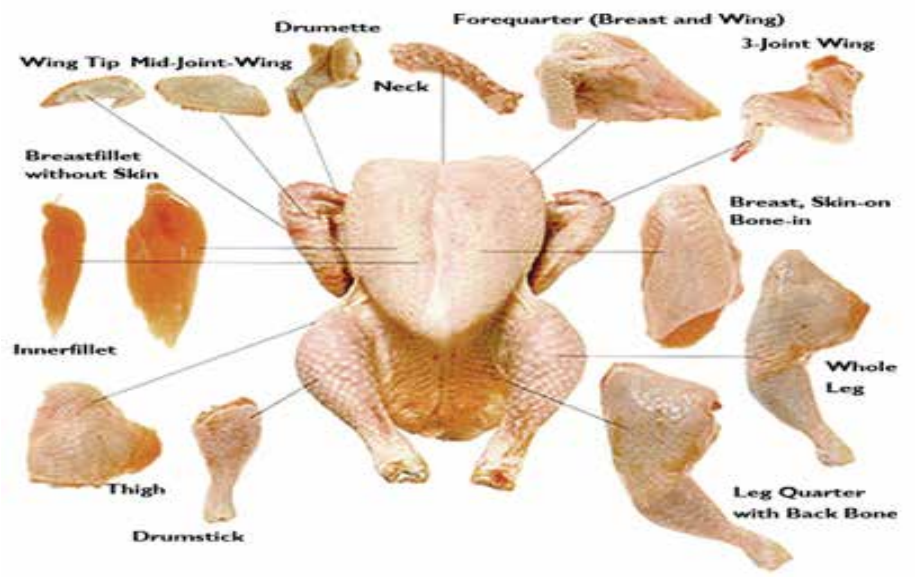


Figure 64. *Poultry meat parts*

- ***Semi-Cooked poultry***: Consumers can be spoilt for choice by marketing semi-cooked poultry strips on the shelves. It is important to ensure that these are flavoured and seasoned. Potential markets include hotels, schools, hospitals, and supermarkets.

- ***Fully cooked poultry***:This is mainly for grill joints, eateries or restaurants to serve customers grilled or rotisserie poultry

- ***Marinated poultry parts***: Marinated poultry parts have increasingly become popular. Most customers especially the chefs from restaurants prefer marinated poultry. They find them juicy with a great aromatic taste. This saves the chefs time required for marinating the poultry which can take up to 72 hours.

- ***Boneless poultry products***: Boneless poultry is popular among the middle class. It is an extensive market, which needs to be tapped. The bones can also be packaged and marketed. These are mainly used in making certain dishes, especially soup.

Value-added Poultry Business Ideas

- ***Poultry restaurants***: As earlier mentioned, the best way to sell fully cooked poultry is by starting a restaurant. It is a great poultry business idea. These can be marketed all year round

- ***Hatchery***: Developing hatcheries can be good business idea. This reduces the need for buying chicks from other hatcheries and one can sell the day-old chicks.

- ***Poultry parks***: Another good business idea is to establish a poultry park. One can rear ducks, layers, and broilers and have people pay to come and see the poultry park. One can choose to venture into value-added poultry business or to add value to poultry. if both are well executed, profits can be made. A strong illustration of this could come from the recent development of ornamental poultry production as a very lucrative business in Kenya.

Specific Poultry Products:

- ***Pickled eggs***: A simple, cost-effective and efficient technology developed for pickling of quail eggs for up to 4 months of storage and marketing at ambient temperature in ready-to-eat form.

• ***Salted Poultry Eggs***: A simple technique for preparation of intact salted poultry shell eggs has been developed which obviates the need for using salt prior to serving boiled eggs and hence a convenient product for egg vendors.

• ***Albumen Rings***: Albumen rings are egg snack food, prepared by cooking blended egg albumen in ring molds, battering and breading the coagulated albumen prior to deep fat frying. It can be popularized as egg snacks at fast food outlets.

• ***Egg Roll***: It is a nutritious, tasty and convenient egg product suitable for meals or as snack foods. This product offers a potential market at fast food outlets. Egg roll filled with 80% scrambled egg and 20% poultry meat mixture (shallow pan fried) is best in flavour, texture, and overall acceptability by consumers. Egg roll has a refrigerated shelf-life of 8 days in vacuum and 6 days in aerobic pack.

- ***Egg crepe***: Egg crepe is a thin, fat, circular product and may be filled with meat or vegetables and rolled or folded. It is an egg-rich product and can be popularized as a convenient egg item at fast food outlets and at homes. Crepes has a shelf-life of 22 days in vacuum and 20 days in aerobic packaging at refrigeration (4 ± 1°C) and for 60 days at freezing (-18 ± 1°C) temperature in both vacuum and aerobic packaging.

- ***Egg Waffles***: Egg waffle is a nutritious, light, crispy and versatile snack food for the breakfast. This product offers a potential market at 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, it can keep well for 10 days in vacuum and 6 days in air packs with satisfactory microbiological quality.

- ***Cured and smoked poultry***: Dressed poultry are brine-cured for 48 hr at 4°C followed by smoking for 4 h at 45°C (Relative Humidity 30%) to produce delicious product having desirable golden colour and typical smoky flavour with longer shelf-life.

- ***Poultry patties***: This is a value-added, comminuted poultry product prepared by utilizing the tough meat of culled layers /discontinued breeder stock. Minced meat, fat, binder, condiments and additives are mixed in a homogeniser twice at 15°C to prepare uniform emulsion which is moulded and finally oven-cooked.

- ***Poultry nuggets***: This is also a comminuted product from poultry meat-based emulsion more or less similar to that of poultry patties and moulded in the form of square or rectangular nuggets.

- ***Intermediate moisture poultry meat***: It is self-stable product developed by immersion of diced poultry meat in infusion solution containing humectants followed by partial dehydration into a semi-moist product which can be safely stored for about 2 months at ambient temperature.

- ***Poultry chunkalona***: A delicious ready-to-eat product prepared from a combination of spent hen meat mince (60%) and pre-marinated tender meat chunks of broiler (25%) along with binders, extenders and seasonings.

- ***Poultry meat spread***: A spreadable product prepared from a combination of pre-cooked, deboned and minced spent hens meat (85%) in combination with cereal starch, egg yolk, seasoning and permitted food additives followed by thermal processing for gelatinization of starch and stabilization of emulsified product. The product has a shelf-life of 12 and 60 days under refrigeration (5°C) and frozen (-18°C) storage, respectively.

- ***Marinated poultry breast fillets***: A value-added poultry product prepared by tumbling marination of broiler pectoral muscle followed by oven roasting to obtain ready-to-eat product.

- ***Vinegar based poultry gizzard pickle***: Vinegar based poultry gizzard pickle is a low cost protein rich, poultry fast food with moderately longer shelf-life at ambient temperature (45 days during summer/ rainy season (~34°C); 75 days during winter (~26°C).

- ***Cooked poultry stock*** (One-minute curried poultry): This is a cost-effective fast food for instant use and highly useful at times of instant need.

8.2. Requirements for setting up poultry products value addition plant

There are many steps to starting food business. The most basic required steps for legally starting poultry products value addition plants are:

i. Decide what product will sell and how it will be made.
ii. Develop a business plan.
iii. Register the name of business with the city council
iv. Take a food safety certification course
v. Apply for a food business license
vi. Complete state and federal tax forms

vii. Determine the business risks and obtain insurance
viii. Identify sources of inputs……poultry, labour, etc….{this could be part of business plan, but it needs to come out clearly}
ix. Start selling product

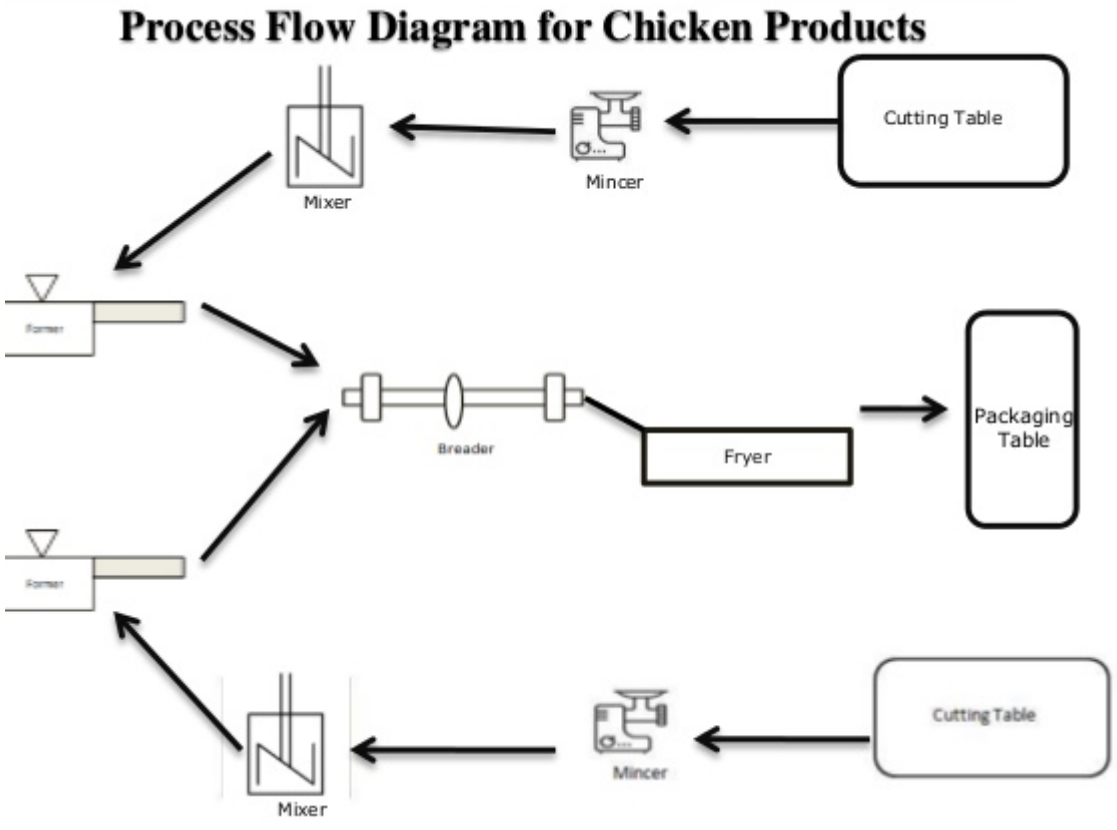


Figure 65. *Process flow for chicken products*

8.3. Processing of poultry products

The poultry processing line includes trained workers, automated equipment, and inspection and testing conducted by certified delegate and plant personnel.

Certified inspectors are required in every plant to monitor the processing line and ensure the poultry products are safe and meet health standards.

8.3.1. Receiving and Slaughter

Poultry arrive at the processing plant from the farm from where they are raised.

Workers trained in humane handling place chicken on a moving line Chicken are calmed by dim lighting and by "rub bars," Chicken are stunned and slaughtered with a quick, single cut to the throat Ensure that each chicken are properly butchered before feather removal, evisceration and cleaning	

8.3.2. Cleaning and evisceration (removal of feathers and internal organs)

This part of the processing line is highly automated in industrial plants. Machines conduct most of the activity.

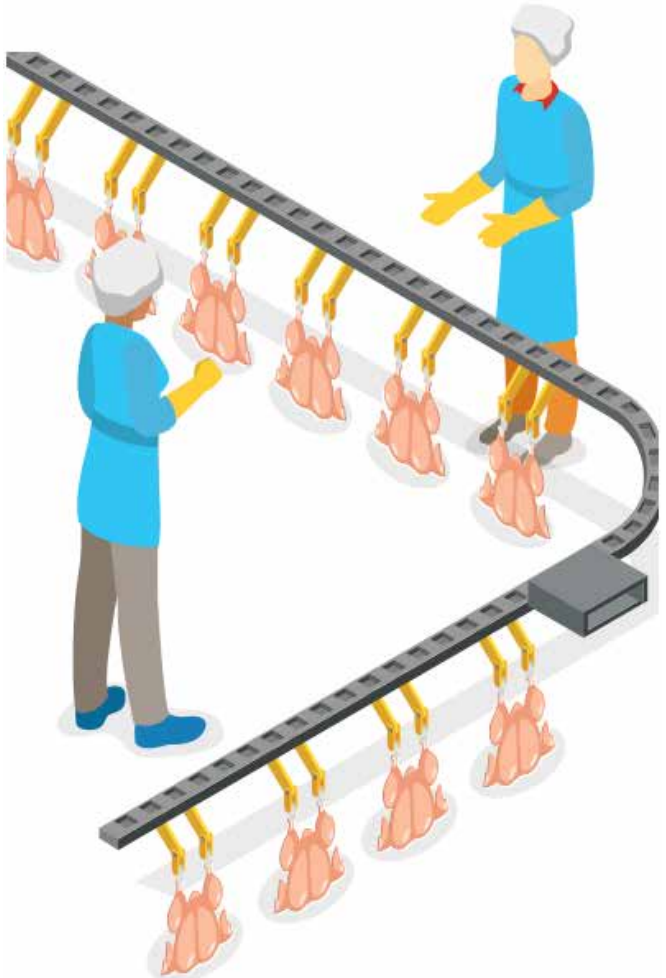
Feathers, internal organs and feet are removed

Carcasses are thoroughly washed

Each carcass is inspected by a member of the processing plant and a USDA inspector for any food safety and quality issues

Carcasses are then chilled to reduce any possible food borne pathogens

The poultry is tested for any potentially dangerous bacteria, like Salmonella



8.3.3. Processing and preparation

Poultry carcasses are cut and deboned to become different products like poultry wings, drumsticks or poultry breasts Poultry might also be cooked in the plant or sent to other plants to be made into products like poultry nuggets, patties or frozen meals.

8.3.4. Packaging and shipping

Once the poultry is cut up into parts, it is packaged.

The poultry products should not leave the plant without being inspected and getting the seal of approval by the certified veterinarian. Finally, the poultry is shipped in refrigerated containers of truck to grocery stores, restaurants or distribution centres.

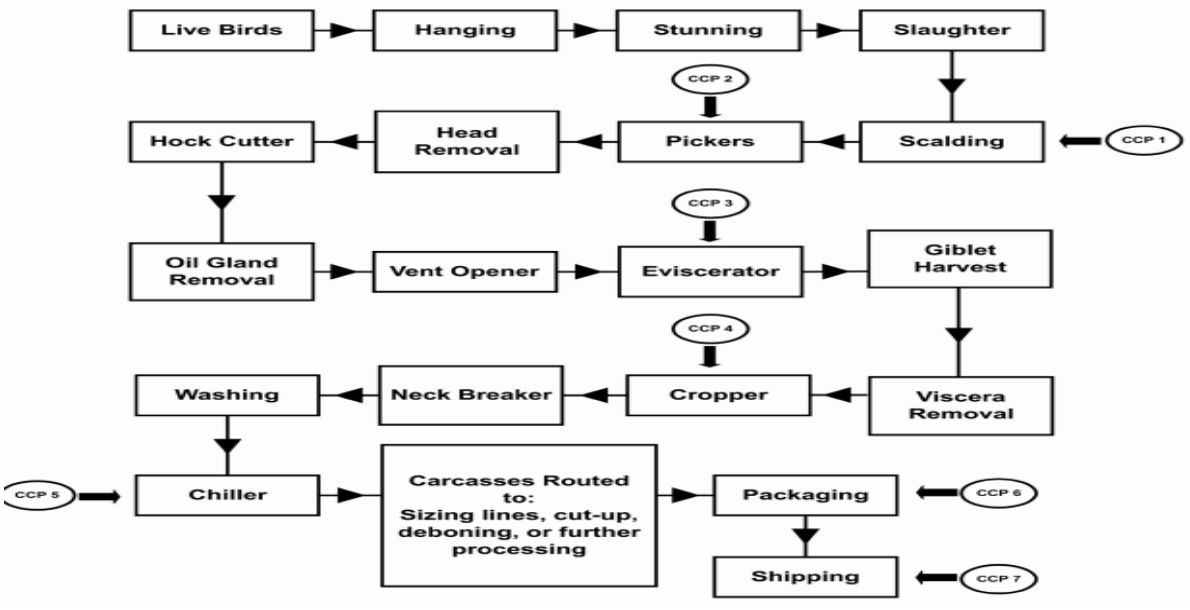


Figure 66. *Example of Poultry Processing hazard analysis critical control point (HACCP) Flow Diagram.*

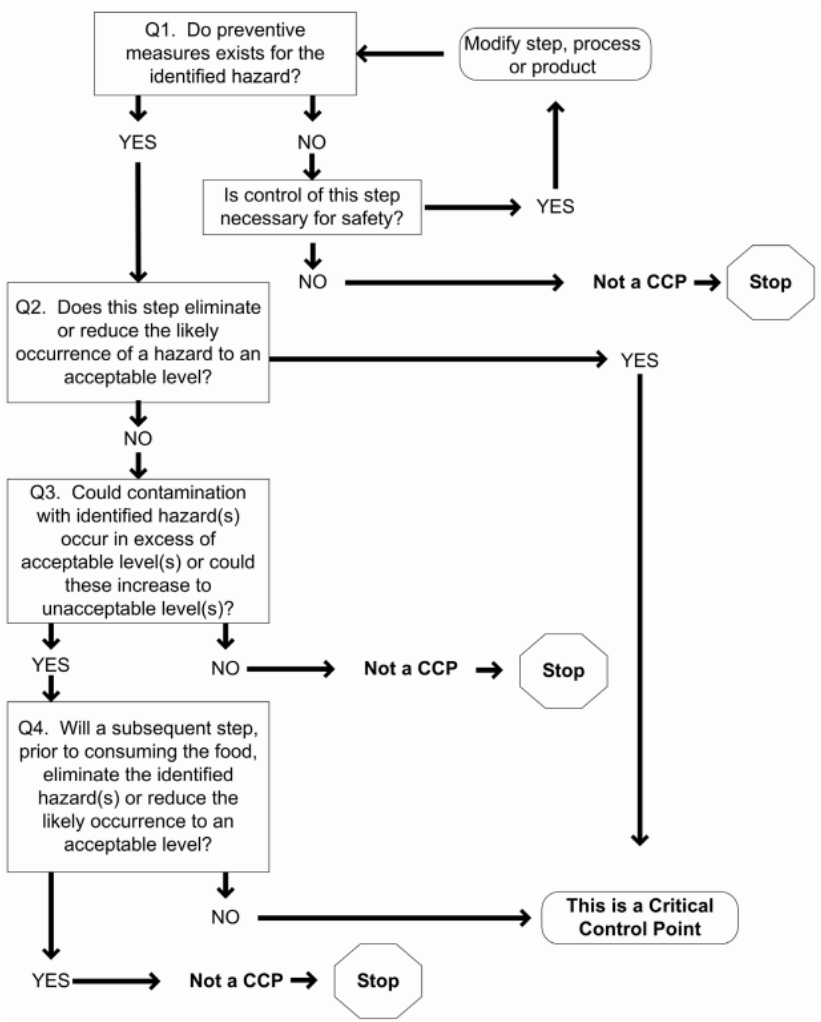


Figure 67. *Critical control point (CCP) Decision Tree (Stevenson and Bernard, 1995)*

8.4. Biosecurity

1. Appropriate fencing
2. Pediluve and rotoluve
3. Personnel changing, showering and sanitary facilities
4. Receipt, storage and transfer of eggs
5. Incubation and hatching
6. Sorting, sexing and other handling of day-old birds
7. Storage of egg boxes and boxes for day-old birds, egg flats, chick box liners, chemicals and other items
8. Equipment washing
9. Waste disposal
10. Dining facilities for personnel
11. Office space.

8.5. Potential of African local poultry products and suggestions for their globalization

The African local poultry industry has a lot of non-exploited potential:

1. Availability of different meats and egg in abundance for processing.
2. Value addition to low value meat cuts and trimmings
3. Low investments for production.
4. Ease of processing using simple technologies.
5. Increasing demand due to better standards of living and changes in lifestyle.
6. High consumer response for organic produces, convenience and nutritious products.

Some suggestions for agri-entrepreneurs:

- The indigenous products should be produced within affordable cost to target group consumers for marketing sustainability.
- Knowledge of the causes of spoilage of these products is necessary and their control is a must.
- In-depth knowledge on new formulations, process optimization, appropriate packaging materials and system as well as

refrigeration facilities are essential requirement for enhancing the quality of the product.

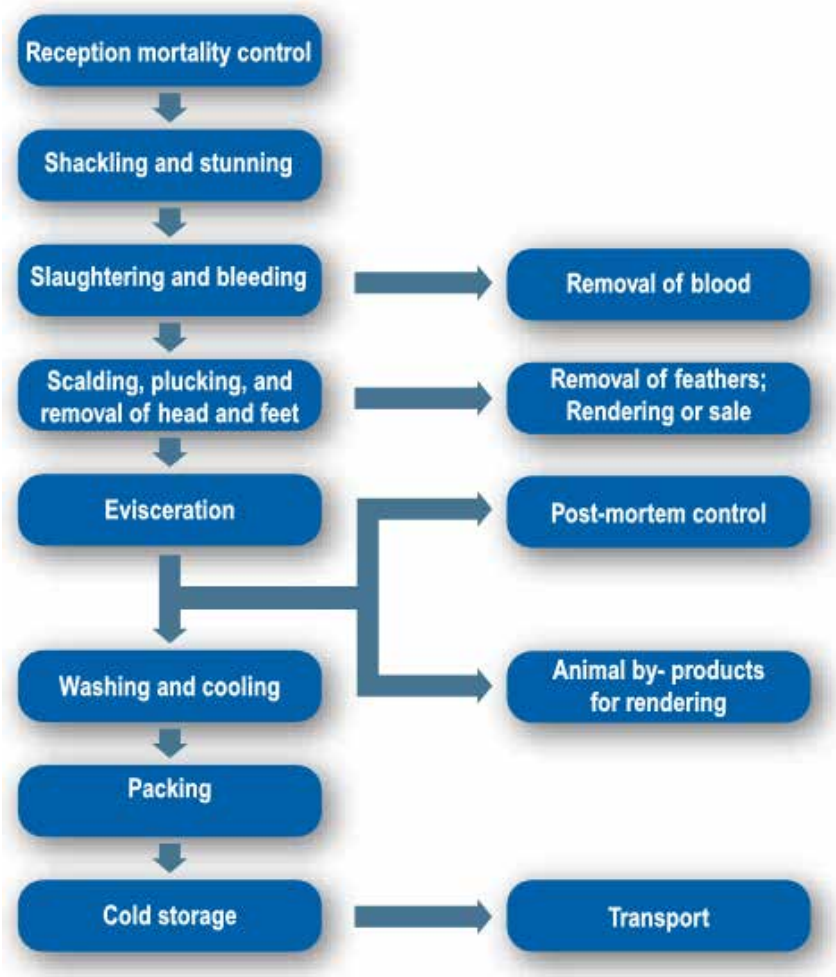
- Processing of protein rich and low-fat meat products like low fat meat balls, tandoori etc. have vast market potential due to increasing demand for health foods.
- Retort pouch processing has potential application for meat curries, meat biryani and hallen for wider distribution and marketing.

ANNEXES

ANNEX 1: POULTRY PARTS

Poultry Breasts	One of the most popular poultry parts, the poultry breast, can be purchased in many different forms. Poultry breasts are considered white meat and are available fresh and frozen in various cuts, such as whole breasts, breast quarters and breast halves.
Poultry Wings	Poultry wings, another very popular poultry product, are available in many forms. They are considered white meat.
Poultry Cutlets	Cutlets are boneless poultry breasts or legs that have been pounded to tenderize and to provide meat that is more uniform in thickness so that it cooks more evenly
Poultry Thighs	Thighs are considered dark meat.
Drumsticks	Drumsticks are the bottom portion of the leg below the knee joint and consist of all dark meat.
Poultry Fillets	Fillets are slices of meat from the poultry breast.
Poultry Breast Strips	Poultry breasts are cut into strips.
Poultry Tenders	Tenders, which are part of the poultry breast, are full pieces or chunks of poultry tenderloins.
Giblets	The giblets consist of the neck, liver and heart.

ANNEX 2: SIMPLIFIED DIAGRAM OF THE VARIOUS OPERATIONS PERFORMED IN POULTRY PROCESSING



ANNEX 3: BIOSECURITY PROCEDURES IN POULTRY PRODUCTION

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Recommendations on the location and construction of poultry establishments

1. All establishments (poultry farms and hatcheries)

a. A suitably isolated geographical location is recommended. Factors to consider include the location of other poultry and livestock establishments, wild bird concentrations and the distance from roads used to transport poultry.

b. Poultry establishments should be located and constructed to provide adequate drainage for the site. Run-off or untreated site wastewater should not discharge into waterfowl habitats.

c. Poultry houses and hatcheries should be designed and constructed (preferably of smooth impervious materials) so that cleaning and disinfection can be carried out effectively. Ideally, the area immediately surrounding the poultry houses and hatcheries should be paved with concrete or other impervious material to facilitate cleaning and disinfection.

d. The establishment should be surrounded by a security fence to prevent the entry of unwanted animals and people.

e. A sign indicating restricted entry should be posted at the entrance to the establishment.

2. Additional measures for poultry farms

a. Establishments should be designed to house a single species and a single production type. The design should also consider the 'all-in all-out' single age group principle. If this is not feasible, the establishment should be designed so that each flock can be managed as a separate epidemiological unit.

b. Poultry houses, and buildings used to store feed, eggs or other material, should be constructed and maintained to prevent the entry of wild birds, rodents and arthropods.

c. Where feasible, the floors of poultry houses should be constructed using concrete or other impervious materials and designed so that cleaning and disinfection can be carried out effectively.

d. Where feasible, feed should be delivered into the farm from outside the security fence.

3. Additional measures for hatcheries

a. The design of the hatchery should take account of workflow air circulation needs, with 'one-way flow' movement of eggs and day-old birds and one-way air flow in the same direction.

b. The hatchery buildings should include physical separation of areas used for the following:
   - personnel changing, showering and sanitary facilities.
   - receipt, storage, and transfer of eggs.
   - incubation.
   - hatching.
   - sorting, sexing, and other handling of day-old birds.
   - storage of egg boxes and boxes for day-old birds, egg flats, chick box liners, chemicals and other items.
   - equipment washing.
   - waste disposal.
   - dining facilities for personnel.
   - office space.

Recommendations applicable to the operation of poultry establishments

1. All establishments (poultry farms and hatcheries)

a. All establishments should have a written biosecurity plan. Personnel in the establishments should have access to basic training in biosecurity relevant to poultry production and understand the implications to animal health, human health and food safety.

b. There should be good communication between personnel involved in the poultry production chain to ensure that steps are taken to minimise the introduction and dissemination of infectious agents.

c. Traceability at all levels of the poultry production chain should be possible.

d. Records should be maintained on an individual flock basis and include data on bird health, production, medications, vaccination, mortality, and surveillance. In hatcheries, records should include data on fertility, hatchability, vaccination, and treatments. Records should be maintained on cleaning and disinfection of farm and hatchery buildings and equipment.

Records should be readily available for inspection on site.

e. Monitoring of poultry health on the establishment should be under the supervision of a veterinarian.
f. To avoid the development of antimicrobial resistance, antimicrobial agents should be used in accordance with relevant directions of the Veterinary Services and manufacturer's instructions.
g. Establishments should be free from unwanted vegetation and debris that could attract or harbour pests.
h. Procedures for the prevention of entry of wild birds into poultry houses and buildings, and the control of vermin such as rodents and arthropods should be implemented.
i. Access to the establishment should be controlled to ensure only authorised persons and vehicles enter the site.
j. All personnel and visitors entering an establishment should follow a biosecurity procedure. The preferred procedure is for visitors and personnel entering the establishment to shower and change into clean clothes and footwear provided by the establishment. Where this is not practical, clean outer garments (coveralls or overalls, head covering and footwear) should be provided. Entry of visitors and vehicles should be registered by the establishment.
k. Personnel and visitors should not have had recent contact with other poultry, poultry waste, or poultry processing plant(s). This time period should be based on the level of risk of transmission of infectious agents. This will depend on the poultry production purpose, biosecurity procedures and infection status.
l. Any vehicle entering an establishment should be cleaned and disinfected in accordance with a biosecurity plan. Delivery vehicles should be cleaned, and disinfected before loading each consignment of eggs or poultry.

2. *Additional measures for all poultry farms*

a. Whenever possible, the 'al l-in all-out' single age group principle should be used. If this is not feasible and several flocks are maintained on one establishment, each flock should be managed as a separate epidemiological unit.
b. All personnel and visitors entering a poultry house should wash their hands with soap and water or sanitize them using a disinfectant. Personnel and visitors should also change footwear, use a boot spray, or use a properly maintained disinfectant footbath. The disinfectant solution in the footbath should be changed on a regular basis to ensure its efficacy, in accordance with the manufacturer's instructions.
c. Any equipment should be cleaned and sanitized before being taken into a poultry house.

d. Animals, other than poultry of the appropriate (resident) species and age, should not be permitted access to poultry houses. No animals should have access to other buildings, such as those used to store feed, eggs or other material.
e. The drinking water supply to poultry house s should be potable in accordance with the World Health Organization or to the relevant national standard, and microbiological quality should be monitored if there is any reason to suspect contamination. The water delivery system should be cleaned and disinfected between flocks when the poultry house is empty.
f. Birds used to stock a poultry house should preferably be obtained from breeder flocks and hatcheries that are free from vertically transmitted infectious agents.
g. Heat treated feed with or without the addition of other bactericidal or bacteriostatic treatments, such as addition of organic acids, are recommended. Where heat treatment is not possible, the use of bacteriostatic or bactericidal treatments is recommended. Feed should be stored in a manner to prevent access by wild birds and rodents. Spilled feed should be cleaned up immediately to remove attractants for wild birds and rodents. The movement of feed between flocks should be avoided.
h. The litter in the poultry house should be kept dry and in good condition.
i. Dead birds should be removed from poultry houses as quickly as possible but at least daily. These should be disposed of in a safe and effective manner. Personnel involved in the catching of birds should be adequately trained in bird handling and basic biosecurity procedures.
j. To minimise stress poultry should be transported in well ventilated containers and should not be overcrowded. Exposure to extreme temperatures should be avoided.
k. Containers should be cleaned and disinfected between each use or disposed of in a safe manner.
l. When a poultry house is depopulated, it is recommended that all faeces and litter be removed from the house and disposed of in a safe manner to minimise the risk of dissemination of infectious agents. If litter is not removed and replaced between flocks then the litter should be treated in a manner to minimise the risk of dissemination of infectious agents from one flock to the next.
m. After removal of faeces and litter, cleaning and disinfection of the poultry house and equipment should be done.
n. For poultry flocks that are allowed to range outdoors, feeders, feed and other items which may attract wild birds should

be kept indoors. Poultry should not be allowed access to sources of contamination, such as household waste, litter storage areas, other animals, stagnant water an d water of unknown quality. The nesting area should be inside the poultry house.

3. Additional measures for layers

Refer to Section 3 of the Codex Alimentarius Code of Hygienic Practice for Eggs and Egg Products (CAC/RCP15-1976).

4. Additional measures for breeders

a. Nest box litter and liners should be kept clean.
b. Hatching eggs should be collected at frequent intervals, at least daily, and placed in new or clean and disinfected packaging materials.
c. Grossly dirty, cracked, broken, or leaking eggs should be collected separately and should not be used as hatching eggs.
d. Hatching eggs should be cleaned and sanitized as soon as possible after collection using an approved sanitising agent, in accordance with the manufacturer's instructions.
e. Hatching eggs or their packaging materials should be marked to assist traceability and veterinary investigations.
f. The hatching eggs should be stored in a dedicated room as soon as possible after cleaning and sanitisation. Storage conditions should minimise the potential for microbial contamination and growth and ensure maximum hatchability. The room should be well ventilated, kept clean, and regularly disinfected using disinfectants approved for this purpose.

5. Additional measures for hatcheries

a. Dead in shell embryos should be removed from hatcheries as soon as they are found and disposed of in a safe and effective manner.
b. All hatchery waste, garbage and discarded equipment should be contained or at least covered while on site and removed from the hatchery and its environs as soon as possible.
c. After use, hatchery equipment, tables and surfaces should be promptly and thoroughly cleaned and disinfected with an approved disinfectant.
d. Egg handlers and sexers, and handlers of day-old birds should wash their hands with soap and water before commencing

work and between working with batches of hatching eggs or day-old birds from different breeder flocks.

e. Hatching egg s and day-old birds from different breeder flocks should be identifiable during incubation, hatching, sorting and transportation.
f. Day-old birds should be delivered to the farm in new containers or in clean, disinfected containers.

Prevention of further dissemination of infectious agents of poultry

When a flock is suspected or known to be infected, a veterinarian should be consulted immediately and, in addition to the general biosecurity measures described previously, management procedures should be adjusted to effectively isolate it from other flocks on the establishment and other epidemiologically related establishments. The following measures are recommended:

1. Personnel should manage flocks to minimise the risk of dissemination of infectious agents to other flocks and establishments, and to humans. Relevant measures include handling of an infected flock separately, last in sequence and the use of dedicated personnel, clothing, and equipment.
2. When infection has been confirmed, epidemiological investigations should be carried out to determine the origin and route of transmission of the infectious agent.
3. Poultry carcasses, litter, faeces and other potentially contaminated farm waste should be disposed of in a safe manner to minimise the risk of dissemination of infectious agents. The disposal method used will depend on the infectious agent involved.
4. Depending on the epidemiology of the disease, the results of a risk assessment, and public and animal health policies, destruction or slaughter of a flock before the end of the normal production period may be u sed. When infected flocks are destroyed or slaughtered, they should be processed in a manner to minimise exposure of humans and other flocks to the infectious agent, and in accordance with re commendations of the Veterinary Service and relevant chapters in the Terrestrial Code. Based on risk assessment, non-infected, high risk flocks may be destroyed or slaughtered before the end of their normal production period. Before restocking, the poultry house including equipment should be cleaned, disinfected, and tested to verify that the cleaning has been effective. Special attention should be paid to feed equipment and water systems. Microbiological monitoring of the efficacy of disinfection procedures is recommended when pathogenic agents have been detected in the previous flock.
5. Depending on the epidemiology of the disease, risk assessment, vaccine availability and public and animal health policies, vaccination is an option to minimise the dissemination of the infectious agent. When used, vaccines should be administered

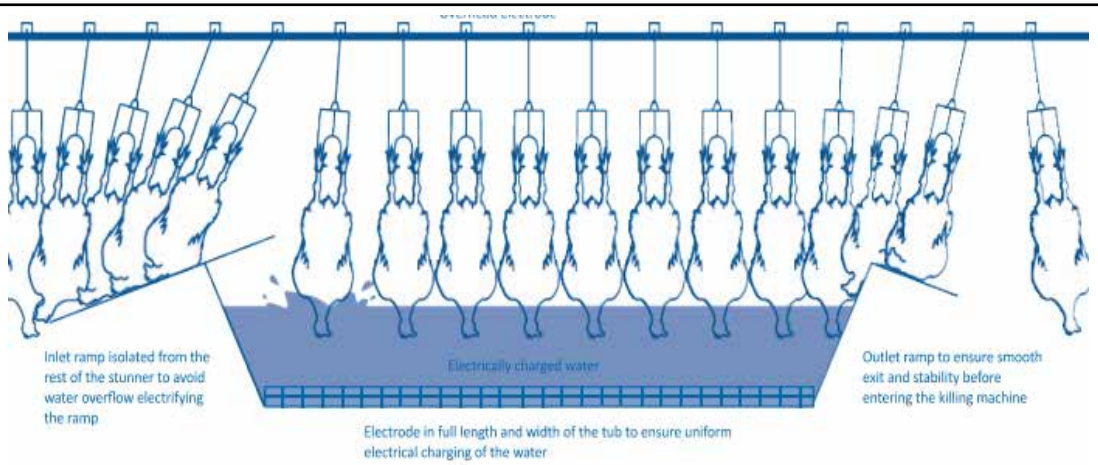
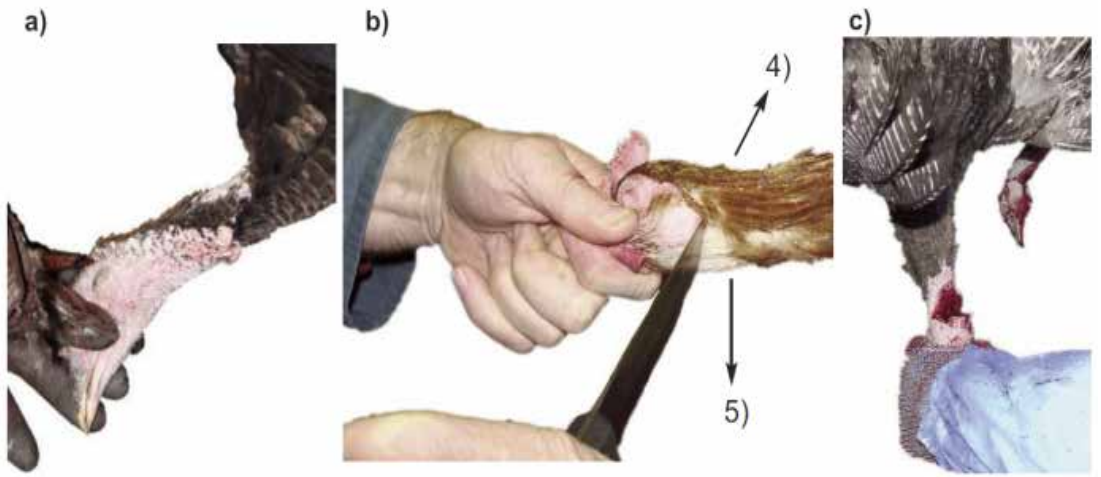
in accordance with the directions of the Veterinary Services and the manufacturer's instructions. Recommendations in the Terrestrial Manual should be followed as appropriate.

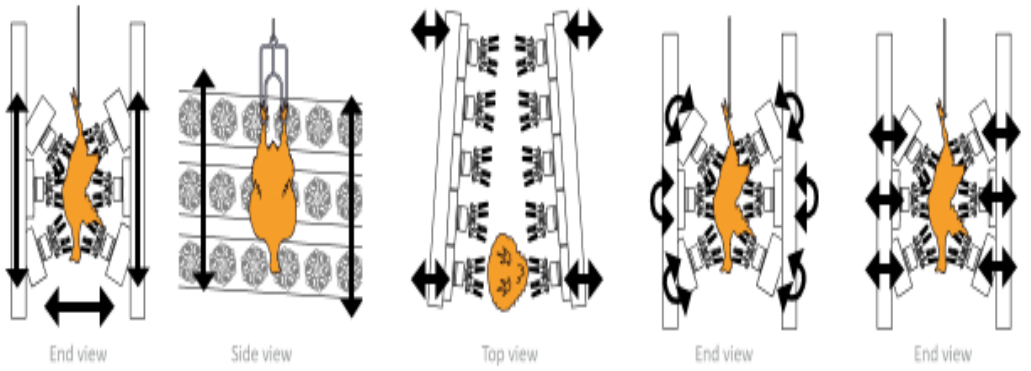
Recommendations to prevent the dissemination of infectious agents to and from live bird markets

1. Personnel should be educated on the significance of infectious agents and the need to apply biosecurity practices to prevent dissemination of these agents. Education should be targeted to personnel at all levels of operations in these markets, such as drivers, owners, handlers and processors. Programmes should be implemented to raise consumer awareness about the risks associated with activities of live bird markets.
2. Personnel should wash their hands with soap and water before and after handling birds.
3. Birds from diseased flocks should not be transported to live bird markets.
4. All containers and vehicles should be cleaned and disinfected every time they leave the market.
5. Live birds that leave the market and go to a farm should be kept separately from other birds for a period of time to minimise the potential dissemination of infectious agents of poultry.
6. Periodically the market should be emptied, cleaned and disinfected. This is of particular importance when an infectious agent of poultry deemed significant by the Veterinary Services has been identified in the market or the region.
7. Where feasible, surveillance should be carried out in these markets to detect infectious agents of poultry. The surveillance programme should be determined by the Veterinary Services, and in accordance with recommendations in relevant chapters of the Terrestrial Code.
8. Efforts should be made to ensure the possibility of tracing all birds entering and leaving the markets.

ANNEX 4: PROCESSING STEPS

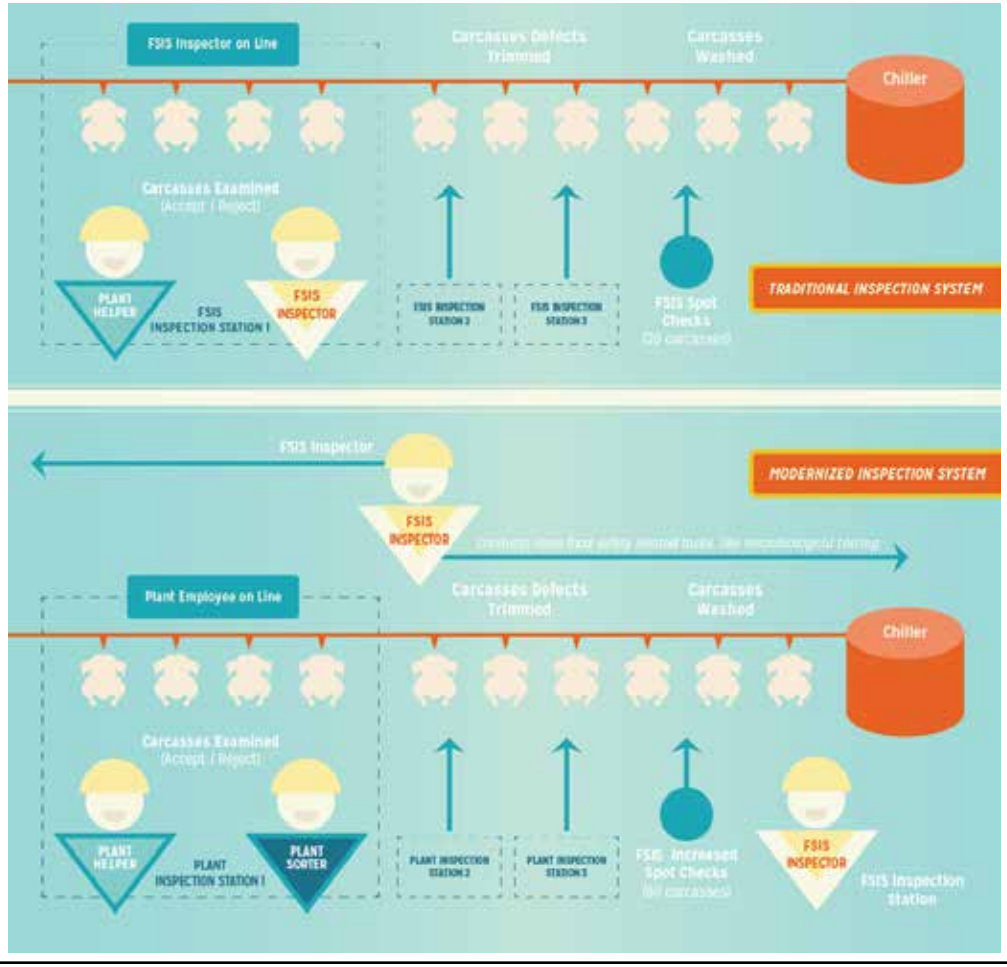
Step I	Activity	
I	Antemortem inspection	 
2	Suspension and shackling of each bird by the legs	 

3	Stunning with electrical shock	
4	Bleeding:	

5	Scalding	
6	Picking	

7	Removal of pinfeathers	
8	Evisceration	

9	Chilling in ice water	

10	Post-mortem inspection	

11	Grading	

Carcass Grading Criteria

Defects	A Grade	B Grade	C Grade	NG (nongradable)
Missing Parts	one or both wing tips and tail	wing tips, wing portions, and tail back area IF not wider than base of the tail or more than halfway to hip joints	any parts beyond wing portion (drumette, entire wing, etc.)	meaty parts (legs, thighs, back, breast portions)
Broken Bones	none	only one if non-protruding	any protruding or more than one non-protruding	no limit
Disjoints	only one	two with no breaks or one with a non-protruding break	more than two	no limit
Exposed Flesh	less than 0.25" on breast and legs less than 1.5" everywhere else	less than 1/3 of the entire part	over 1/3 of the entire part	no limit

Mix up the cards to create classes for practice then grade or place based on the standard criteria.

The chicken carcasses pictured weigh between two and six pounds. **More than one carcass of the same quality grade may be in the class at the contest.**

12	Packaging	

ANNEX 5: EQUIPMENT FOR POULTRY PROCESSING UNITS

Model 1 50 Birds/day: NYD

Equipment summary

1. 4 Cone killing stand
2. Stunning/Sticking knife
3. Dry plucking machine
4. Holding table
5. Feather bins × 2
6. Mobile racks × 2
7. Wash hand basin × 2
8. Scale
9. Cleaning equipment/hose lines (High pressure power washer)
10. Insect electrocutors × 2
11. Electrical fittings
12. 12 Drainage fittings
13. Ceiling fans
14. Office equipment: Desk, table, chairs, filing cabinet, telephone etc
15. Changing room equipment: Lockers, benches, sanitary ware, showers etc
16. Laundry equipment: Sink, cupboard, clothes lines etc
17. Boot wash

Staffing

1	Reception/sticker	1
2	Plucker	1

3	Manager/dispatcher	1
4	Cleaner/labourer	1
5	Launderer	1
Total		5

Equipment Specifications

Killing stand: Four cones to swivel about a central pillar and suspended over a blood trough. Total height about 1.2m, total diameter of 800mm, heavy duty hot dipped galvanised steel throughout.

Stunner/Sticking knife: Low voltage stunning unit in self-contained splash proof box approximately 0.25 × 0.25m. Fitted with safety trips which can cut out one or both contact pads in the event of a short circuit. The stunning prod consists of a stainless steel blade of 150mm length in a nylon non-slip handle and electrical contact pads.

Dry plucking machine: Machine comprises a 1.1 kw (1 1/2 hp) motor driving a shaft supported by a bearing assembly. The shaft drives a plucking head by a belt. The plucking head consists of a series of rotating plates held at an angle by a thrust plate at each end of the plate bearing. As the discs rotate they close, drag in the feathers, grip them and pull them from the bird. As they continue to rotate, they separate, and release the feathers into a collection bag to the rear of the machine. The plucker is of adjustable height from about 1 to 1.5m. Voltage to local specifications, single phase.

Holding table: 1m × 600mm × 900mm height, heavy duty food grade stainless steel top and frame. Top to be slightly convex, no shelves, adjustable height feet.

Feather bins: High density polyethylene, 1001 capacity. Tight fitting lid. Approx 2.5 × 0.6 × 0.6m.

Mobile rack: The unit is shaped as an "A" frame mounted on four 120mm castors. The unit is approximately 1.2m × 600mm × 1.8m high. Horizontal bars hold 140 birds suspended by their feet. Hot dipped galvanised steel after manufacture.

Wash hand basin: Heavy duty (not domestic) stainless steel with drainer. Hot and cold taps operated by knee or arm lever. Approximately 750 × 450mm.

Scale: Electronic top pan balance. Range 5kg × 10g. Water resistant. Voltage to local specifications.

High Pressure Power Washer: To produce a high velocity jet of hot water for cleaning purposes. An electrically operated pump passes water from a small storage tank through an electrically powered heat exchanger to raise the temperature of the water at the nozzle to 95°C. The pump also raises the pressure of the water at the nozzle to about 41 bar (600 PSI) at 95°C and 90 bar (1300 PSI) at the lower temperature of 68°C. Fitted with a detergent facility which permits the application of a range of detergents to increase cleaning efficiency.

Cleaning equipment: All cleaning equipment to be manufactured in plastic, nylon or stainless/galvanized steel (preferably seamless) these items should conform to hygienic standards. Comprising: a high pressure washer system with heavy duty industrial couplings, components and hose lines suspended overhead. Hose lines to be of heavy duty plastic with pressure release tap to withstand 6.8 bar. Industrial wet'n'dry vacuum cleaner, mobile bucket trolleys, mops and wringers, scrubbing brushes (with and without handles), stiff brooms and buckets (minimum capacity 13 litres).

Insect electrocuters: An ultra - violet light source set within a metal case to attract virtually all flying insects. Once the insect has been attracted to the unit, it comes into contact with an electrically charged grid where it is electrocuted and falls into a large collection tray at the base of the unit. Approximately 250 × 250 × 610mm, UV light output 160 Watts.

Electrical Fittings: To IP 54/56/65 standard for safety. Equipment should be water resistant, heavy duty.

1. Drainage fittings
2. Heavy duty grilles cast iron.
3. Ceiling fans:
4. Heavy duty (industrial) variable speed control, water resistant.

5. Office equipment:
6. Standard furniture, heavier duty preferred.
7. Changing room equipment:
8. Industrial quality.
9. Laundry equipment.
10. Industrial quality.
11. Boot wash:
12. Heavy duty, locally fabricated to fit chosen site.

ANNEX 6: EQUIPMENT FOR POULTRY PROCESSING UNITS

Model 2 200 Birds/day: Chilled whole poultry carcass

1. Poultry crates × 100
2. 8 Cone killing stand
3. Stunner/Sticking knife
4. Waterfall dip tank, with thermometer
5. Flight feather remover
6. Holding table, 2 × 1m
7. Bowl plucker or 1.5m plucker
8. Feather bins × 3
9. Mobile racks × 3
10. Evisceration carousel or Evisceration table
11. Evisceration tools, 3 sets
12. Single sided giblet station × 1
13. Carcass washer
14. Sink unit/sterilizer × 2
15. Wash hand basin × 3
16. Icemaker, for use with ice tank only
17. Ice tank or Spiral washer chiller
18. Packing table × 2
19. Shelving
20. Offal truck
21. Scale
22. Dry storeroom
23. Cold storage
24. Blast freezer
25. Freezer storage
26. Insect electrocutors × 3
27. Electrical fittings
28. Drainage fittings
29. Ceiling fans
30. Office equipment: Desk, table, chairs, filing, cabinet, telephone etc
31. Changing room equipment: Lockers, benches, sanitary ware, showers etc
32. Laundry equipment: Sink, cupboard, clothes lines etc
33. Boot wash
34. Cleaning equipment/hose lines (High pressure power washer)
35. Bagging machine × 2
36. Bags, trays, film, cartons etc
37. Optional air conditioning

Staffing

1	Reception/sticker	1
2	Scalder	1
3	Plucker	1
4	Evisceration	1
5	Truss/Packer	2
6	Manager/dispatcher	1
7	Cleaner/labourer	1
8	Launderer	1
Total		9

Equipment Specifications

Cone killing stand, Stunner/Sticking knife, Holding table, Feather bins, Mobile racks, Wash hand basin, Scale, High Pressure Power Washer, Insect electrocutors, Electrical fittings, Drainage fittings, Ceiling fans, Office equipment, Changing room equipment, Laundry equipment, Boot wash, Steam cleaner: All as model 1

Poultry crates: Commercial standard in heavy duty plastic to hold 10–12 live birds. Washable under high pressure

Waterfall dip tank, with thermometer: A 1.22m waterfall dip tank which ensures the bird is immersed in hot water. Powered by a 0.75kw motor and heated by LPG or electricity.

Flight feather remover: Two horizontal metal shafts of 300mm in length and 50mm diameter set at 2– 5mm gap are powered by a 1kw motor. As the shafts rotate, they grip the offered flight feathers and pull them from the wings. The action is similar to that of a washing mangle. With safety guards/stops to prevent fingers and wing meat being drawn into the roller jaws.

Bowl plucker or 1.5m plucker: Aluminium bodied plucking machine mounted on legs. Round plucking bowl contains two double,

rubber flails which are rotated by an electrical motor of 4kw. Carcass to manufacturers weight specification are placed into the bowl and plucked in about 35 seconds.

Plucker comprises tank holding a horizontally mounted stainless-steel drum of about 0.5m diameter. The drum holds protruding rubber fingers of about 200mm. The drum revolves briskly away from the operator taking the feathers from the offered carcass and throwing them to the back.

Evisceration carousel: A circular tray made of heavy-duty aluminium of 1.25m in diameter at waist height. A wheel is located above this tray at a height of 1.5m from which is suspended a series of poultry hangers. One to five operators stand around the tray and each performs a part of the evisceration process. The wheel is turned by hand so that the next carcass is presented to the operator. Offal is dropped into the tray. The tray has a hole through which the offal passes into an offal truck.

Evisceration table: 2m × 1m × 900mm height. Heavy duty industrial stainless-steel table with cutting board. A small hole is cut into the surface of the table, under which an offal truck or bin can be placed.

Evisceration Tools: A set of heavy-duty stainless-steel tools for the removal of most of the organs from the cavities of the bird, the head, neck and associated tissues. A comprehensive set of tools comprise; fork/spoon, knife, hook (for roping), rollcut secateurs, hand singeing gun, stubbing knife, drawing tool and lung remover (serrated loop).

Single sided giblet station: Comprising: Table, 3 giblet pans and 3 pan supports. Giblet pans, chopping blocks and cleaning screens are arranged over a large heavy gauge steel plate basin which is mounted on four substantial legs fitted with two spray traps for connection to mains water supply. Unwanted material is automatically washed away leaving the working surface clean and uncluttered.

Carcass washer: water hose suspended from the ceiling with a gun-style water nozzle. Water is sprayed onto the carcass by operation of the trigger.

Sink unit/sterilizer: For cleaning and sterilizing poultry processing tools and implements. Comprising; 1m long stainless-steel sink unit with draining board and an electrically operated sterilizer constructed from heavy gauge stainless steel, 0.2 × 0.3 × 0.3m.

Icemaker: Self-contained stainless-steel machine producing flaked ice at approx-25°C from a mains cold water supply. Production capacity 400 kg/day. Standard storage capacity 200 Kg. Dimensions (W × D × H) 1.08 × 0.85 × 1.58m. Extra storage bins (0.38m^2) required to increase storage capacity to 500 Kg. Mains water, electricity and a drain required.

Ice Tank: Insulated tank to contain slush ice for initial cooling of poultry carcass. Dimensions 2.5 × 0.6 × 0.6m

Spiral washer chiller: Insulated stainless steel tank containing water previously cooled over an in- built refrigeration coil to 4°C. The refrigeration compressor, motor, valves etc. are integral with the machine and to a capacity specific to the production system. A programmable timer is supplied to pre-chill the water in readiness for production. May be supplied with an auger to assist passage of carcass.

Packing table: As holding table

Shelving: Heavy duty (industrial) hot dipped galvanised or stainless steel.

Offal Truck: Heavy duty galvanised steel truck mounted on four industrial castors/wheels. Approximately (L × W × D) 0.6 × 0.6 × 0.45m. Comprising, galvanised steel basket inside the truck, into which offal is placed and a tap at the base for draining liquids.

Dry storeroom: A dry, well ventilated and lit store room approximately 3 × 4m. Insect proof air bricks for ventilation fitted with industrial heavy duty shelving. Under extreme environmental conditions a dehumidifier or air conditioning unit may be required.

Cold storage: Modular construction cold storage cabinet (2°C). Approx. 2.5 × 3m. To cool 300kg of poultry carcass from 10°C to 2°C in 12 hours under prevailing environmental conditions. Power and drain required.

Blast freezer: Self-contained machine for freezing of up to 100 birds (150kg) from 2°C to- 40°C within 2 hours. Dimensions (w/d/h) approx. 2045 × 3315 × 2590m. Power supply and drain required.

Freezer storage: Modular construction walk-in freezer (-20°C). Approx. 3 × 4m. To hold 450kg of poultry carcass at -20°C. Power and drain required.

Bagging machine: An electrically operated machine for manual vacuum bagging/wrapping of birds one at a time in high shrink plastic film bags. Power required. Bags, trays, film, cartons etc.

High shrink plastic film which prevents dehydration, acts as a moisture barrier and is permeable to oxygen, thereby maintaining meat colour. Also expanded polystyrene trays and plastic cartons for hygienic meat packaging.

Air conditioning: To suit local conditions

ANNEX 7: EQUIPMENT FOR POULTRY PROCESSING UNITS

Model 3 350 Birds/hour: Chilled whole poultry carcass and portions

1. Poultry crates, × 1000
2. Complete hanging/sticking/bleeding/scalding equipment, comprising: loading bar, 15m overhead conveyor for killing and bleeding out, 75 S/S shackles, 2.5m bleeding trough and 3m waterfall dip tank.
3. Stunner/sticking knife
4. Flight feather remover
5. Bowl plucker or 1.5m plucker with booster flail
6. Feather bins × 3
7. Pinning table or finisher
8. Evisceration unit comprising: 16m conveyor line, 65 shackles, 3.7m evisceration trough and mobile offal truck.
9. Carcass washer
10. Giblet processing station, comprising table, 3 pans and 3 pan supports
11. Gizzard skinner
12. Mobile racks × 10
13. Evisceration tools, 4 sets
14. Secateurs
15. Boning knives × 48
16. Pinning knives × 24
17. Knife sharpener
18. Thermometer
19. Carcass washer
20. Sink unit/sterilizer × 42
21. Wash hand basin × 2
22. Icemaker for use with ice tank only

23. Ice tank or spiral washer chiller (both optional)
24. Refrigeration for carcass(optional)
25. Packing table × 2, 2 × 1m
26. Poultry portioning machine
27. Shelving
28. Scale × 2
29. Dry store room
30. Blast freezer,
31. Freezer storage
32. Cleaning equipment/hose lines(High pressure power washer)
33. Insect electrocutors × 5
34. Electrical fittings
35. Drainage fittings
36. Ceiling fans
37. Office equipment: Desk, table, chairs, filing cabinet, telephone etc
38. Changing room equipment: Lockers, benches, sanitary ware, showers etc
39. Laundry equipment: Sink, cupboard, clothes lines etc
40. Boot wash
41. Bagging machine
42. Trays, films, and cartons for packaging
43. Offal skip
44. Air-conditioning(optional)

Staffing

Killing and Plucking		
1	Unloading, handling and washing crates	1
2	Removing birds from crates and hanging onto conveyor line	1
3	Killing	1
4	Plucking machine operators	4
5	Pinning, inspection of plucked birds 2 and hanging plucked bird onto conveyor	
Total		9
Evisceration		
1	Slitting necks, detaching from crop and depositing into evisceration trough	1
2	Cutting round vents and opening aperture	1
3	Drawing out viscera but leaving it attached to the carcass	1
4	Removing liver, hearts and gizzards and placing them in the appropriate giblet trays. Detaching inedible offal and allowing it to fall into the evisceration trough	1
5	Inspecting inside the carcass, removing remainder of lung tissue, removing head and placing in evisceration trough. Removing neck and placing into the appropriate giblet tray	2
6	Cutting off feet and hanging carcass onto air conditioning racks	1
Total		7
Offal preparation		
1	Slitting and washing gizzards	1
2	Sorting and packing edible offal	1
3	Supervisor, moving full and empty offal trays and assisting	1
Total		3
Cooling		
1	Handling and moving air conditioning racks in and out of chill room, and to and from various workstations	1
Total		1

Packing		
1	Putting chilled packed offal inside carcass	1
2	Tying down, banding or trussing	1
3	Putting bird inside bag	1
4	Weighing and placing pre-printed weight label inside bag	1
5	Sealing bag and placing in freezer tray	1
Total		5
Supervisory and reliefs		4
Grand Total		29

Equipment Specifications

Crates, Stunner/sticking knife, Flight feather remover, Finisher, Bowl plucker or 1.5m plucker with booster flail, Feather bins, Mobile racks, Evisceration tools, Spiral washer chiller, Carcass washer, Sink unit/sterilizer, Wash hand basin, Shelving, Scale, Dry store room, High pressure power washer, Insect electrocutors, Electrical fittings, Drainage fittings, Ceiling fans, Office equipment: Desk, table, chairs, filing cabinet, telephone etc, Changing room equipment: Lockers, benches, sanitary ware, showers etc, Laundry equipment: Sink, cupboard, clothes lines etc, Boot wash, Trays, films, and cartons for packaging: As for 200 Birds/day.

Complete hanging/sticking/bleeding/scalding equipment, comprising: loading bar, 15m overhead conveyor for killing and bleeding out, 75 S/S shackles, 2.5m bleeding trough and 3m waterfall dip tank.

An oblong open structure in galvanised steel, measuring 7 × 1.5m comprising the superstructure to hold an overhead rail. The rail is about 2.2m from the floor. The rail holds a conveyor system of approx. 15m in length comprising 75 stainless steel shackles supported by a rod and trolley system. The shackles are "W"-shaped and used for holding poultry by their legs. Each shackle is separated and attached to its neighbour at 0.2m intervals by a chain. This continuous loop is driven by a motor at a speed of 0.6–1.4m/min. A loading bar of 1.0m is positioned at the same height as the poultry shackle to steady it as the poultry is loaded. As the shackles move round the system they pass over a 2.5m stainless steel bleeding trough at the second bend. This "L"-shaped structure is free standing on adjustable stainless-steel legs. Continuing on its journey, the rail guides the conveyor downwards by

about 0.5m for the dead poultry to pass into the stainless-steel waterfall dip tank. This scalding tank is 3m in length and 0.6m wide. It is free standing on adjustable stainless-steel legs. It has a drain and a system for maintaining its water level. The scald water is heated to temperature by electricity or gas. Finally, the rail rises to its original level before turning two bends to reach the loading bar again. See Drawing 3.

Pinning table:

1 × 0.6 × 0.9m height, heavy-duty stainless-steel top and frame with adjustable feet. For the removal of pin feathers from poultry. Evisceration unit comprising: 16m conveyor line, 80 shackles, 3.7m evisceration trough and mobile offal truck.

An open structure in galvanised steel comprising the superstructure to hold an overhead rail. The rail is about 2.2m from the floor and is about 16m in length on a continuous loop which is roughly "L"-shaped. See Drawing 3. The rail holds a conveyor system comprising 80 stainless steel shackles supported by a rod and trolley system. The shackles are "W"-shaped and used for holding poultry by its legs. Each shackle is separated and attached to its neighbour at 0.2m intervals by a chain. This continuous loop is driven by a motor at a speed of 0.6–1.4m/min. The shackles pass over a stainless-steel evisceration trough. This trough measures 3.7m × 1.0m and stands about 1m from the floor. It is a wide "V" shape in cross section and slopes to the mobile offal truck situated at one end. The trough is provided with water taps to assist with transport of the viscera to the truck. The trough holds three giblet pans mounted on supports. The overhead rail then passes through the bird washer (which see) and over the pinning table to complete the circuit. The mobile offal truck comprises a perforated container of 0.5^3m, made of galvanised steel. The container is supported on a trolley of four wheels, a handle and a tap at base to drain liquids.

Carcass washer

To wash the carcass thoroughly both externally and internally after it has been completely eviscerated. Incorporating a water spray and two soft flail loaded spindles. The gentle sponging action ensures a clean carcass. Adjustable legs and an accommodation for various bird sizes. The two cleaning drums are rotated by two independent electrical motors. Alternatives include replacement of the flails with 12 angular adjustable spray heads. A pump ensures water at high pressure cleans carcass.

Giblet processing station:

Comprising table, 6 giblet pans and 6 pan supports. Giblet pans, chopping blocks and cleaning screens are arranged over a large heavy gauge steel plate basin which is mounted on four substantial legs fitted with two spray traps for connection to mains water supply. Unwanted material is automatically washed away leaving the working surface clean and uncluttered.

Gizzard skinner:

Two intermeshed serrated rollers powered by a geared electric motor remove the skin after the gizzards have been cut open and thoroughly washed to remove all the grit. This machine can be mounted either over the eviscerating trough or above the giblet station so that the skins are washed away as they are peeled off.

Secateurs:

- Heavy duty stainless steel
- Boning knives:
- Heavy duty stainless steel, in a non-slip nylon handle
- Pinning knives:
- Heavy duty stainless steel, in a non-slip nylon handle
- Knife sharpener:
- Heavy duty

Thermometer:

Electronic battery or mains operated digital display instrument constructed in heavy duty, splashproof plastic with a 150mm stainless steel washable probe.

Icemaker:

Self-contained machine producing flaked ice at approx -25°C from a mains cold water supply. Production capacity 5000 kg/day. Storage capacity up to 5000 kg. Dimensions (W×D×H) 1.72 × 2.15 × 1.85m. Plug in unit requiring only connection to water, power

supply and drain.

Ice tank (optional):
Insulated tank to contain slush ice for initial cooling of poultry carcass. 5 × 1.4 × 1.4m

Refrigeration (optional)
To cool 4 racks of 150 birds (900kg of poultry carcass) from 35°C to 2°C in 2 hours under prevailing environmental conditions.

Packing table:
As holding table

Poultry Portioning Machine:
Electrically operated machine in stainless steel. Bird is placed onto guarded blade for portioning. With rest for bird placement.

Blast freezer:
There are two options:
Built in blast freezer room (as shown) to hold eight racks, equivalent to about 750–900 carcass or 1500kg poultry carcass.

3 × standard blast freezing machines of 300 bird capacity (450kg). Mains power supply and drain required. Each standard unit is 2045 × 5070 × 2895mm (w/d/h). This would give greater flexibility and control over the processing operation.

Both units have an operating temperature of -40°C with average air speed of 2–4m/s to cool poultry from 5°C to -40°C in 2 hours under prevailing environmental conditions.

Freezer storage:
Modular construction walk-in freezer unit (-20°C) approx. 9 × 4.5m. Power and drain required.

Bagging machine:

A vacuum packaging machine for bagging/wrapping birds in high shrink plastic film bags. Power required. Birds arrive by conveyor, with fully automatic wrapping and sealing for virtually continuous packaging.

Offal skip:

Standard skip to take 14001 of offal waste

Air conditioning

To suit local conditions

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