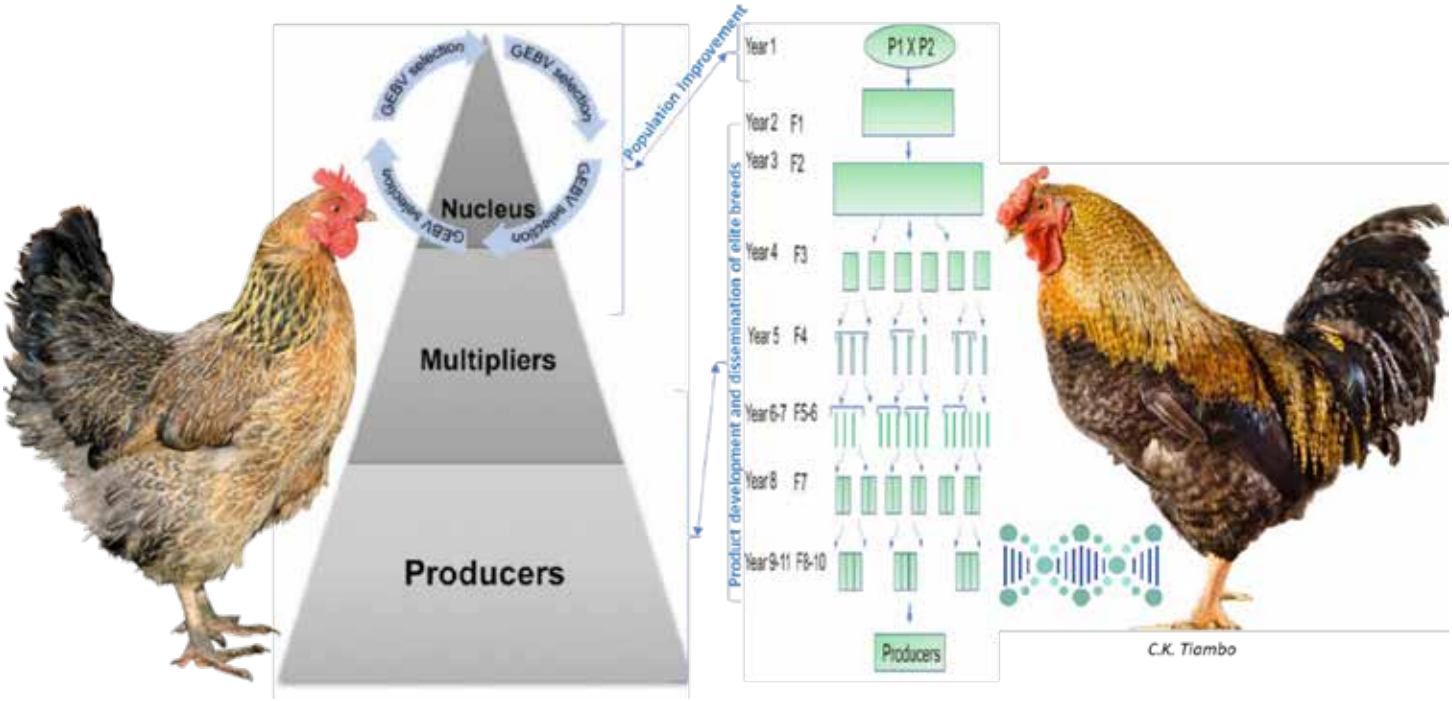
AFRICAN UNION
INTERAFRICAN BUREAU
FOR ANIMAL RESOURCES

LiVe2Africa
Sustainable Development of Livestock for Livelihoods in Africa

EUROPEAN UNION

DRAFT

TECHNOLOGIES FOR THE PROMOTION OF LOCAL CHICKEN VALUE CHAIN IN AFRICA



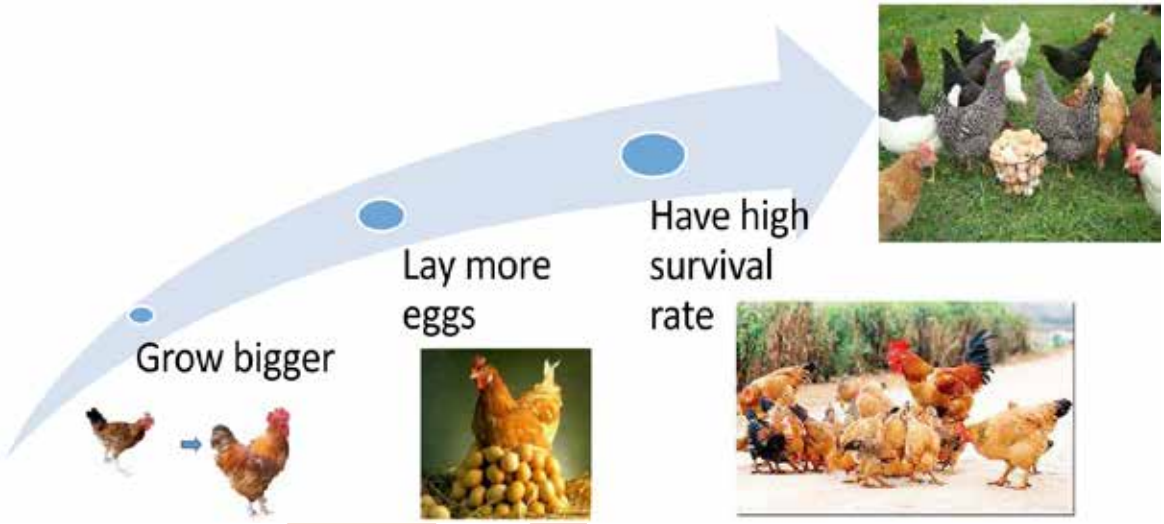
INTRODUCTION

Family/traditional chicken farming is in principle a small-scale chicken production by households using family labour and, and when possible, locally availability feed. Chicken can roam freely, foraging the large part of their feed. The supplement can be provided by the farmer. The work, carried out by the members of the family, is not remunerated.

Family chicken farming is rarely the only means of existence for the household but represents one of the many integrated and complementary activities of the farming system that contribute to its general well-being. They are often used simultaneously for several objectives and can be as efficient as specialized commercial breeds if we consider multiple productivity vocations including incubation and brooding, meat, and egg production as well as cultural uses.

It constitutes an undeniable 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, it is affordable to women and children. Other reasons why family chicken should be given priority: (1) directly reduce poverty by generating income, (2) indirectly provide primary education to all, (3) directly promote gender equality and empower women, (4) indirectly reduce child mortality, (5) directly improve maternal health.

The objective of this document is to help transforming smallholder chicken production in Africa, by providing chicken that can:



GENERAL CHARACTERISTICS AND FACTS ABOUT AFRICAN CHICKENS

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

They are:

- Generally hardy, adapted to harsh environmental conditions, rustic.

- self-reliant, feed themselves by looking for kitchen wastes, insects, worms, lizards and plant seeds and leaves.
- Small and slow growth rates.
- Meat and eggs have good, attractive pigmentation, leanness, tastes, and suitability for special Nigerian dishes.
- Good brooding aptitudes,
- Age at sexual maturity is between 133-169 days under an extensive system.
- Poor egg producers (40-50 eggs/year under an extensive management system).
- They have good fertility and hatchability rates.

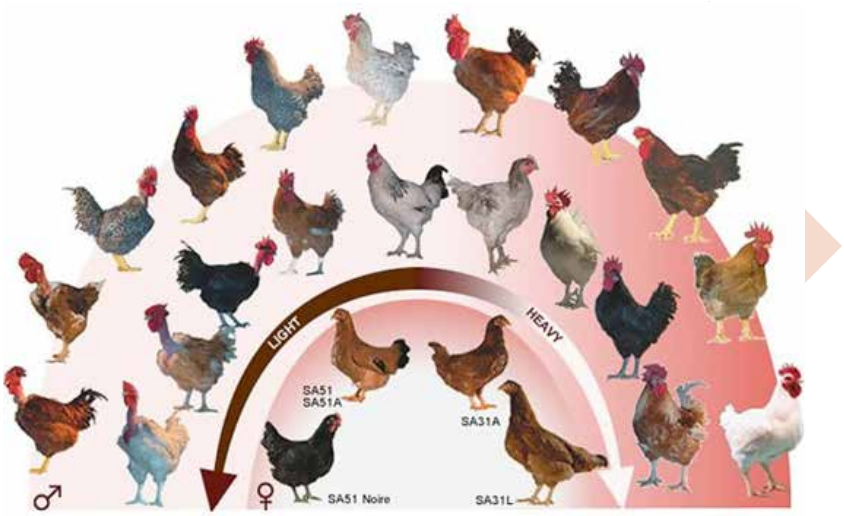
Sources : NAFIS, http://www.nafis.go.ke/livestock/poultry-chicken/indigenous-chicken-kienyenji/breeds-of-indigenous-chicken/

Local chickens are genetically adapted to harsh environment characterized by limited feed resources, bad weather conditions, pathogens, and predators. They are also characterized by great genetic variability, hardiness, better brooding aptitudes.

There is a great diversity of African chicken genetic resources, dual purpose and locally adapted, which just need little attention for their productivity to satisfy the need of the local and international market for meat and eggs.

There are also a number of locally improved or adapted breed which can support the commercial production systems in Africa.

The SASSO family picture of breeders roosters and hens



Kuroiler (composite)

Shika Brown

National Animal Production Research Institute (NAPRI) in Shika, Zaria,

FUNAAB Alpha chicken

Noiler

Fulani

Performance of the cocks @ 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

Performance of the 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

There exist many other high performing genetic types and ecotypes of chicken in Africa, but most of their potentials are not efficiently used.

Kabir (composite)

Obtained from
GreenGold AgroVenture
Cameroon

African farmers also hold several exotic strains locally adapted for meat, egg and mixed production: Vedette, Rhode Island Red, Plymouth Rock, New Hampshire, Orpington, Brahma, Cornish, Leghorn, Sussex, Flaveroles, etc. Below are 10 productive Chicken Breeds for backyard meat and/or eggs and Commercial Production. They are adaptable to varying climatic conditions.

Sussex

Sussex chickens are dual-purpose birds and lay about 250 eggs annually in varying shades of light brown. They come in 8 different colours, the most common being the pure white body with a black neck and tail feathers. They are very calm and love the free range.

Rhode Island Reds (RIR)

RIR are dual-purpose chickens, 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 tough and lay lots of 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 is also, one of the productive chicken breeds and they originate from Australia. They are raised for both eggs and meat because they are very good layers and hardy. Australorp lay about 250 brown eggs in a 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 sweet or docile temperament. They have some beautiful laced colour varieties, gold, blue and silver. The Wyandottes also come in many other colours.

Jersey Giant

The Jersey Giant chickens are dual-purpose chicken and the hen lays about 260 brown eggs a year. Jersey Giant chickens are very large. These blue, black, and white giants are the largest of the pure breeds. They are calm, docile, and excellent for beginner flocks

Leghorn

Leghorn chickens are productive layers. The hen lays about 280 white eggs a year. They are not calm or docile, rather they are flighty. They may startle easily. 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 hardy. The Orpington are fluffy and come in multiple of colours, blue, buff, black, white and lavender). They are also very beautiful and friendly.

Barnevelder

The Barnevelder is a cross between the Dutch Landrace and Asian jungle fowl and a native to Holland. A Barnevelder hen lays around 200 eggs per year. These eggs are small to medium-sized and a light speckled brown colour. This breed is mostly a black with brown tipped feathers. This breed is better suited for the backyard. It isn't a great flyer so you would not need to clip their feathers.

Marans

They appear like Plymouth Rocks and are mostly dark grey with white flutters. Marans are also dual purpose and lay about 200 eggs a year. They are renowned for their vibrant dark brown and tasty eggs. They are usually medium in size. Marans are a very gentle and do not require much space to roam. However, they are not tame and so are not good pets.

Breeding techniques generally consist of:

- Introducing an improving cock while avoiding inbreeding and popularize the F1 population,

- Introduce fertile eggs, chicks, or pullets of improved breed and
- Reduce losses from predation, theft, disease,

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 seen 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.

Scavenging chickens are a particularly good source because of their varied diet.

Nutritive value of eggs

Egg is 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.

Overview of SWOT Analysis Chicken Sector- both for eggs and chicken

STRENGTHS	WEAKNESSES
1- Low cost Protein in the country 2- Good growth rate- CAGR is around 5% for eggs and 7% for chicken; The CAGR of GVA for last 5 years for egg and chicken is 13% and 15% respectively. Rising economy & growing emphasis on chicken products. 3- Livestock contributes 12% to rural household monthly Income; Chicken alone can contribute half of the same Coping up with captive production of Soya bean & maize 4- Consolidation of integrated operations would strengthen chicken supply chain	1- Lack of infrastructure facilities for Value addition such as Chicken processing, warehousing, Cold storage, refrigerated vehicles 2- High Maize & Soya price fluctuation leading to availability issues of chicken feed at reasonable prices 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 LIT birds for upgraded family chicken 3- Untapped potential for the export & value-added chicken products.	1- Avian influenza, Newcastle disease and other emerging/re-emerging diseases 2- Calamity

Advantages in choosing local chickens for farming

- They are self-sustaining i.e. can raise their own replacement stock
- They are hardy birds that can survive hard conditions
- Management requirements are not critical as those of commercial exotic breeds
- They are immune to some diseases and parasites
- Their products fetch more money than those from exotic birds

Limitations in choosing local chickens for farming

- They have a low growth rate
- They produce fewer small-sized eggs and comparatively little meat
- People keep them without commercial purposes
- They have been neglected by breeders/scientists despite their potential

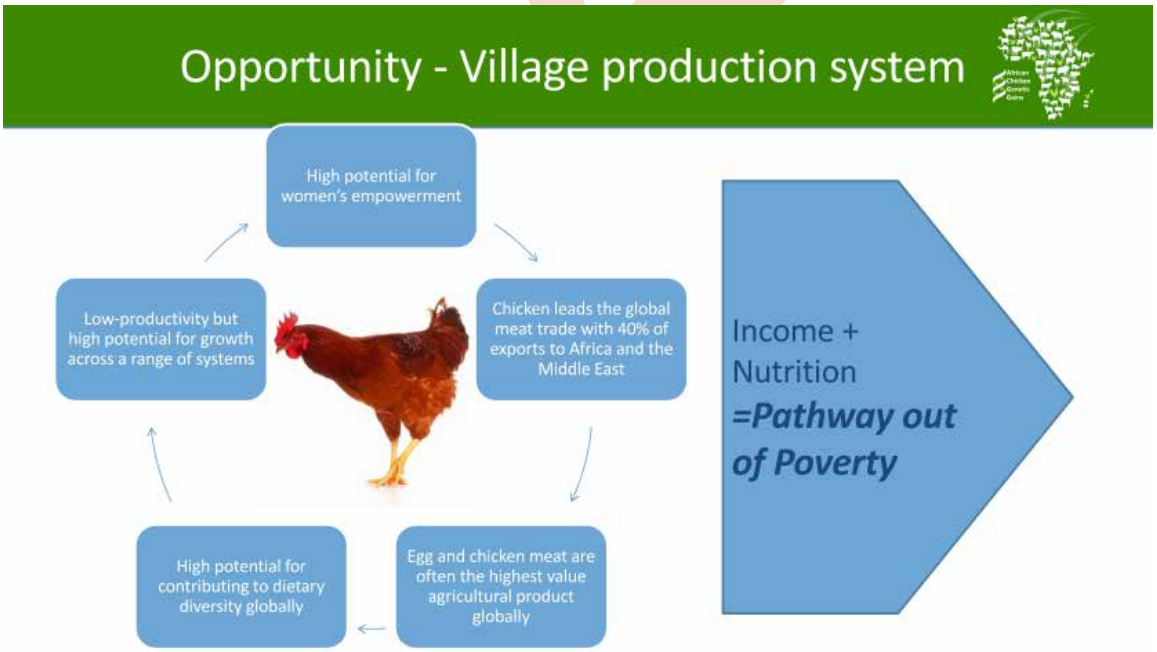
Growth Drivers and Emerging Trends for eggs and chicken in Africa

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

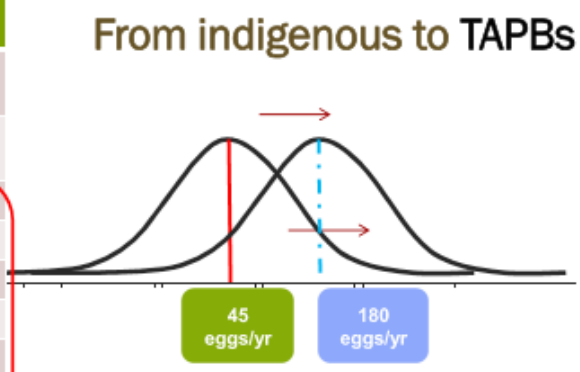
- rising incomes and a rapidly expanding middle class,
- emergence of vertically integrated chicken producers that have reduced consumer prices
- lowering of production and marketing costs.

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 chicken industry growth in Africa. Further, disease surveillance, monitoring and control will also decide the fate of this sector.

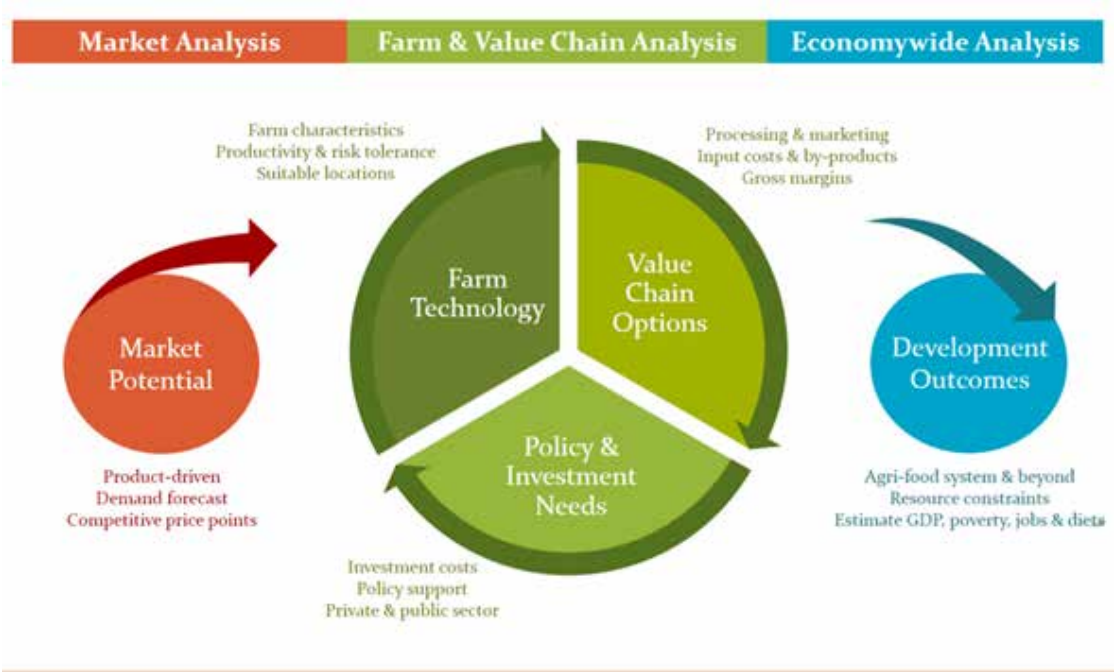
These achievements and growth rates are still being sustained despite the ingress of avian influenza which was a severe setback for the industry, showing the resilience of the subsector, perseverance of the private sector and timely intervention by the government.



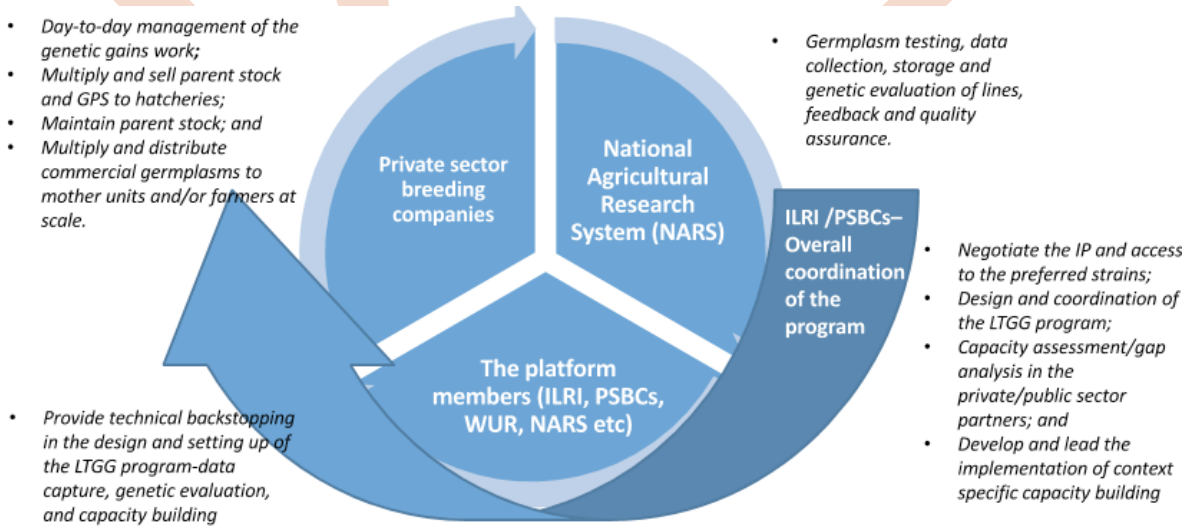
Geography / Conditions	Breed	Average eggs/ year
West Africa scavenging (sub)-humid	Indigenous	33
East Africa scavenging (sub)-humid	Indigenous	58
Egypt	Fayoumi	146
South Africa	Koekoek	204
Ghana (intensive feeding)	Naked Neck	288
Ghana (intensive feeding)	Frizzle Feather	287
Uganda	Kuroiler	180
India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



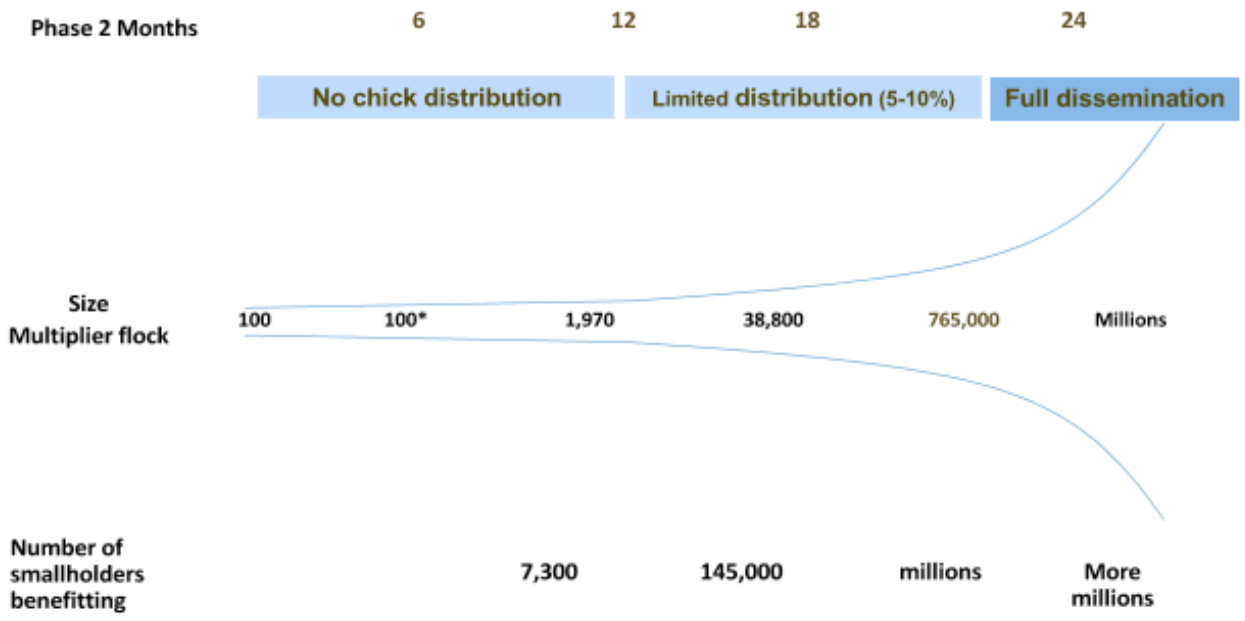
Source : Mwacharo et al 2008; Dessie et al 2011



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



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

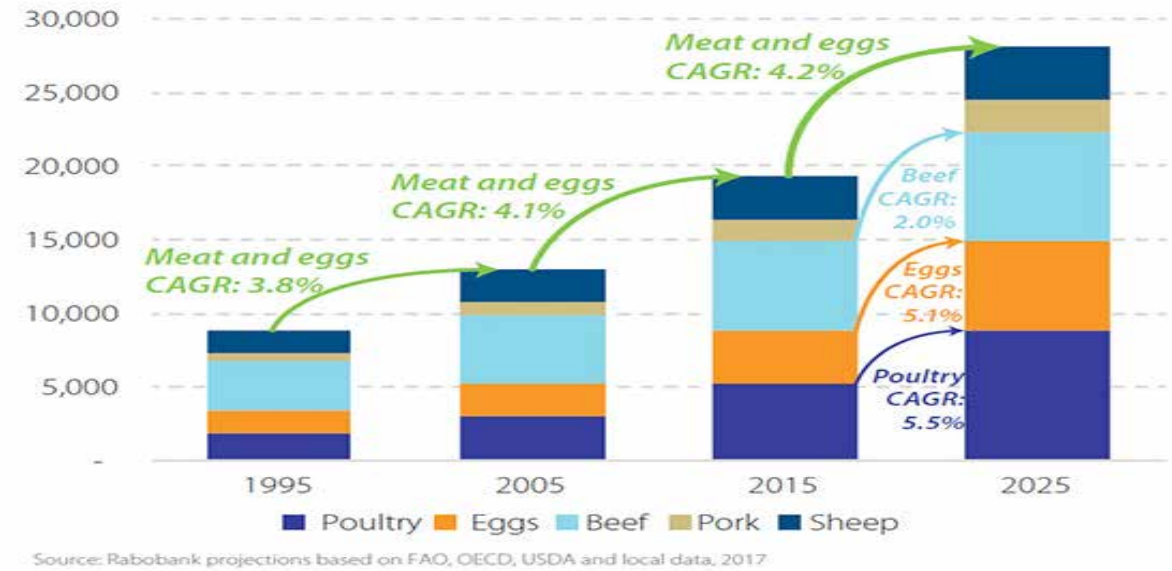


This model can be implemented simultaneously in multiple geographies and countries.

I- LOCAL CHICKEN VALUE CHAIN IN AFRICA

1) Profile of the African local chicken sector

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



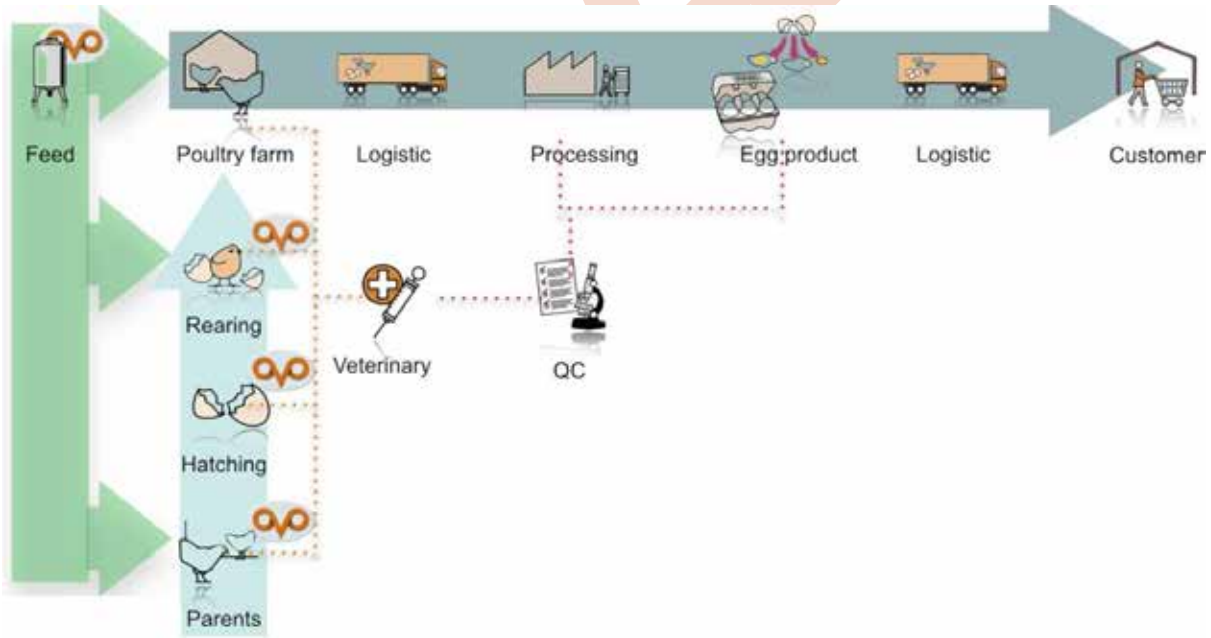
The African chicken and egg industry are in a fast growth mode with huge investment opportunities in distribution through butcher shops and restaurant chains. opportunities for investors in several areas:

- Meat processing: Developing a modern chicken value chain
- Breeding: Establishing a modern breeding supply chain

- Equipment: Supplying the right equipment for the growing, more modern, industry
- Animal nutrition: Setting up feed mills to supply more modern compound feed, distributing premixes and additives
- Grains & oilseeds: Developing adequate supply for local feed manufacturing

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).



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.

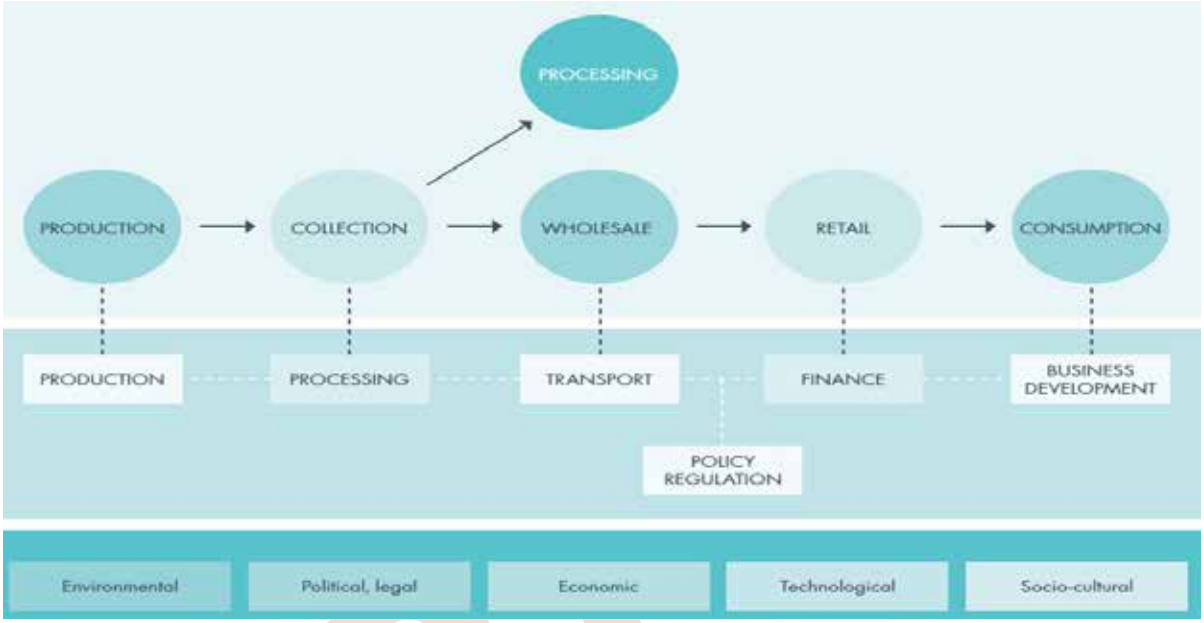


Fig.: Major livestock value chain components and potential areas of advisory and technical interventions.

3) **Governance mechanism of the value chain via local chicken 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, 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:

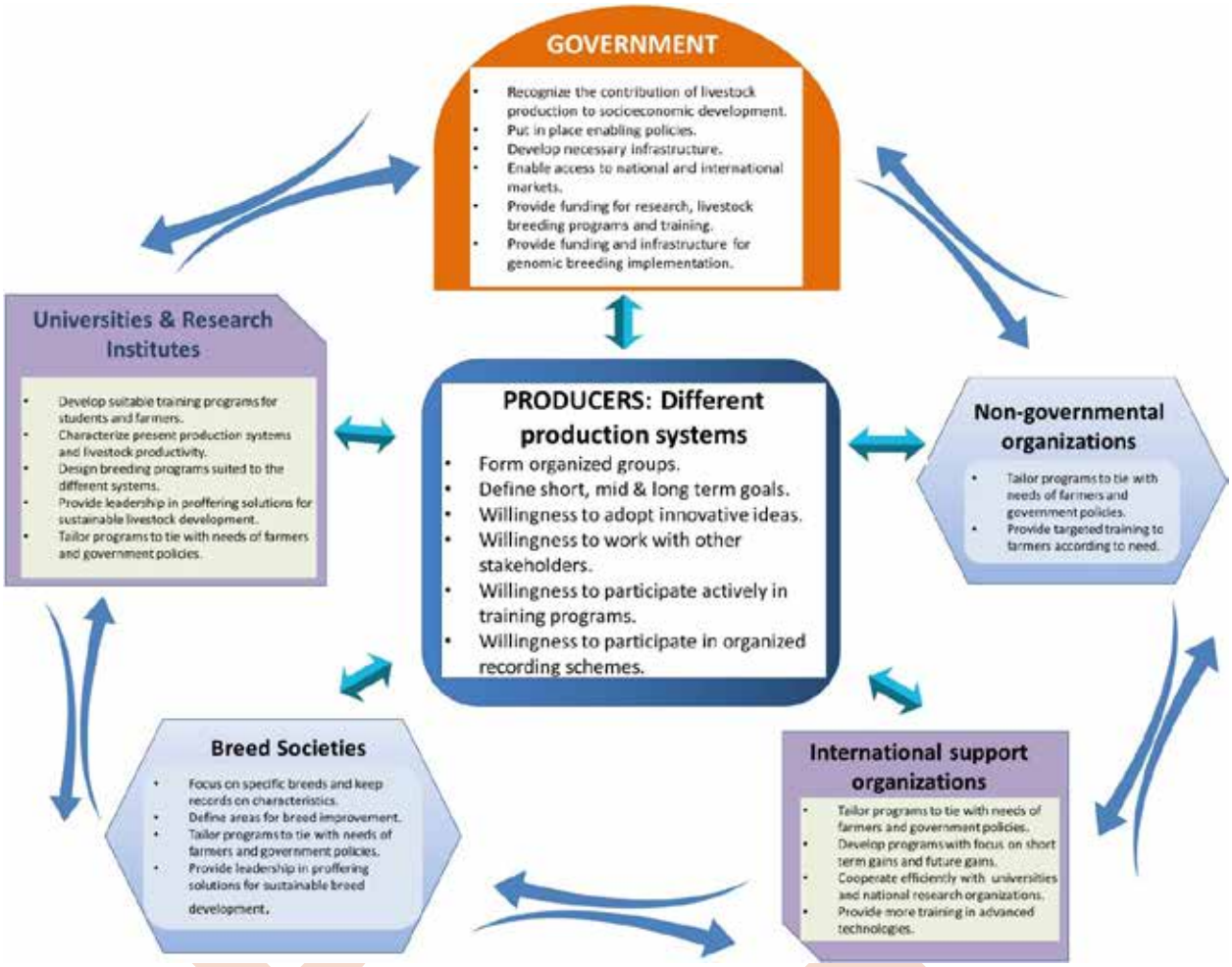
- Ensuring compliance with regulatory requirements and compliance with the requirements of this VC Guide,
- Non-conforming product management,
- Corrective and preventive action management,
- Welfare (who ideally should be independent of the production function).

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 met.

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 needs conducive environment to grow for which policy support & intervention is required mainly for disease surveillance, Drug residue and drug/ vaccine quality control, standardization & quality control of chicken 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 & export boosting etc.

For successful implementation of structured genomic breeding programs for African livestock 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.



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

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. We can distinguish four main categories of family poultry systems:

- Small extensive ranching,
- Extensive breeding in freedom,
- Semi-intensive farming,
- Small intensive farming.

1) Characteristics of the various production systems

a) Free range

- Poultry are dependent on local food resources, in some areas, a food supplement is distributed to birds

- Low level of inputs
- Poultry can move freely in the environment, but movement is limited by crops
- The composition and size of the herd are variable
- Generally, no shelter for poultry, sometimes Accommodation for the night
- Breeds adapted to the local environment
- Production generally intended for sale
- Provision of food, shelter for the night and sometimes water
- Not confined in an enclosure during the day
- A large part of their diet comes from wandering
- The majority of food is produced on site and sometimes distributed to hens and chicks

b) **Semi-intensive**

- Specialized exotic breeds
- Trade in eggs and live birds
- Growing demand for animal health services
- Purchase of certain feed for poultry
- Investment in housing / infrastructure
- Food and water for poultry
- Specialized in the production of meat or eggs

c) **Small-scale intensive**

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

2) **Chicken housing**

Local chicken, given its zootechnical parameters, is not profitable when produced in absolute confinement. Food expenses will dramatically increase operating costs. For local poultry, it is important that the animals are at certain times of the day outside the henhouse in search of a few natural foods and in optimal

ventilation conditions. The fact that poultry are found at certain times of the day outside the chicken coop supports the designation of semi-free-range poultry habitat

a) **Importance of the poultry house**

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

b) **Choice of the site**

- 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 the wind;
- The site must not be too rough.

c) **essential features of housing and design**

- Building a large chicken house ideal for chicken
- Be rainproof
- Be secure from windy rains
- Have smooth surface walls to stop mites and other pests from hiding
- Periodically spraying the chicken unit with insecticide and disinfectants
- Periodically removing the dropping/cleaning the chicken house regularly

- Have good ventilation and in hotter areas at least 2 sides should be partly chicken wire mesh
- Preferably have cemented floor for ease of cleaning and disinfecting
- Be rat-proof
- Using plenty of litter after cleaning the chicken house
- Keeping the right number of birds in chicken houses
- Separating chicks from old birds

d) **How to set the egg-laying house ?**

- Floor accommodation (hens, canes and turkeys);
- 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.

The quarantine building can be constructed from local materials (round hut) and placed at a suitable distance from the chicken coop;

e) **Materials and equipment**

- Plan a route 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);
- xyphoid waterers exist in manual and automatic to be placed in the chicken coop or under the trees of the course
- Provide 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 chickens);
- Provide a litter in wood shavings or chopped straw.
- Provide transport cages for live poultry
- Mini 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 every bird.

- 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 designs 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. Pelletization of dried manure further stabilizes the material, reducing dust. Some countries are using Black soldier fly (BSF) larvae are an alternative system for manure treatment.

- Remote Access Livestock Monitoring: Our Livestock Monitoring System allows chicken 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 chickens at a 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 (maggots, earthworms, termites, etc.);

- Animal health monitoring at all ages will be provided by the veterinarian.

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

- Density in chick 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 jour au 14th day)	30	1/3 surface
3rd week (15th jour au 21e day)	20	1/2 surface
4th week (22nd jour au 28th day)	15	2/3 surface
From 28th day	10	Toute surface

- 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
Plywood length	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

3) **Feed and feeding**

In the family poultry sector, the feeding system must be based on a sustainable strategy which consists of training and educating farmers on available food resources and their uses. These 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 makes them aware of their need to be trained 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 poultry feed (purchase, storage and supply).

Free range chickens find their food in the environment. Chickens' food is only very rarely adapted to their needs and their access to water is insufficient. Chicks most vulnerable compete with adult birds for food. Many birds die young for lack of food and because of diseases.

The scavenging residual feed base

- Household waste
- worms, snails, and insects
- Cereals 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 chicken production, constituting up to 70% of the total. Of 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 feed grain used in chicken feeds worldwide is maize. The plant protein source traditionally used for feed manufacture is soybean meal, which is the preferred source for chicken feed. Feed supplements like probiotics, vitamins, minerals, amino acids, mold inhibitors, enzymes, preservatives, coccidiostats, antioxidants etc. are mostly imported.

The total feed requirement of organized chicken sector is nearly 23 MMTs and nearly the whole of it is in compounded form.

- **Free range system**

Here, chicken feeding depends on all edible items like maggots, earthworms, ticks, insects. There is a concern about the potentially dangerous effects of using pesticides. The integration of poultry production with rice cultivation, market gardening, fish farming, cattle breeding or pig production also makes it possible to diversify food sources

- **Semi-intensive system**
  - The majority of the nutrients ingested come from rations prepared on the farm or from balanced commercial food
  - Food available during wanderings includes insects, worms and grass
  - 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
  - Access to a balanced ration limited to certain periods of the day
  - 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 poultry is not as high as that of poultry raised in an intensive system
  - Regular access to an outdoor course provides nutrients such as: phytic phosphorus, vitamin D, protein from insects and worms, fiber from grass
  - Birds also benefit from the sun, fresh air and can exercise

b) **Feed and water**

The young chicks remain confined in the pen. They must receive a full ration

Fresh and clean water should be distributed to drinking troughs inside chicken coops. Chicks should always have free access to water

The feed resources available on the chicken runs may not contribute to more than 30% of the total needs of poultry

Only proper nutrition and nutrition 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 for 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 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 exact amount of nutrients with a very small margin of error vitamins
- Flaws in feeding or watering systems are the two enemies of intensive production systems.

c) **Feed formulation**

- Farmers can mix their own feeds using the abundant carbohydrate and protein feed available in their area.
- Feeding should be accompanied by green feeds and fruits such as pawpaw.
- Only palatable green feeds should be given to birds. Avoid poisonous feeds

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	-

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
Son de Blé	1.2	5.55	9.2	0
Pal 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

Cutting-edge technology in chicken nutrition

Single-cell protein products such as algae, bacteria and yeasts are now showing promise to meet the demand. Technology has made it feasible to produce transgenic feeds with high protein and amino acid contents (quality protein maize with high lysine & tryptophan), low anti-nutritional factors (Canola meals with low erucic acid, tannins, and glycosinolates) and with high vitamin activity (yellow sorghum with high beta-carotene activity), etc.

The synbiotics (probiotics and prebiotics) have been considered as suitable substitute 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 amino acids in fermentation process to produce the limiting amino acids in particular in large quantities for the feed industry.

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.

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

4) **Chicken health and disease management**

Strengthening surveillance, prevention and control of avian diseases (Newcastle disease, chicken pox, parasitic diseases) 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:

- the availability and accessibility of appropriate vaccines (i.e. thermotolerant, single-dose format);
- raising farmers' awareness of the importance of vaccinating their herds;
- the existence of sustainable supply mechanisms, including the presence of well-trained community vaccinators and the possibility of cost recovery;
- 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).

b) **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:

- Create a physical barrier to the entrance to the farm for people and objects
- Provide sources of clean water and food
- Housing poultry in a structure that prevents them from being in contact with wild birds and rodents
- Use "all full-all empty" management systems
- Farm workers must not keep birds at home
- Change clothes and shoes before entering and leaving the farm

- Quarantine newly introduced or returning birds
- Perform compartmentalization and zoning for a = sick birds
- Thoroughly clean and disinfect buildings

c) **Control of parasites and diseases**

- External parasites that affect local chicken include chicken body louse, stick tight flea, chicken lice, ticks, feather mites and leg mites.
- Control can be done using commercial/synthetic or herbal insecticide.
- Herbal preparations are cheaper for local chicken, but a lot of research is still needed in this area to establish proper dosage.
- Internal parasites include worms and coccidia.
- Worms can be eliminated using a potent dewormer preferably given as a tablet because these chickens have low water consumption.
- Deworming should be done at least every month.
- Commercial coccidiostats can be used alternately with herbal preparation. These must be given to birds on 8th, 9th, and 10th days of age. Repeat as directed by veterinarian.
- In early days, vitamins-mineral mixtures should be given to chicks to minimize losses.
- Vaccination of birds especially against New Castle Disease. Target first vaccination at the beginning of the dry seasons, repeat after one month and every four months thereafter.
- Vaccination against Newcastle disease
- De-worming
- Remove mites and lice manually or better still using medicated powder
- Provide water as much as possible
- May supplement free range with other feeds e.g. maize bran and concentrates
- Avoid buying chicken in dry seasons because diseases, especially Newcastle, are more rampant in dry seasons
- Avoid buying birds when there is a disease outbreak
- Buy birds of almost the same age i.e. 2-3 months are more ideal. Avoid buying old birds
- Plan for synchronised mating and therefore synchronized reproduction and production to ease management

d) **food safety**

Eggs and chicken meat should be free of salmonella and other zoonotic germs, and mycotoxins; therefore, production conditions must integrate hygiene and biosecurity measures and be subject to inspection by a

technician, veterinarian

e) **Cutting-edge technology in chicken health**

Epidemiology, economics and impact assessment, studying the evolution of pathogenic infectious agents with varying infectivity, virulence, transmissibility and adaptations over time to re-emerge; analysis of social factors responsible for transmission of pathogens, studying genetic resistance factors;

Technology development and improvisation: For example, development of tools for diagnosis, 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.

Innovation tools that consider effective use and application of new technologies: For example, participatory epidemiological tools, GIS techniques etc. to help effective need-based input and service delivery.

f) **Women vaccinators and extension agents**

They 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.

5) **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, 1m2 will accommodate 20 chicks up to 4 weeks old.
- Temperature control: 35C for day-old chicks, 24-27C for 1 week. Reduce heat as they grow especially at night.

Debeaking

- Both males and females are debeaked at 10-14 days of age and again at 12-14 weeks of age.
- For females, leave 2mm beak from the nostrils, whereas for males, cut half of the beak between nostrils and tip of the beak.
- Both upper and lower beaks are cut off straight. Give vitamin K in water 1 day before debeaking and electrolytes for 2 or 3 days from the day of debeaking.

Uniformity

- 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.
- From 4 weeks of age, group the chicks according to body weight.
- The weak chicks should be taken extra care for attaining uniformity.
- At any stage, the flock must be having at least 80% uniformity.

Production standards for breeding stock

Trait	Standards
No. of sire/ 100 dams in deep litter or slats	10
No. of sire/ 100 dams 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	1.25
Average body weight of male at culling age	2.0
Average body weight of female at culling age	1.5
Average mortality during growing period	5%
Average mortality during laying period	8%

Parent stock performance potential

Traits	Male	Female
ody 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	

b) **Feeding system management**

- The feeds given to layer parents will be more or less similar to that of commercial layers in respect of major nutrients.
- But the breeder feeds, especially the breeder hen feed is enriched with all micronutrients like trace minerals and vitamins in order to obtain high rates of fertility and hatchability besides peak egg production.
- 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.

c) **Reproduction management**

Management of Layers

- Allow for good air circulation in laying house
- Layer needs on average 120 gm of food per day
- Distribute food troughs and water troughs evenly (one basin/50 birds)
- Provide grit at 20 weeks
- Laying nests must be kept in dark places, collect eggs 3 times a day, allow a nest/5 hens
- Provide soft clean litter
- Store eggs with the small end down
- Clean dirty eggs with steel wool/coarse leaves (never wash them)

- Add greens to the diet and whenever possible vitamins to water
- Debeaking at the onset of lay
- Culling when egg production drops below 40%

How to programme/synchronise egg laying and incubation in local chickens

- Assume a farmer has 14 local hens and 2 indigenous cocks
- Give each bird own nest when they start to lay. Place dry grass on top.
- Boil one egg from each bird and put it in nest as a landmark for each hen. Mark the egg.
- 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.
- Leave boiled egg in nest.

d) **Vaccination, Health and biosecurity program management**

Vaccination plays a very big role in disease protection for any kind of chicken breeds. Therefore it is important to offer vaccines for the local chicks especially for some very common chicken diseases like Gumboro and Newcastle.

- It is similar to the programme followed for commercial layers.
- The programme varies from place to place and time to time, depending on the prevalence of diseases in the area.
- The only difference will be, killed vaccines are given, for diseases like N.D., I.B.D., I.B., REO and M.G., before the onset of egg production.
- Sometimes, N.D., I.B.D. and I.B. killed 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.
- Moreover, the flock must be tested for Mycoplasma and Salmonella at around 16 weeks of age, to eliminate the positive reactors.
- 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.
- LaSota vaccination will be invariably followed after deworming.

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

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 know these vaccinations alone may not help to totally eliminate the occurrence of these diseases. There are other factors that you must also take into account. These in include the hygiene of the feeding and drinking equipments, ventilation of your chicken structures, quality of your feeds, vitamins and minerals and many others.

6) **Constraints to a sustainable local chicken value chain development**

These include

- Production related constraints: inadequate access to improved breed, Access and affordability of feed, Disease control, predation, inputs supply,
- Lack of knowledge and skills, for genetics and breeding
- Inadequate capital at all levels and marketing
- Marketing, commercialisation, and socio economics
- Farmers organization and production skills
- Poor stakeholder management:
- Family is chicken is not clearly understood:
- Poor husbandry practices
- Poor marketing channels:
- Lack of entrepreneurship

III- PRODUCTION ECONOMY AND MARKETING OF CHICKEN 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 and actors 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 customer needs and therefore answer the following questions:

- What to produce?
- For whom to produce?
- When to produce?

- How to produce?

The answer 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, an interconnection (WhatsApp group) of breeders between them and a connection with the actors of the value chain can be of use.

1) **Small-scale chicken project design**

Family poultry projects should take into account 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 improvement costs (change)

2) **Microfinance and credit access**

The changes in terms of improving family poultry farming require an increase in the use of production inputs, and an increase in market sales. This requires an increase in the use of external technologies, including a need for financing which can only be satisfied by the use of credit. The systems most likely to support these productions 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) **Chicken farmers associations**

The development of producer networks has the following objectives:

- Consolidate knowledge and coordinate the development of family poultry farming;
- Serve as a forum to exchange ideas, methods, resources and results;
- Document the results and disseminate the information;
- Coordinate training and human resource development; and
- Identify opportunities for research and development, cooperation and funding

Avantages

- Group purchasing of inputs
- Group purchases of breeding materials and equipment
- Purchase of chicks
- Organization of vaccination campaigns against MNC and avian smallpox
- 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 sale prices
- Genetic improvement and dissemination of avian genetic resources

The formation of associations of breeders who can in turn support vulnerable poultry farmers is a key element in the development of the poultry sector. Support services include training for capacity building, input supply and marketing assistance. 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.

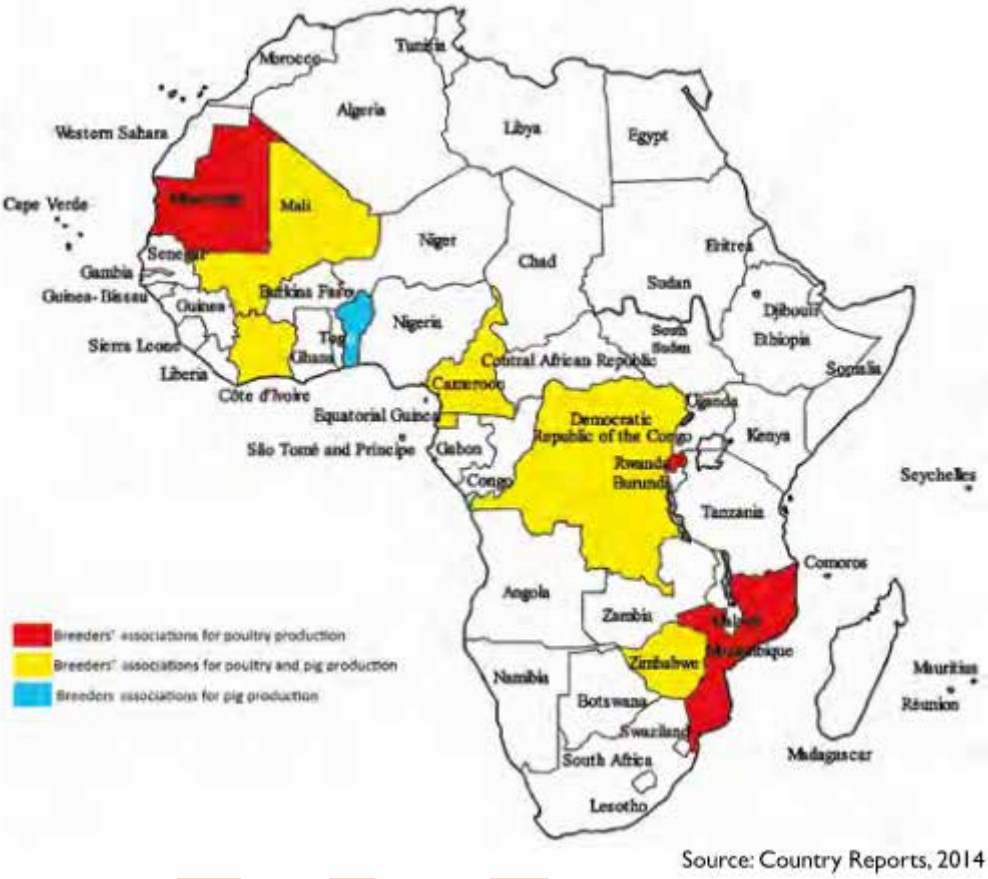


Figure: African countries with established national livestock breeders 'associations for chicken and pigs

4) **Local chicken business plan**

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

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

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

- **Day old chicks**: The success of your business will partly depend on the quality of day-old chicks which you buy. After getting experience, you may then hatch your own chicks, which will reduce your expenses as you will no longer need to buy day old chicks. There are many different breeds of chicken, and the right breed to choose will depend on your needs.

- **Feed and nutrition:** 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 chickens come back for the night. Clean water should be provided in shady areas during the day to avoid heat stress. You will also need proper vaccines and medications to prevent diseases and promote growth of your free range and backyard chickens

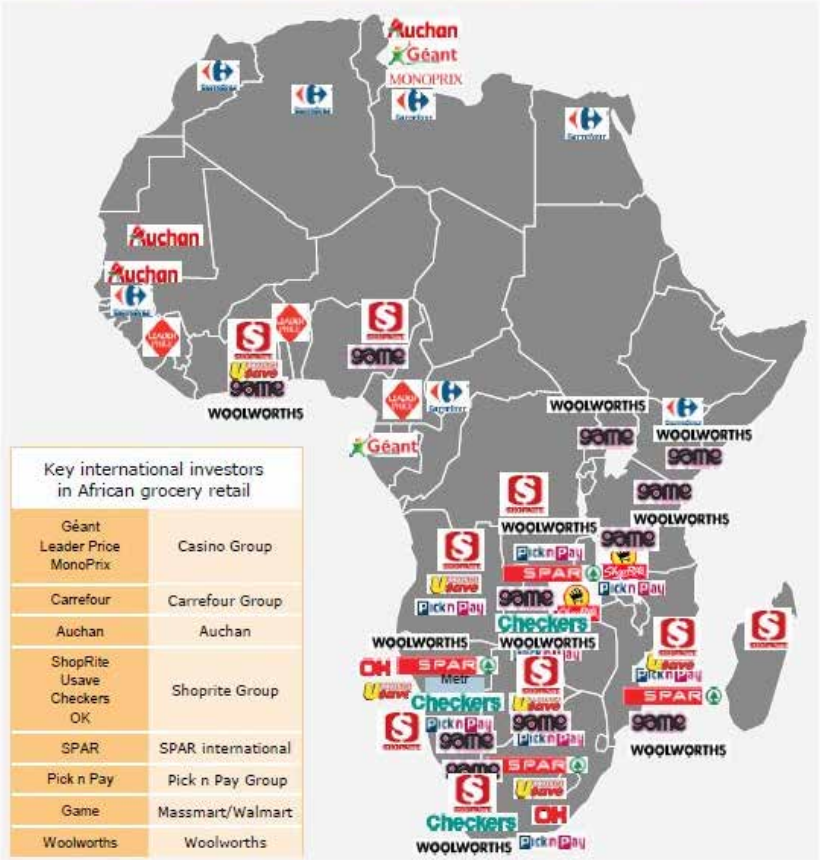
- **Management and labour:** The number of farm workers you need will depend on the size of your free range and backyard chicken project. If you are running a small business e.g. 100 birds/cycle, you and your family may be enough to take care of the chickens. However, if you are rearing 2000 birds per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

- **Capital**: The amount of capital required for a free-range chicken farming business depends on the scale of the project. Sources of capital include bank loans, and equity investors. Don't have access to capital? Start small and grow your business overtime! Free range chickens are very profitable, so if you reinvest the profits you get, you can quickly grow. You will require a good free-range chicken and eggs production business plan to guide you in your business.

- **Market for meat and eggs**: The market for free range chickens is high and increasing, as more people are moving towards organic and healthier food. Many people prefer organic free-range chicken meat, as compared to broiler chicken meat. This is because free range chickens are highly nutritious, delicious, organic, and healthier. Thus, the demand for free range organic chicken's meat continues to rise. Free range chickens have a higher price than broiler chickens, as they are considered to be more superior. You can supply your free-range chicken meat and eggs to individual households, butchers, schools, restaurants, companies, supermarkets, organizations, events, abattoirs etc. You can sell your free-range chicken as live birds or you can slaughter and freeze them and sell them as dressed chicken. As you grow your business, you will also be able to export your free-range organic products.

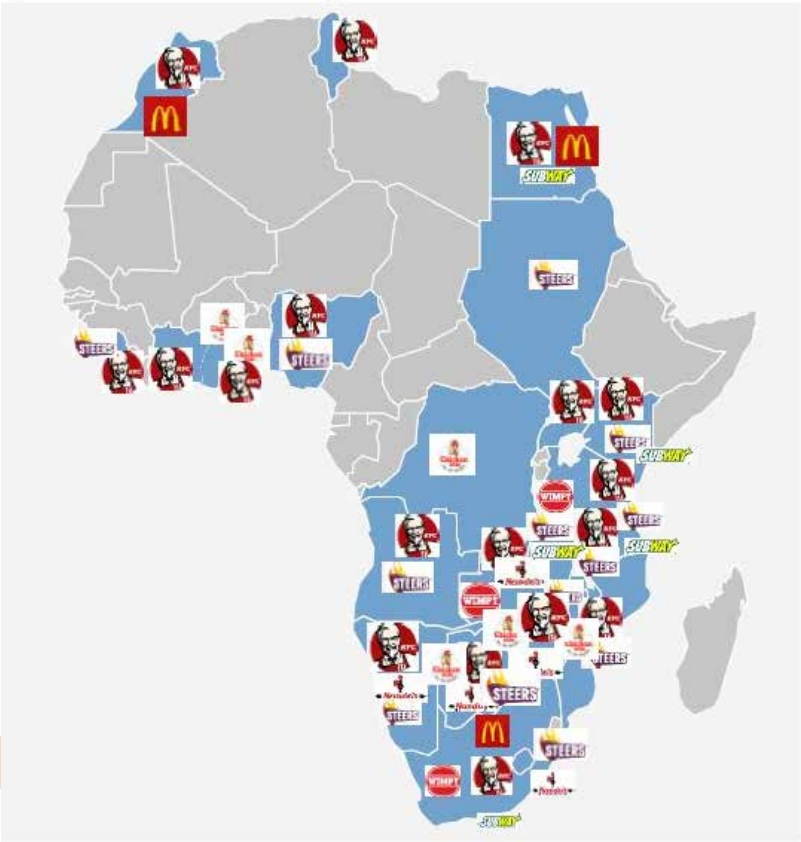
Supermarkets and restaurant chains are expanding in Africa to tap into changing market interests among Africa rising middle class.

Internationalization of modern grocery distribution in Africa



Source: Rabobank 2020

Quick-service restaurant expansion in Africa



Source: Rabobank 2020

Write down your business plan: The free-range chicken farming business plan can be used for many purposes including:

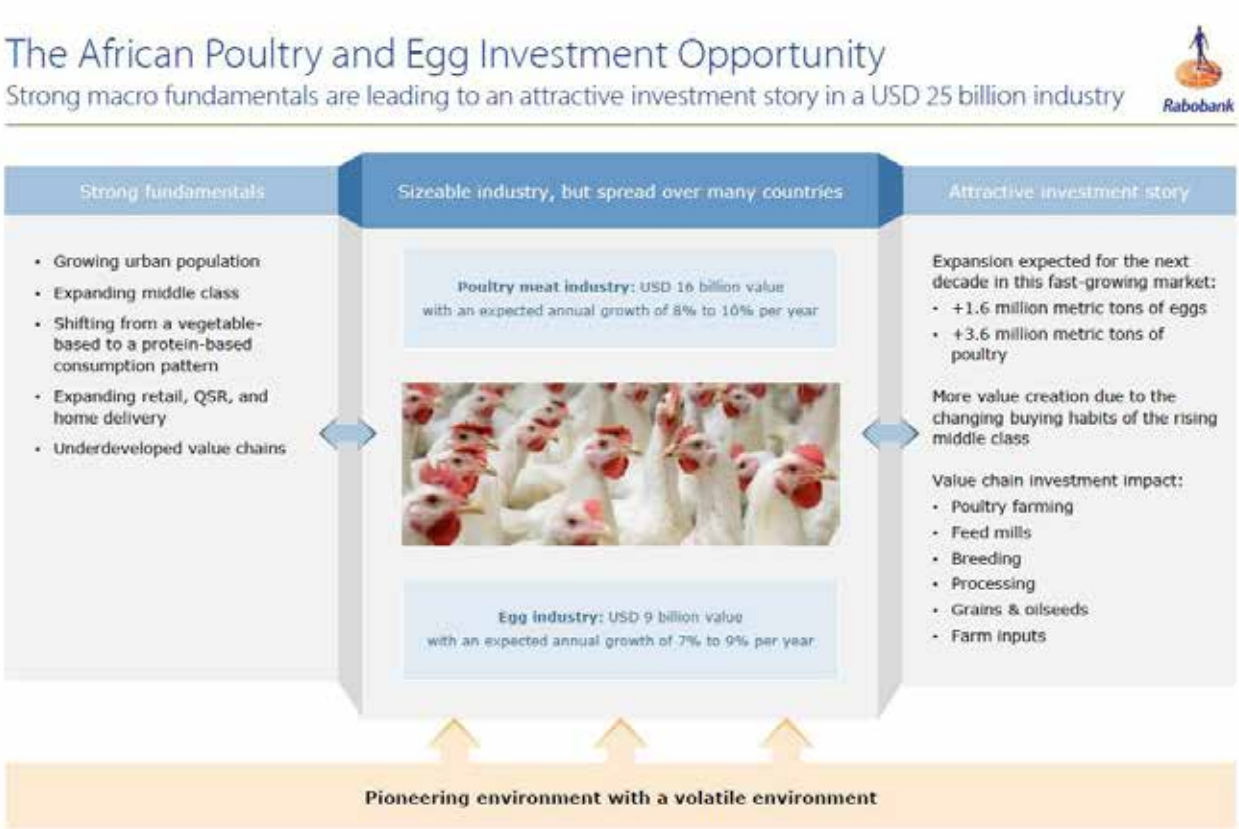
- Raising capital from investors/friends/relatives.
- Applying for a bank loan.
- Start-up guide to launch your free-range chicken farming business.
- As a project/business proposal.
- Assessing profitability of the free-range chicken business.
- Finding a business partner.
- Assessing the initial start-up costs so that you know how much to save.
- Manual for current business owners to help in business and strategy formulation.

Your chicken farming business plan should include, but not limited to:

- Marketing Strategy
- Financial Statements (monthly cash flow projections, income statements, cash flow statements, balance sheets, break even analysis, payback period analysis, start-up costs, finan-

cial graphs, revenue and expenses, Bank Loan Amortization)

- Risk Analysis
- Industry Analysis
- Market Analysis
- SWOT & PEST Analysis
- Operational Requirements (Including technical aspects of how to keep and rear the chickens, feed requirements etc)
- Operational Strategy
- Why some people in the chicken business fail, so that you can avoid their mistakes
- Ways to raise capital to start your chicken business



IV- PRODUCTION TECHNOLOGIES AND INNOVATIONS

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:

- Poultry development interventions must be adapted to socio-economic, cultural and logistical conditions.

- An appropriate development strategy must be drawn up according to the characteristics of the poultry systems.
- 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.
- 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.
- Practical training, exchange visits between poultry farmers, and follow-up sessions are all effective ways to build capacity
- 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:

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

1) Selection

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

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

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 have little experience and knowledge in the field of 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 unsuitable 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.

3) poultry health

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

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:
- Review mating ratios weekly
- Establish a well-planned male-reduction programme
- Use recommended mating ratios as a guide only, and adjust them to local circumstances and flock condition.

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:

- Alertness and activity has declined
- Body weight is not on target
- Legs and feet are not straight or show signs of bent toes or footpad abrasions
- Body condition is not as expected
- Comb and wattles are not an intense red color and the beak is not uniform
- Males exhibit no feather loss around the shoulders or thighs
- Vent is pale in color with no signs of feather wear
- Females show visible damage or excessive feather loss.

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 chickens 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.
- The breeder males must be fed with a low protein diet having 13-14% protein only because high protein diet will affect sperm quality as well as semen volume.
- 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.
- 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
- Decreased Sudden Death Syndrome
- Decreased Leg Disorders

6) Eggs incubation and Brooding technologies

a) Foster mothers

b) Cooperative incubation and brooding

7) Use of feed additives and supplements

- Antibiotic growth promoters
- Antioxidant
- Anti-stress
- Enzymes
- Eubiotics
- Fortified omega-3 egg
- Immunomodulators
- Mycotoxin binders
- Nucleic acid
- Organic acids
- Phytobiotics
- Prebiotics
- Probiotics
- Synbiotics

V- BREEDING AND REPRODUCTION TECHNOLOGIES

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:

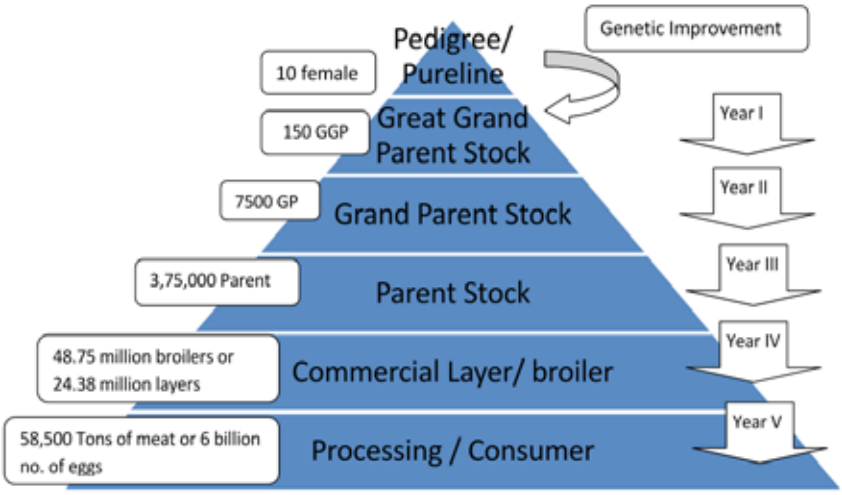
- age (not too old)
- the health status of (healthy).
- ridges and barbs: thick, dark red, soft, warm, large;
- large and deep eyes;
- the short, heavy bill, without deformation;
- the long, straight breastbone, inclined downwards;
- supple skin;
- the hardiness of the breed or strain
- the GMQ growth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

Reproduction management

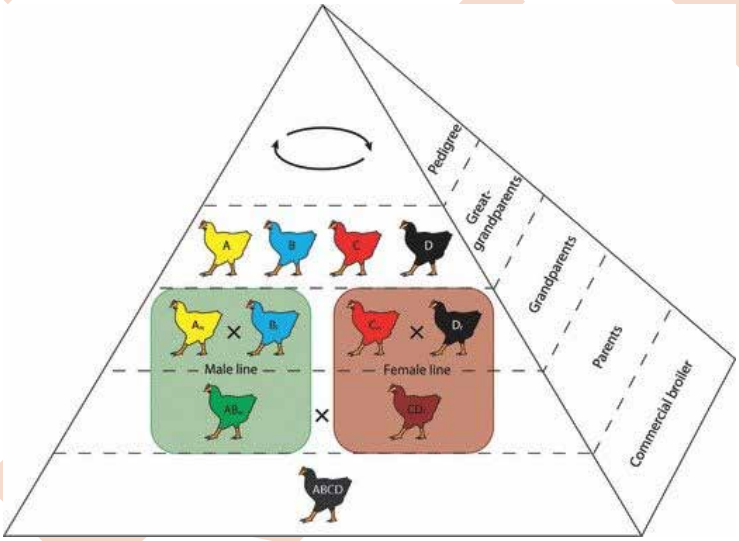
- Breeding of the rooster at 6 months of age and cull at 3 years of age
- Breeding of the hen at 6 months and culling at 18 months
- Avoid inbreeding by changing roosters regularly
- Provide 01 rooster / 06-10 hens;
- Mating takes place in the course reserved for breeders and / or in the breeding room;
- The laying begins from 6 months (about 01 egg every two days);
- Put near the nest a drinker and a manger (a hen can hatch 12 to 15 eggs for 21 days);
- Incubation can be artificial, using a mini incubator set between 38 and 39 ° C. In this case, the eggs must be turned 02 times a day;
- candle the eggs on the 8th and 18th days;
- After hatching, allow the chicks to dry, then transfer them to the preheated chick;

- 06 weeks later, transfer them to the fattening henhouse.

Pyramidal organization of Chicken Breeding Stocks



A typical modern broiler chicken breeding programme represented as a pyramid where each level represents a generation. The great-grandparent line/purelines 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.



Breeder Management

- The layer breeder management is more or less similar to the management of commercial layers.
- 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.

- 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

- The layer parent stock can be reared successfully on deep litter, slats, slat cum litter or in breeder cages.
- The floor space requirements will be 1860 cm2 in deep litter, 1400 cm2 on slat/wire floor and 450 cm2 in cages for females and 700 cm2 in breeder cages for male breeders.

Males and Artificial Insemination

- Day old male parent chicks are supplied dubbed and detoed. Males are reared separately from 0-21 weeks of age.
- Start with 12% males in case of natural mating and 8% in case of artificial insemination.
- At the beginning of the breeding season (22 weeks), introduce 8 males per 100 females.
- 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.
- 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 chicken breeding. Biotechnological and immunological tools must be adopted in combination with breeding methods to develop robust stocks having higher production level like

- Quantitative Traits Loci (QTL) through genome wide scan,
- microarray analysis for elucidating biological pathways and
- identifying the genes involved biological processes, mining of allele for identifying useful alleles affecting phenotype.
- The genetic modifications like transgenesis, knocking down a gene and RNAi, use of CpG motifs, proteomics, nanotechnology, epigenetics, aptamers, *in-ovo* approaches and even CRISPR gene editing technology holds immense potential.
- 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.

- 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.

1) **Artificial Insemination**

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

- 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.
- Even though AI is well developed technique in cattle, is not so well developed in chicken because no standard technique is available to store chicken semen for a long period.
- 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.
- At farms, where AI is practiced the males are kept separately in individual cages where sufficient space is available for movement of the birds.
- There should be a particular team of workers to associate collection and insemination of semen.
- Frequent changes of personnel in the team may affect the normal behaviour of birds.
- Rough handling should be avoided, if not it may develop fear reaction, which affects the semen volume during ejaculation.

Characteristics of chicken 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 chicken 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.

Why AI in chicken?

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:

- Incompatible individuals to mate
- Progeny test and specific male's reproduction
- Increase female's mating rate
- Increase male's utility
- better use of the cage feeding system in hatchery operations.
- one male of high genetic merit for a particular trait of interest to serve more females, therefore increases the number of offspring per cock.
- Adjust insemination frequency.
- Increase inseminated ratio.
- Early selection of cock.
- Research and development on frozen semen

Artificial insemination in chicken 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.

Equipment

- A 1 cc plastic syringe, a medicine dropper, and a glass eye cup
- More intricate equipment such as temperature-controlled collectors for the semen, injections guns and collection aspirators can be used in commercial chicken breeders.

- Small glass funnel with stem plugged with wax.
- Inseminating syringe
- Wide mouthed glass vial.
- Small pyrex semen cup
- Large flask to hold water at 180 C to 200 C range for short time holding of semen.

Chicken Artificial Insemination Gun

Selection requirement of male and female chickens used in the insemination process

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

The Male Procedure for semen collection

In chickens and turkeys, the abdominal massage technique involves massaging the cloacal region to achieve phallic tumescence. 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

- The first step in AI program is manual collection (milking) of the semen
- For semen collection, a team of two members are generally involved, one for restraining the male and the other for collecting semen.
- 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.
- 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.
- 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.

- Massage should be rapid and continuous until the cock protrudes the papilla from the cloaca.
- 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.
- Collect the semen from the extension of copulation organ with a small tube or any cup-like container.
- Avoid contamination of semen with faeces and feather.
- About 0.5 mL can be collected.
- If the semen flow is too slow, it can be increased with a small milking action.
- Chicken semen beg begin to lose fertilizing ability when stored >1 hr.
- Liquid cold (4°C) storage of chicken semen can be used to transport semen and maintain spermatozoa viability for ~6-12 hr.

Semen evaluation at the time of collection

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

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).

Semen volume and sperm concentration in different species of chicken

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

Sperm viability

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

Plasmalemma 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. 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.

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.

Insemination

- For insemination, pressure is applied to the left side of the abdomen around the vent.
- 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.

- In order to prevent injury, the female cannot have any hard-shelled eggs in the lower area of her oviduct.
- The presence of such an egg would hinder the journey of the sperm to the ova.
- For maximal fertility,, inseminations may be started before the initial oviposition.
- 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.
- In native chickens, inseminating 0.02-0.03 mL and 8~10×107 spermatozoa of pooled semen is required.
- AI can be at intervals of 7 days.
- In summer time, inseminating at intervals of 5 days and 0.04 mL semen are suggested.
- When fertility tends to decrease, it may be justified to inseminate more frequently or use more cells per insemination dose.

All equipment used for insemination should be thoroughly cleaned and dry before Use.

- 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.
- In practice, inseminating chicken after 3 pm obtained better results.
- In turkey flocks much better results are obtained if insemination is done after 5 pm.
- It is difficult to inseminate non-laying hens.
- Usually insemination is done when the flock reaches 25% egg production.
- Hens are inseminated twice during first week. Then at weekly intervals.

Procedure

- Bird is held by the legs with the left hand down and tail tucked back and against the operator chest.
- The thumb of the right hand is placed against the upper lip of the vent then with a rounding motion

press the abdomen muscle.

- Do not squeeze with fingers but apply pressure evenly with the palm of the hand.
- When the oviduct is everted, the second operator inserts the syringe into oviduct as far as it is going inside without exerting pressure.
- The insemination apparatus is introduced into the vagina about 1 inch and semen is deposited at the junction of vagina and uterus.

Dose and frequency of insemination

- Chicken: 0.05 ml, once in a week
- Turkey: 0.025 ml once in every 2 weeks
- Ducks: 0.03 ml once in every 5 days
- Goose: 0.05 ml for every 7 days.
- 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

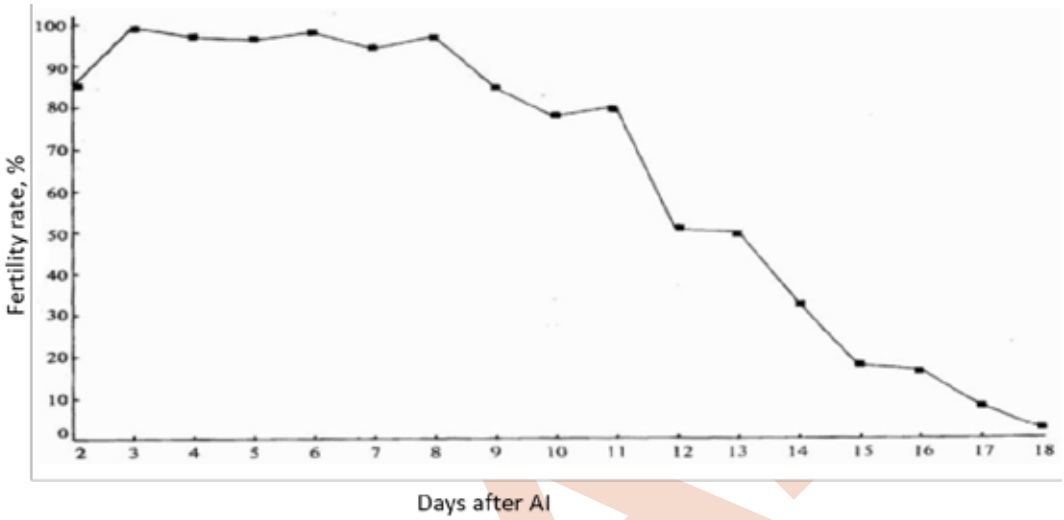
- Goose: 66 days
- Duck: 8-9 days
- Chicken: 12 days
- Turkey: 22 days

In practice to maintain semen quality:

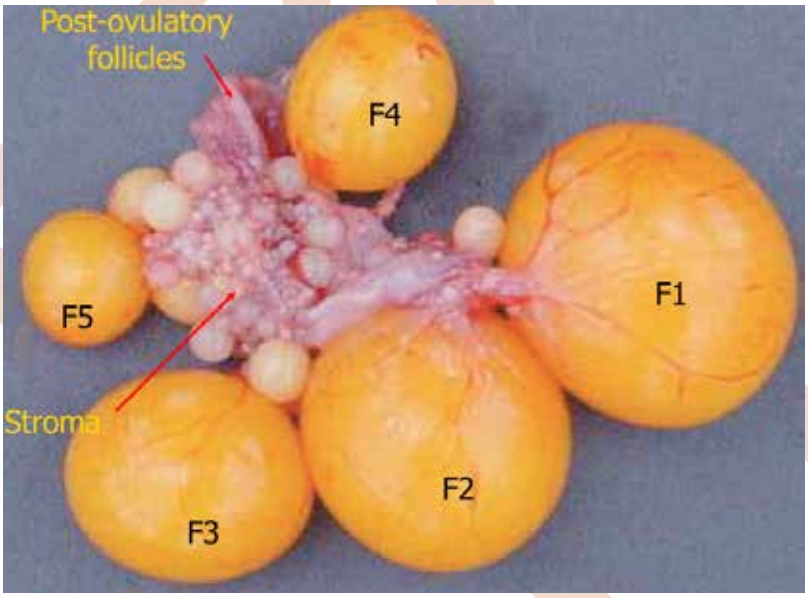
- Periodically collect semen.
- For each batch, collect 5 cocks semen and then inseminate 75 hens

Evaluation of fertility

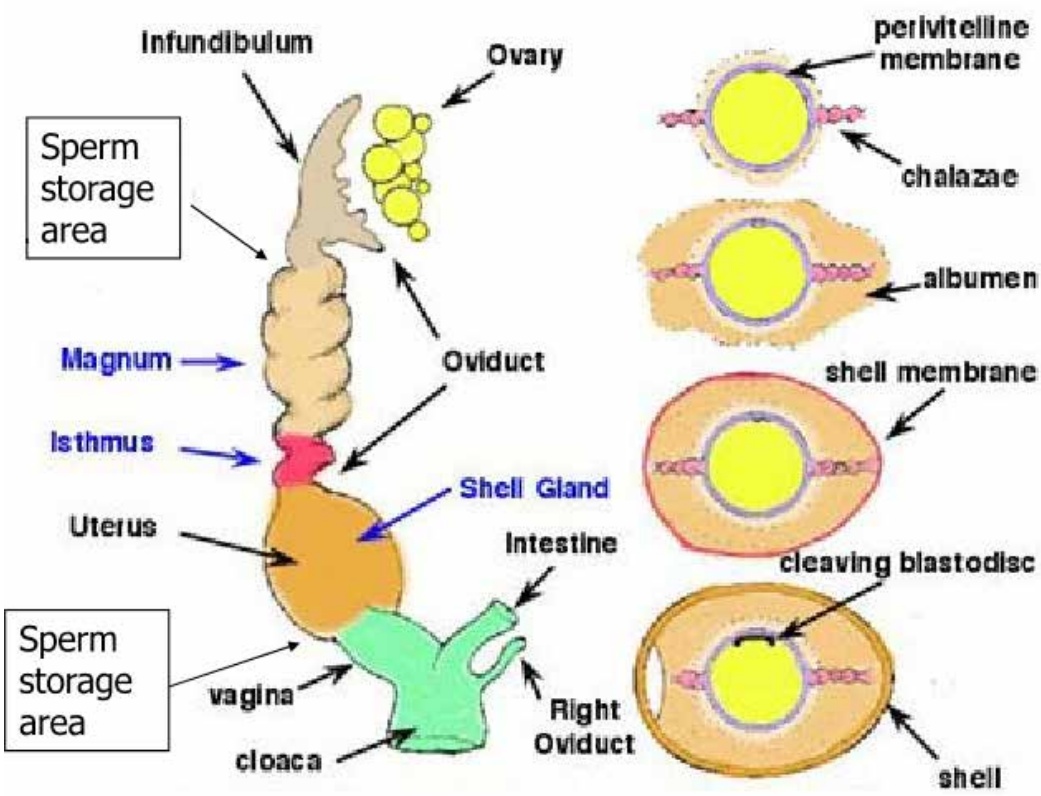
With AI programs, it is often desirable to determine the fertility status of a flock before the next weekly insemination. There are several options available: breaking-out fresh eggs and examining the GD to differentiate a fertilized from an unfertilized or early dead embryo; setting normal but culled 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.



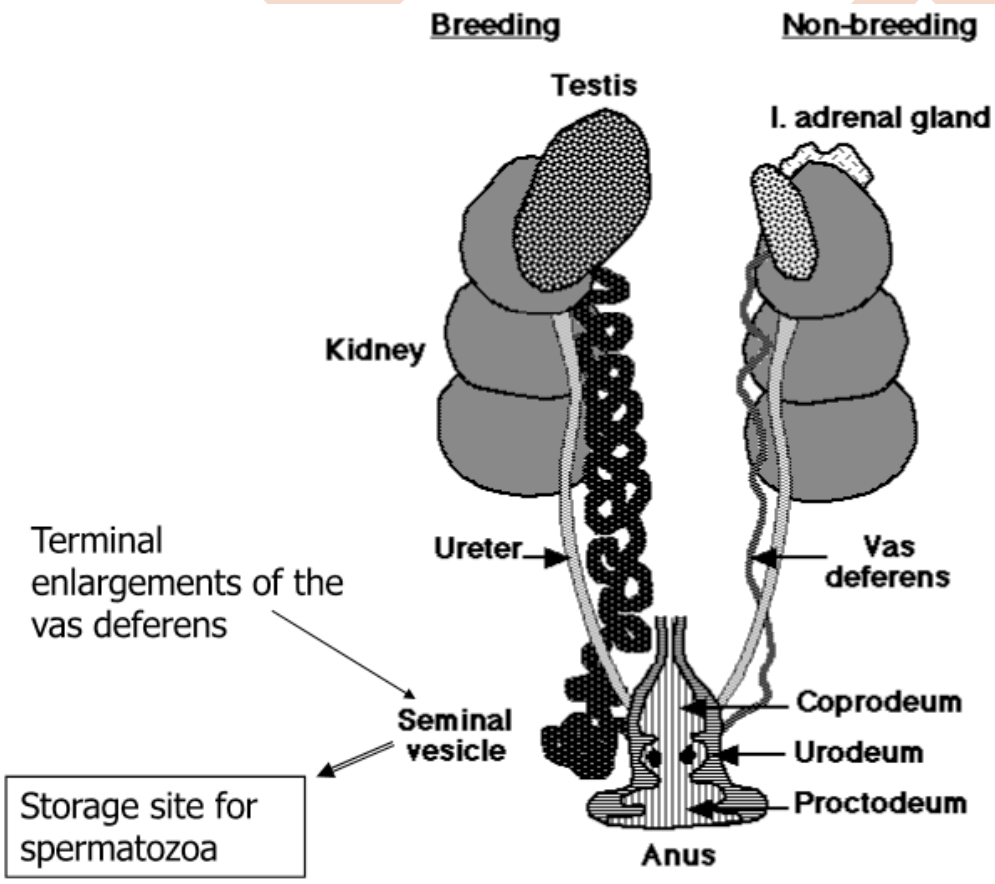
Duration of fertility and fertility rate after single AI of hen



The ovary of laying hen



Ovary and oviduct of bird



Avian Testes

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 night time, 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 after-noon 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 table purpose.

- Fumigate hatching eggs with formaldehyde gas at 3 X concentration and store in an egg store-room, until 6 hours before setting.
- 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.

2) **Eggs incubation technologies**

Hatchery operation and sanitation

- The eggs are set according to the demand or order for pullet chicks.
- 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.
- The remaining hatching eggs may be either sold as hatching eggs for other needy hatcheries or sold for table purpose.
- 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.
- Discard weak female chicks also, weighing less than 32 grams.
- Unlike the old design, the modern hatcheries locate the tray cleaning room etc., atleast 30 m away from the main hatchery, on sanitation grounds.

Several parameters are susceptible of affecting the incubation performances

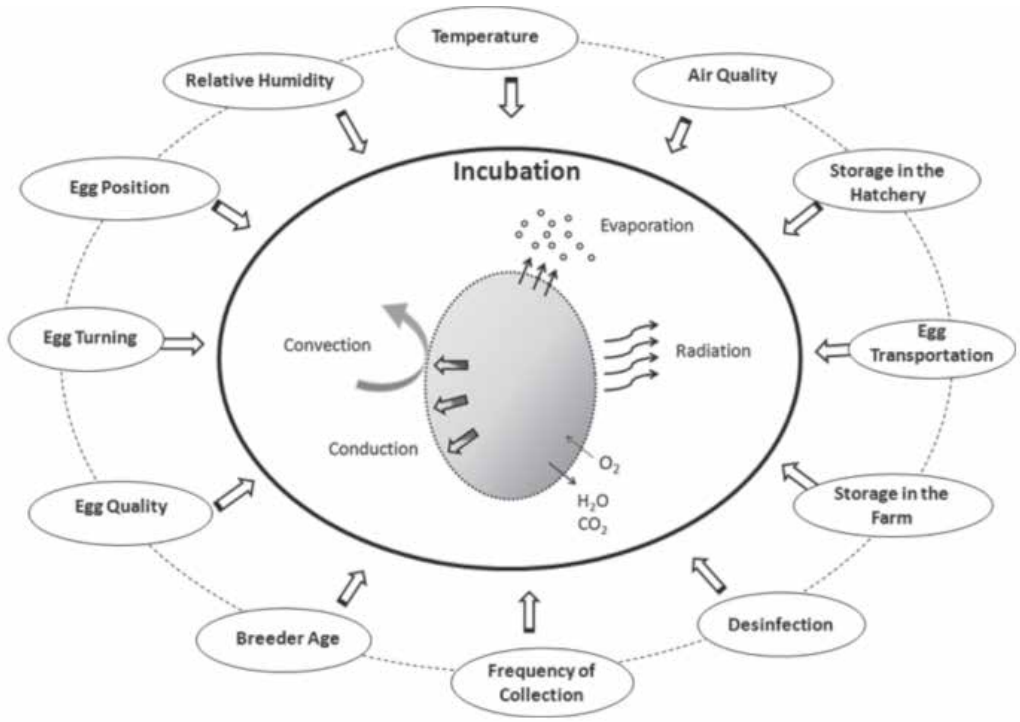


Figure: Physical exchanges of the eggs with the environment during incubation (heat transfer, water loss and gases exchanges) depend of the egg characteristics (size, composition, form, and eggshell thickness, porosity and heat and water vapor conductance), embryo metabolism rate and physical incubation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

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

- Correct and even temperature controlled by a thermometer or thermocouple
- Correct humidity controlled by ventilation rate and water application
- Correct oxygen and carbon dioxide concentrations controlled by ventilation
- 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.

Incubation by mother hens

- Usually one hen starts incubating by staying overnight on the boiled egg
- Leave this hen on the boiled egg for 10 days while it is waiting for other birds
- After the 10 days, give all the birds that would have started incubating (within the 10 days) 17 selected but recently laid eggs
- Leave the birds that refuse to incubate alone
- If you want to eat or sell, eat/sell those which were laid first (old ones).
- Avoid giving these eggs to birds for incubation: very small, round eggs, very dirty, cracked eggs,

extremely pointed eggs, very big eggs, very old eggs.

- 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.

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.

	Fowl	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.

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%.

Ventilation and Carbon Dioxide/Oxygen Concentration

Embryonic growth is optimised 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.

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.

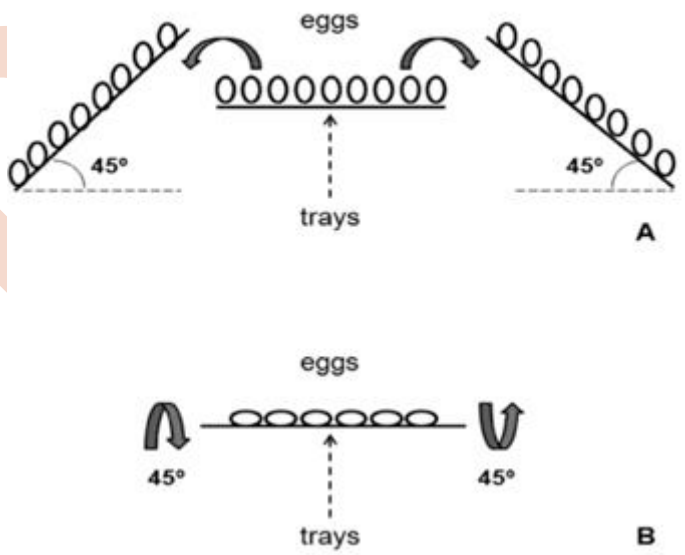


Figure: Egg turning in vertical (A) and horizontal (B) incubators

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 Incubation

Eggs 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.

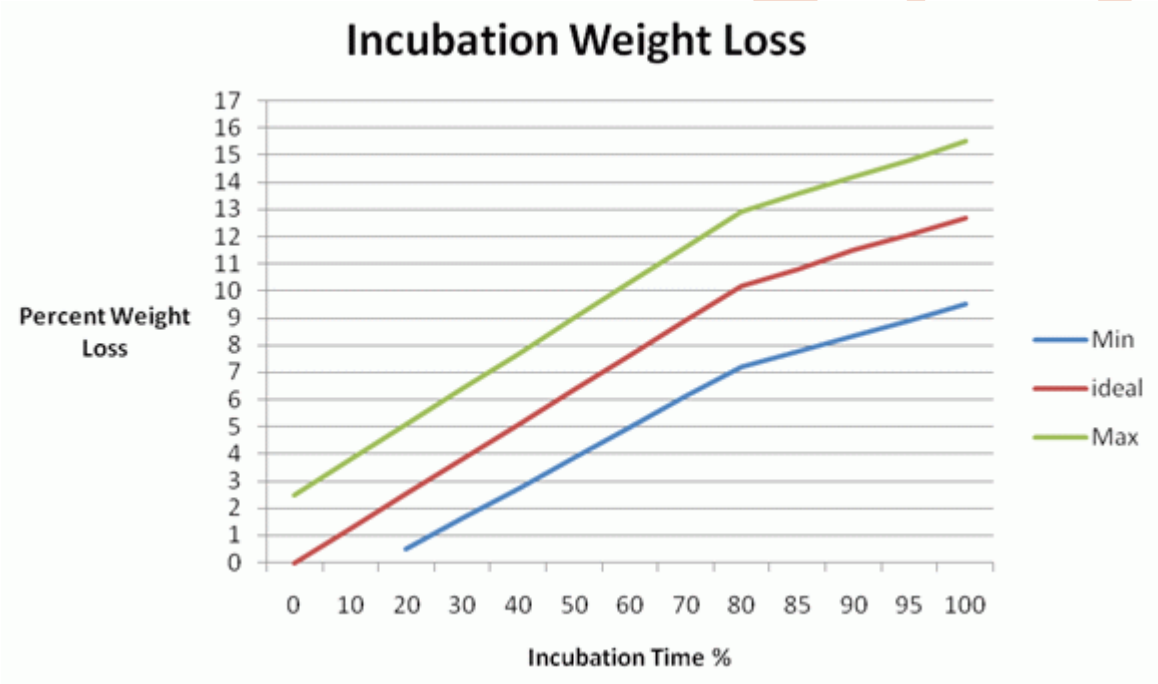


Figure: Percentage of weight loss during incubation period with ideal weight loss and tolerances illustrated with maximum and minimum values.

Possible causes of hatching problems

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

Top tips to keep your roosters virile

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

Squad Rotation

just like any good premiership manager rotates and rests his top scorer don't let your randy rooster overdo it. The ratio of hens to rooster needs to be realistic, which is typically about 10-12 hens per rooster. Try though he 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.

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 you wish to continue raising chicks.

Candling

A quick and easy way to check the ability of your rooster to continually fertilize his hens is through candling. This method has been practiced for many years through the use of specialized lights (sold at farm and garden stores) 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. This may be the origin of the saying 'can't hold a candle to him'. As you candle eggs over the course of a few days, it will be possible to observe a growing embryo and shrinking air sack, although soonest visible are blood vessels. 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 you wish 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 you desire. Then, once that mating is complete, arm yourself with the proper light and candle resulting eggs for confirmation of a successful mating. Though candling can be a tough skill to master, once you have some experience under your belt, it is sure to save disappointment down the road as well as egg waste at the same time.

Don't Get Bogged Down

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

Windbreaks – Create a sheltered area

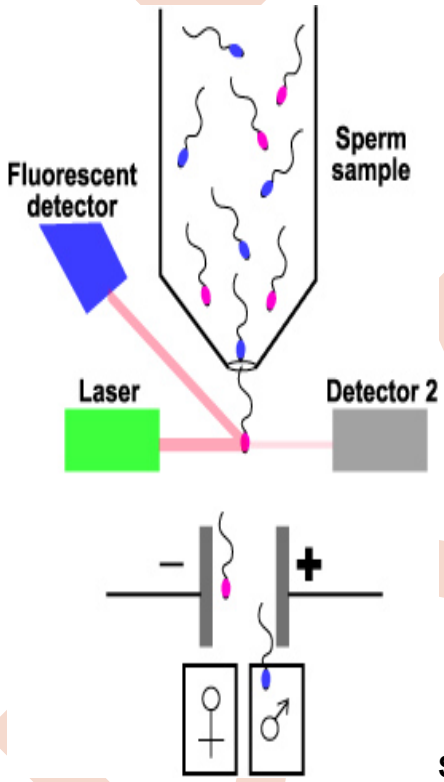
Shelter from the elements, other than your coop is essential. A piece of corrugated roofing leant against a fence or wall facing towards the prevailing wind or take a couple of legs off an old table will create a freestanding shelter. This has the added benefit of reducing the amount of muck been brought back into the coop.

Moving your Coop

If you are lucky enough to have the space. Move your coop to a drier area in winter.

Chicken Vitamins

Multivitamins for chicken come in many different types, from the pleasant smelling "Chicken Spice" powder which can be mixed in with the feed (use cod liver oil to get the powder to stick to the food if you use a dry feed), to the rather smelly "seaweed tonics" that can be added to the drinking water. Chicken 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.



3) **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

4) **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.

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

5) ***Sexing chicks***

There are three ways of sexing chicks:

- 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 give-away. Gently spread the chick's wings: if the feathers are of equal length, you have a male; if the feathers alternate between long and short, you have a female. Finally, females will often develop tail feathers before the males do. Keep up boys!
- 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.
- 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. Your vet will definitely have more luck!

6) **Sexing grown chicks**

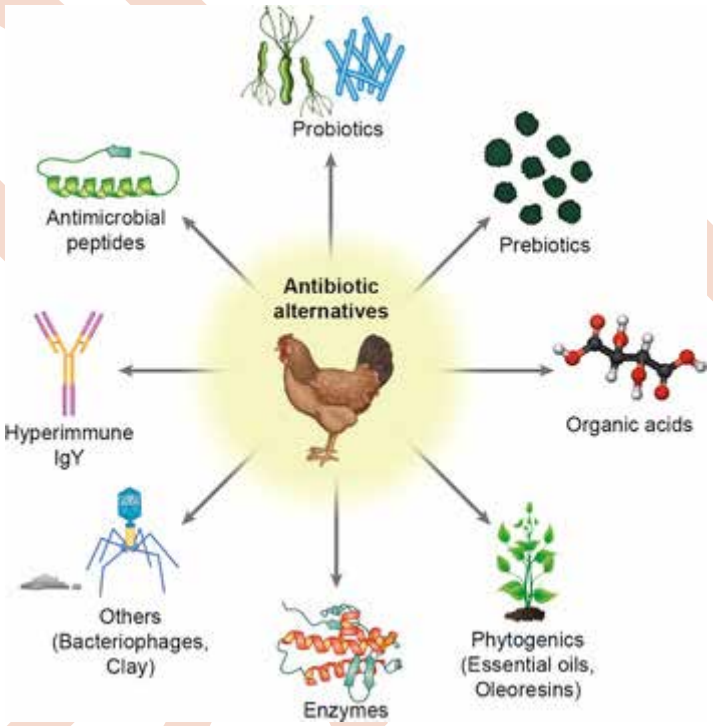
Once your chooks have completely developed, it's usually quite easy to tell the girls from the boys - chances are you can do it by instinct.

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

7) **Use of bio-stimulants**

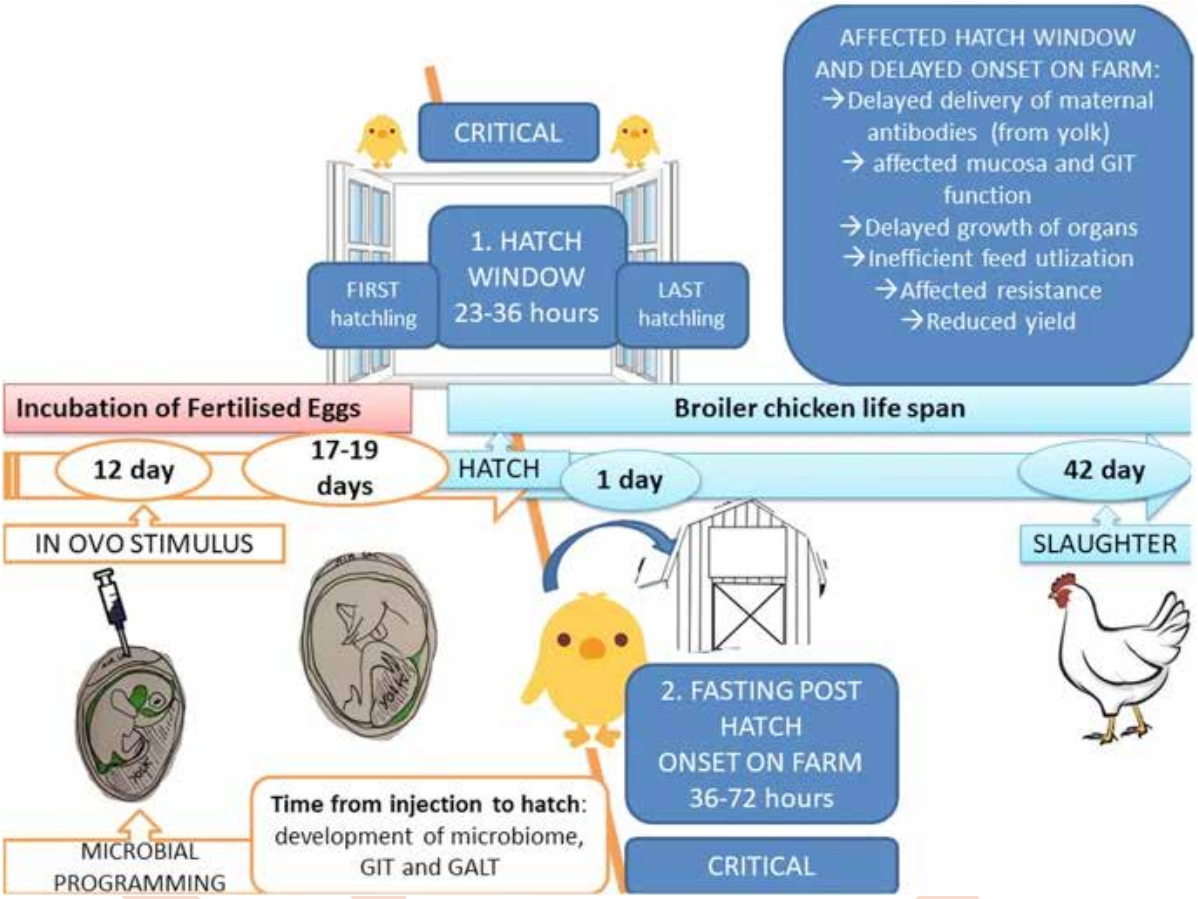
Prebiotics and synbiotics – in ovo delivery for improved lifespan condition in chicken

One of the precision livestock farming tools in chicken 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.



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 chicken. Two critical perinatal moments are shown (hatch window and fasting post-hatching), when the newly hatched chicken is the most receptive to environmental stressors



8) **Short Periods of Incubation During Egg Storage (SPIDES)**

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.

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.

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.

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 pro-

longed 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.
- Chicken quality will generally be better after SPIDES treatment compared to untreated eggs.
- Setting too soon after heat treatment can have negative effects.

9) 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 chicken bioreactors, production of knock-in/out chickens, low-allergenicity eggs, and disease-resistance models.

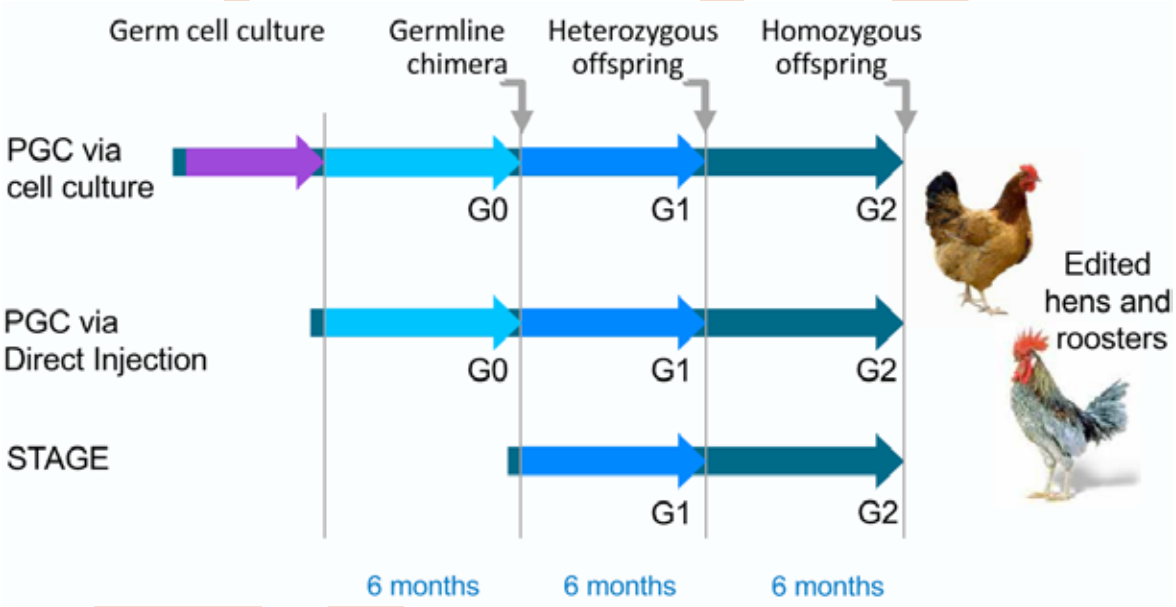
Important steps for the generation of genetically modified chickens.

Year	1987	1994	2004	2006	2013	2013	2015	2016	2017	2017
Contribution	Generation of the first genetically modified chicken using retroviral vectors	Generation of the first genetically modified chicken by DNA microinjection	Transgenic chickens using lentivirus carrying a transgene	Isolation and long-term culture of PGCs followed by transfection and generation of eGFP transgenic chickens	Targeted gene editing in PGCs and generation of the first gene knockout chickens	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	2015 Dimitrov et al., 2016	Taylor et al., 2017	Trefil et al., 2017

Methods to make a transgenic or edited chicken

- Primordial Germ Cells (PGCs)
    - Progenitors to ovum and sperm forming cells
    - Are accessible either outside or inside of the growing chick embryo
- PGCs OUTSIDE – highly skilled culture (not trivial)
    - Non-homologous recombination (van de Lavoir et al, 2006)
    - Gene targeting (Schusser et al, 2014)
    - Gene editing (Park et al, 2014)
- PGCs INSIDE – accessing the germ cells in vivo (in ovo)
    - Integrating lentiviral systems (McGrew et al, 2004)
    - Direct Injection in vivo (Tyack et al, 2014)
- Sperm Transfection Assisted Gene Editing (STAGE)
    - Another approach which could speed up gene editing in chicken (Cooper et al, 2017)

Timeline approximations for application of the technologies



Applications of genome engineering

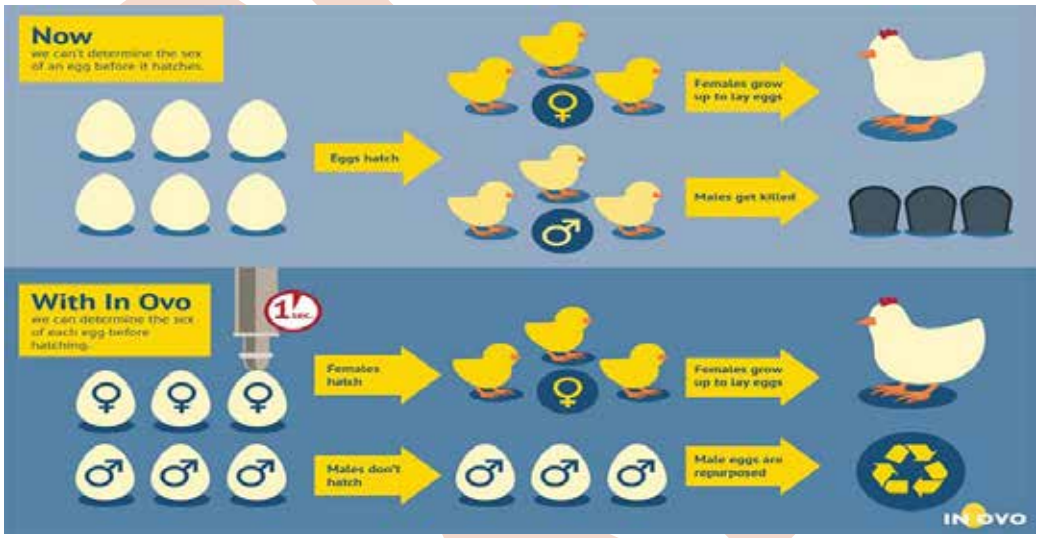
- Improving eggs as a substrate for vaccine production
- Allergen free eggs

- Disease resilience
- Sex selection
- Improved growth

10) **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 chicken 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 an alternative high-value protein source. The following mentioned are the most well-known methods that are ready for practice or may be ready for use within a year.



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 fertilisation. Mixed with fluid from fertilised eggs, this marker changes 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.

PCR (Plantegg)

Plantegg uses a PCR method, which uses 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.

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 chickens. 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.

11) **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.

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 feathring)	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, mes-entery and blood vessel walls	Protection of skin against UV radiation, improved radiation from the skin, increased pack cell volume and plasma protein

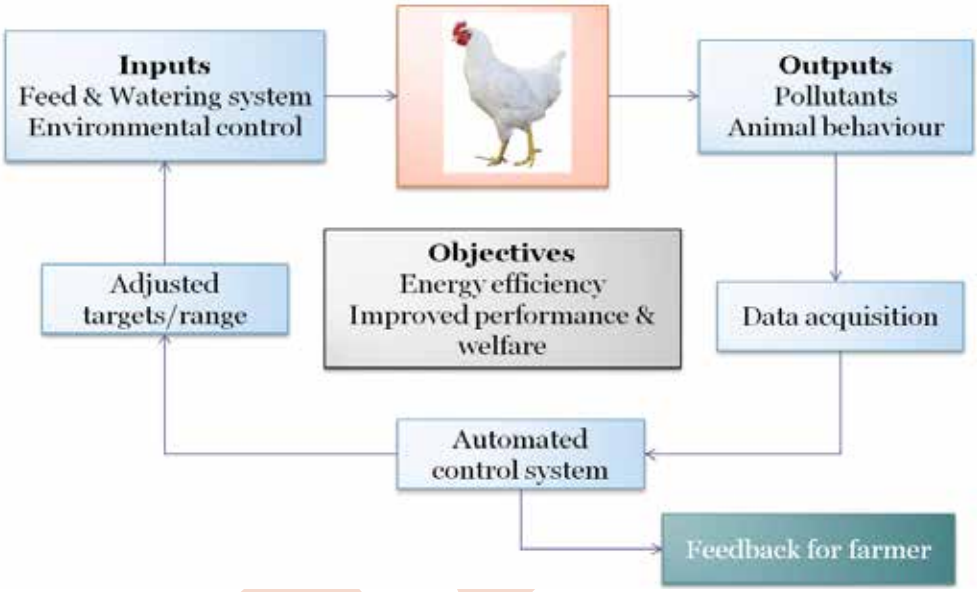
VI- PROCESSING / VALUE ADDITION TECHNOLOGIES

1) *In ovo* vaccination
2) Fumigation with 10% paraformaldehyde
3) Egg albumen (frozen, refrigerated liquid, or dried) for sandwiches, ovo vegetarian, gluten free meals
4) Egg yolks (frozen, refrigerated liquid, or dried) for salads dressing, baked goods
5) Powdered/ lyophilized eggs
6) Specialty egg products (pre-peeled hard cooked eggs, egg rolls or “long eggs,” egg patties, quiches, quiche mixes, scrambled eggs, etc
7) Extraction with organic solvents followed by a purification to remove co-extracted lipids
8) Extraction by salt solutions and purified by gel filtration on Sephadex G-50

VII- TECHNOLOGIES IN INPUTS AND SERVICES FOR CHICKEN

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

Precision chicken 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.

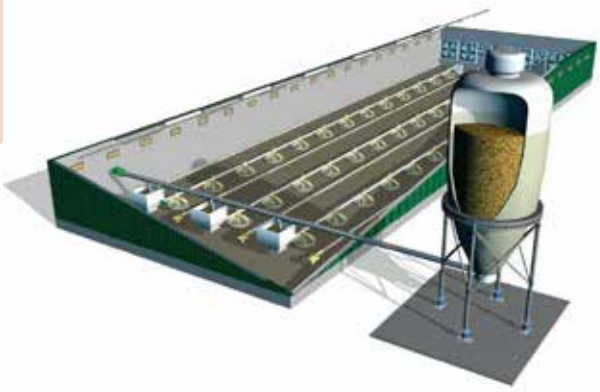


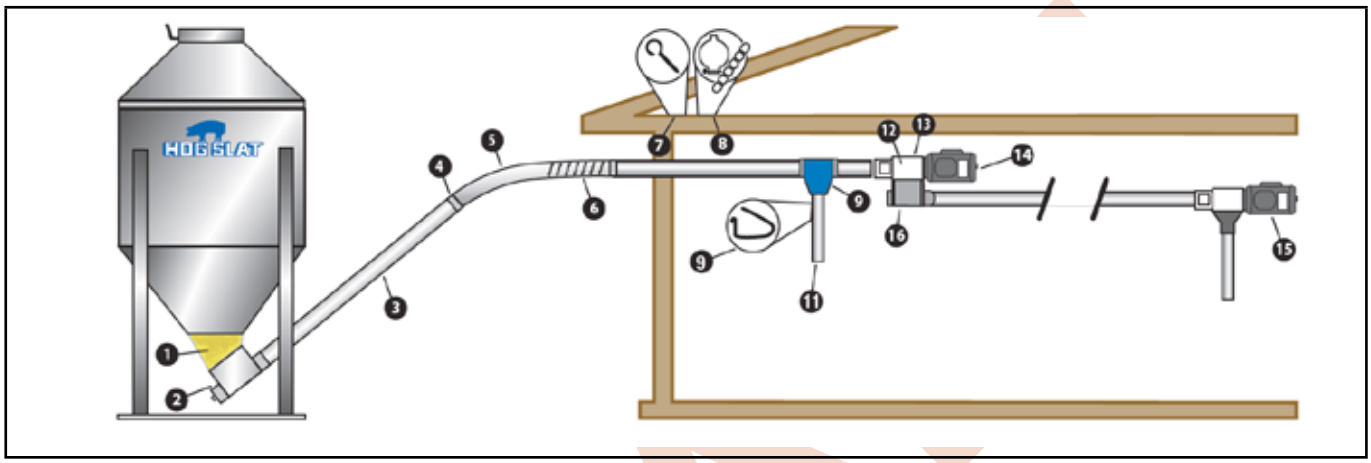
Precision chicken model

This allows real-time monitoring of birds' activities allowing the PLF system to make changes to the chicken 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. PPF 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.

1) Chicken 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 chicken farms.





2) Weighing systems for feed and animals

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

Types	Main advantage

Versatile chicken 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.
Chicken scale for layers 	Due to its low weight of only 2 kg, Incas 2 is well-suited for use as a mobile chicken 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.
Chicken 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.
Chicken 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.

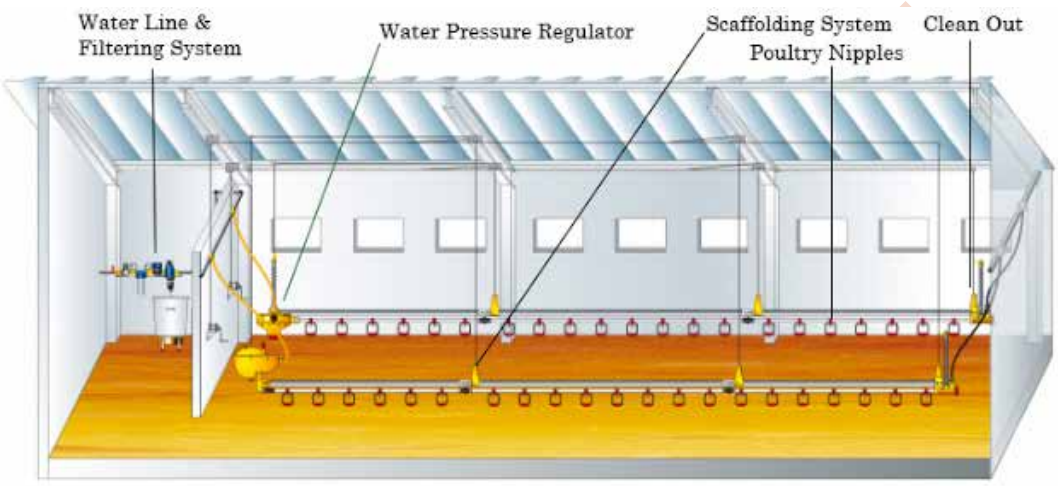
Weighing computer as stand-alone solution  	All measured values can be saved directly in the weighing computer or transferred to a PC using a memory module. From here, the data can be analysed in tables or graphs by means of the corresponding software (optional). An automatic comparison with a pre-defined 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 your 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 chicken 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.

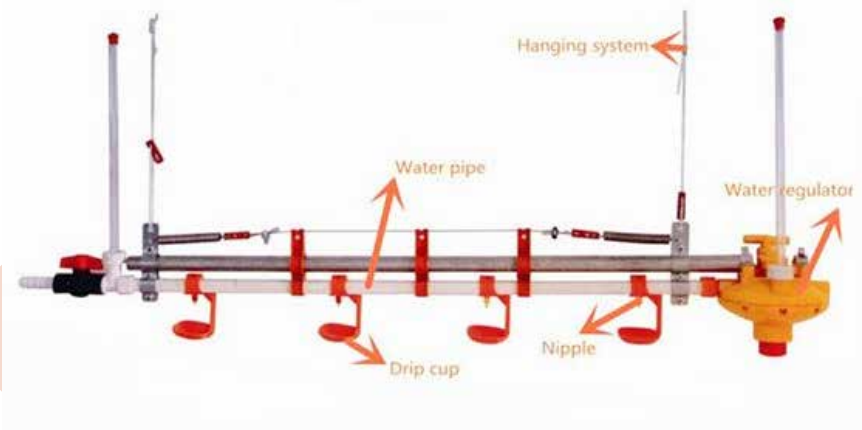
3) Watering lines

One of the basic needs of chicken is unlimited access to clean water. The following are factors and tasks

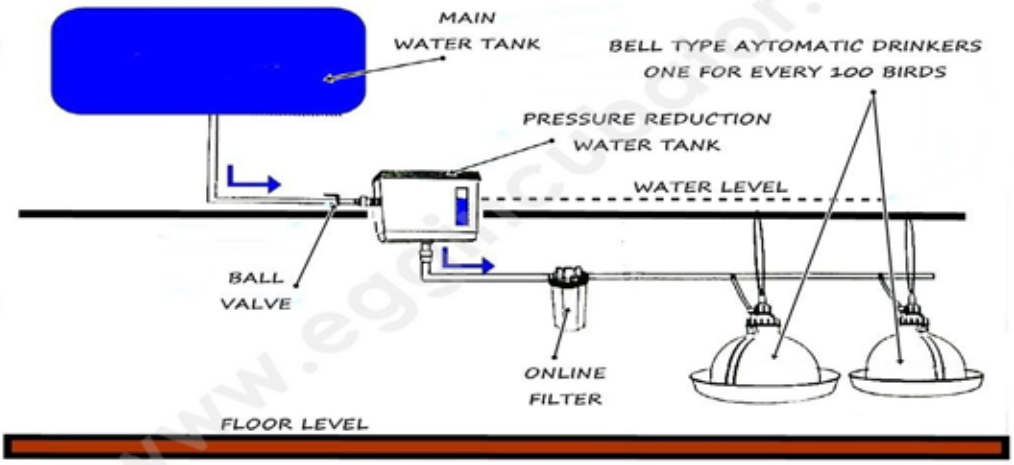
that should be considered in a successful drinker line management programme.

- 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.
- Minimise 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.
- Sanitise regularly: Using the correct sanitiser 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 bird water demand. If the litter is too damp, lower the pressure.
- Change water filters regularly: Filters must be changed when pressure drops to maximise 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.





Main Components of a Bell type Poultry Watering System



It is possible have locally made water lines well adapter to your infrastructure need

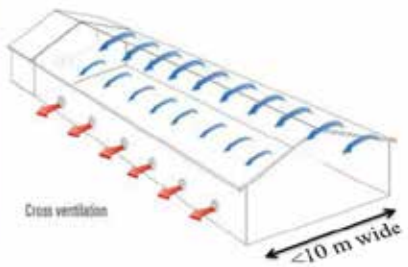
4) Chicken ventilation and monitoring systems

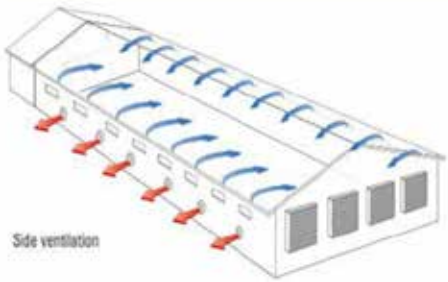
Ventilation in a chicken house supplies fresh air that is essential to sustain life. It also helps reduce the extremes of temperature, humidity and air contamination to tolerable limits for confined chickens.

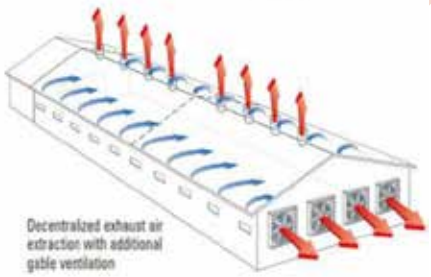
Legally there are certain air quality requirements that a ventilation system must be able to provide.

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

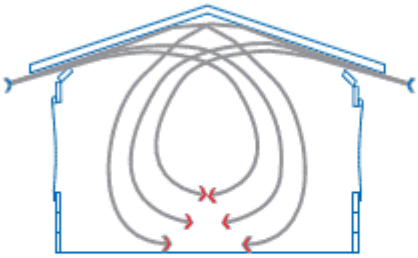
- **Cross ventilation** (fans on one side of the house and inlets on the other side –works best in houses of less than 10 m wide)
- **Sidewall ventilation:** fans and inlets on same sidewalls
- **Attic inlet ventilation:** fans are distributed at the side-walls, inlets are in the roof





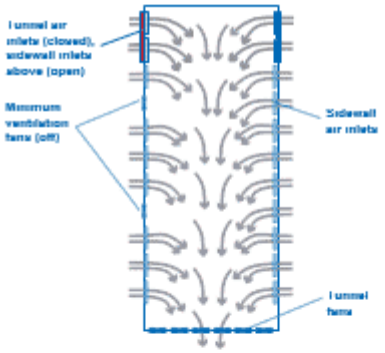


MINIMUM VENTILATION



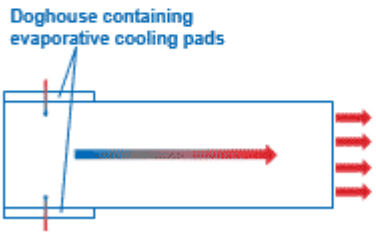
- most commonly used during brooding (chicks) and periods of cold weather, or whenever house temperature drops below the set-point
- timer driven process
- evenly distributed inlets
- inlets operate on the basis of "negative pressure"
- brings in fresh air from outside
- cold incoming air is directed to the peak of the roof
- used to remove excess moisture to control RH
- exhausts stale in-house gases
- adequate well distributed heat required
- air movement at bird level very low

TRANSITIONAL VENTILATION



- used when the temperature in the house rises above the set-point temperature and when it is too cold, or birds are too young for tunnel ventilation
- temperature driven process
- primary function is to remove excess heat
- brings in a large volume of fresh air from outside
- inlets operated on the basis of negative pressure
- air directed up to the peak of the roof

TUNNEL VENTILATION



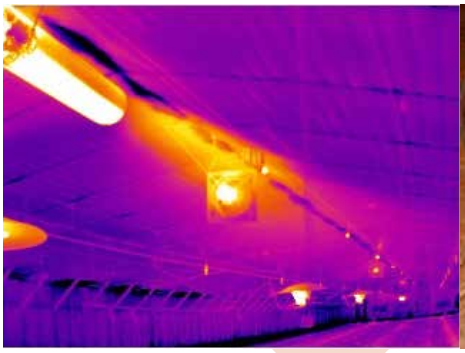
- used in hot (or hot with high RH) weather
- usually used when birds are older (fully feathered)
- primary function is to remove excess heat
- used when transitional ventilation is no longer able to keep birds cool
- generates "high-velocity" air flow at bird level
- creates a wind-chill effect that helps cool birds
- important to have a fast air exchange rate

5) Cooling / Heating systems

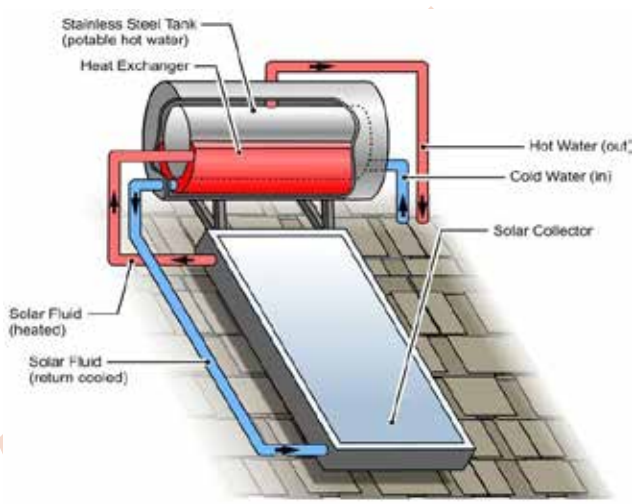
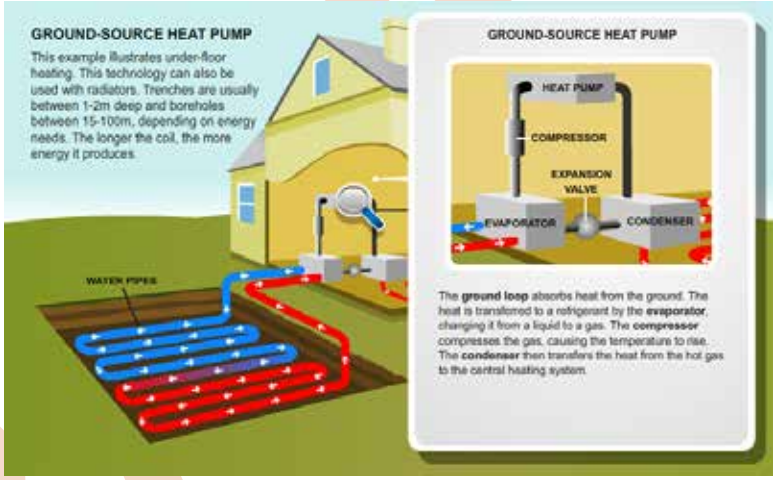
There are three fundamental types of heat transfer:

- **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.

Technology options for the control of chicken house temperatures are:

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 ag. house cooling	
Portable evaporative coolers	

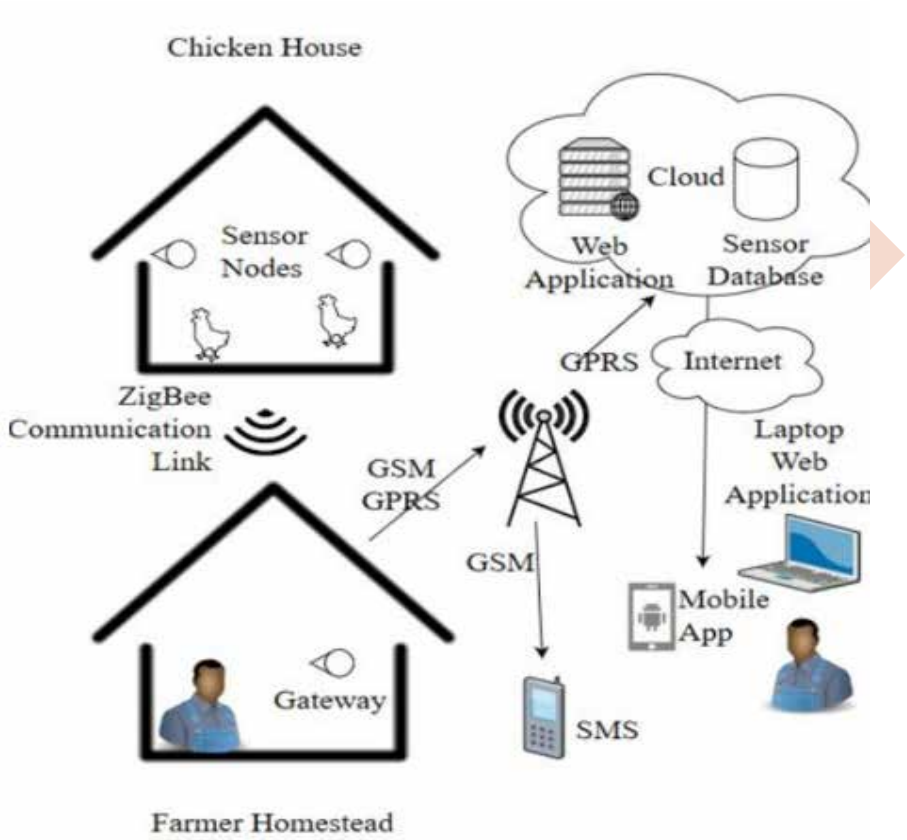
Alternative heating options

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 your 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 chicken 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 chickens' heating requirements.	

6) Control and surveillance systems

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



7) Lighting systems

It is important that chicken 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.

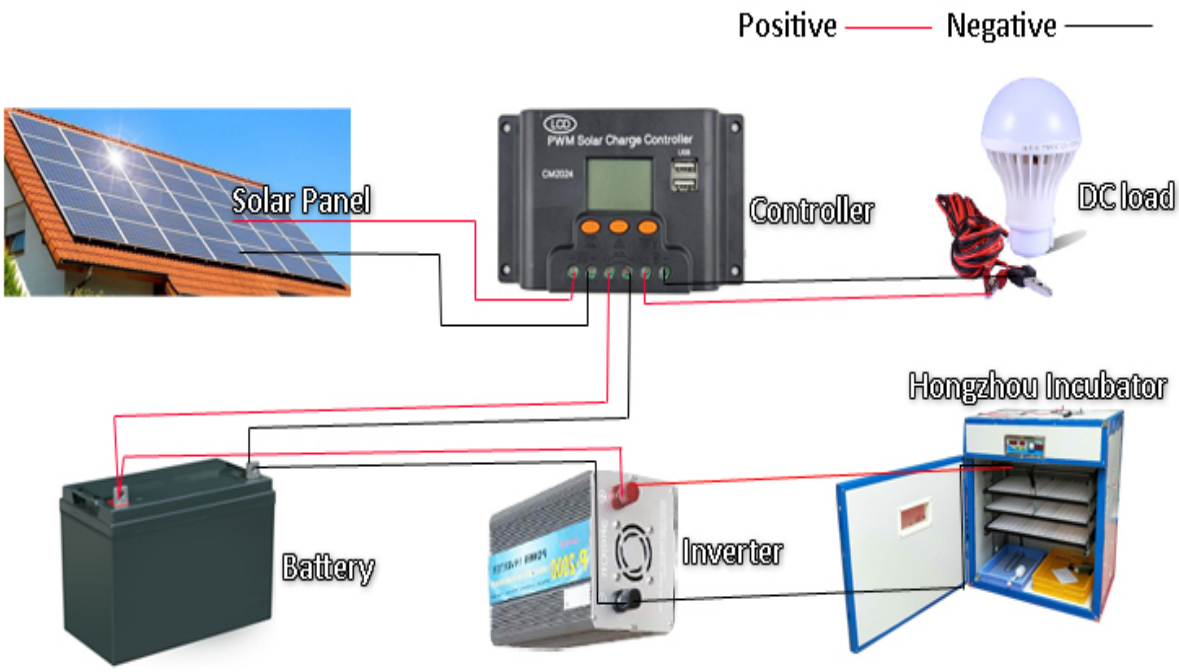
Advantages and disadvantages of dim lighting regimes (0-10 lux)

Advantages	Disadvantages
• Reduced fuel 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

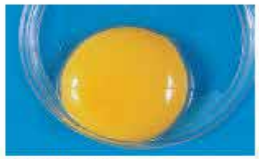
Hatcheries and Incubation

Foster mother incubation	
Kerosene-Powered Chicken Egg Incubator	
Homemade plastic container incubator	 https://www.youtube.com/watch?v=yUojPVhYcA0
	

Solar energy powe
matic egg incubatc



CHICK EMBRYO DEVELOPMENT



INFERTILE
- No development.

DAY 1
- Appearance of tissue development.

DAY 2
- Tissue development very visible.
- Appearance of blood vessels.

DAY 3
- Heart beats.
- Blood vessels very visible.

DAY 4
- Eye pigmented.

DAY 5
- Appearance of elbows and knees.

DAY 6
- Appearance of beak.
- Voluntary movements begin.

DAY 7
- Comb growth begins.
- Egg tooth begins to appear.

DAY 8
- Feather tracts seen.
- Upper and lower beak equal in length.

DAY 9
- Embryo starts to look bird-like.
- Mouth opening appears.

DAY 10
- Egg tooth prominent.
- Toe nails.

DAY 11
- Comb serrated.
- Tail feathers apparent.

DAY 12
- Toes fully formed.
- First few visible feathers.

DAY 13
- Appearance of scales.
- Body covered lightly with feathers.

DAY 14
- Embryo turns head towards large end of egg.

DAY 15
- Gut is drawn into abdominal cavity.

DAY 16
- Feathers cover complete body.
- Albumen nearly gone.

DAY 17
- Amniotic fluid decreases.
- Head is between legs.

DAY 18
- Growth of embryo nearly complete.
- Yolk sac is still on outside of embryo.
- Head is under the right wing

DAY 19
- Yolk sac draws into body cavity.
- Amniotic fluid gone.
- Embryo occupies most of space within egg (not in the air cell).

DAY 20
- Yolk sac drawn completely into body.
- Embryo becomes a chick (breathing in air cell).
- Internal and external pip.

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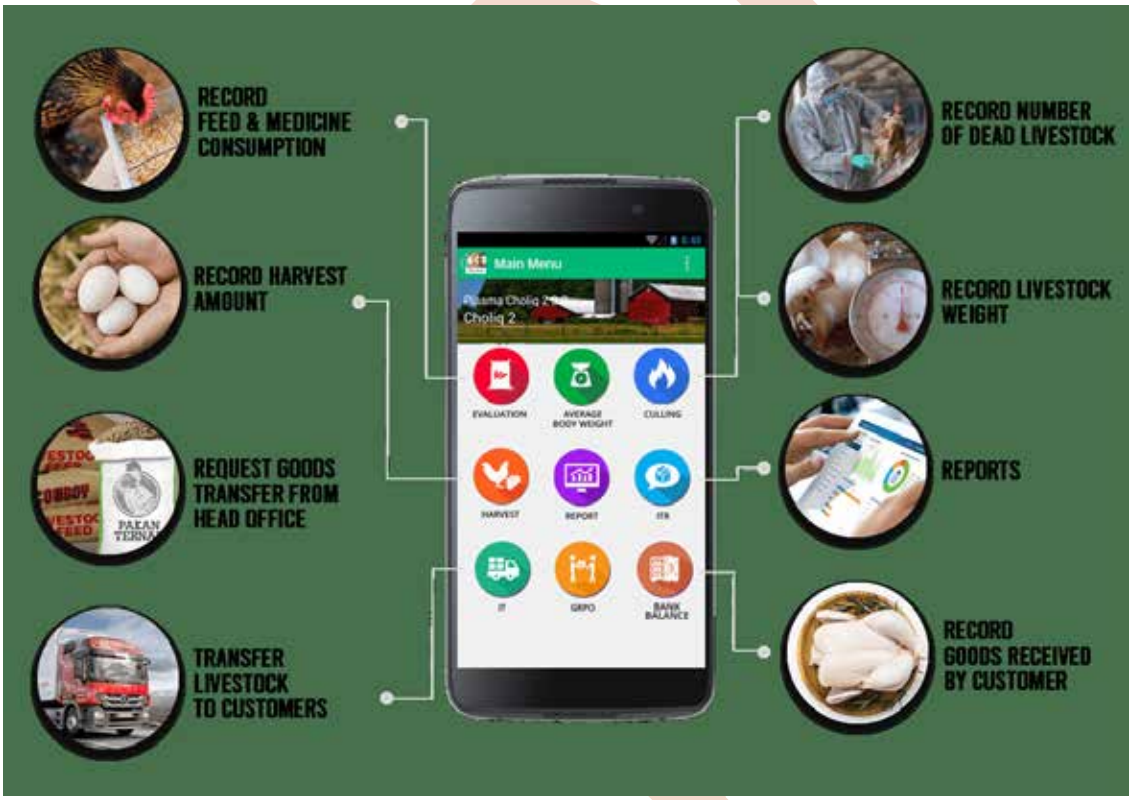
8) Mobile apps for chicken production and extension services

Mobile communications technology has become the world's most common way of transmitting voice, data, and services, and no technology has ever spread faster.

Mobile phones:

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



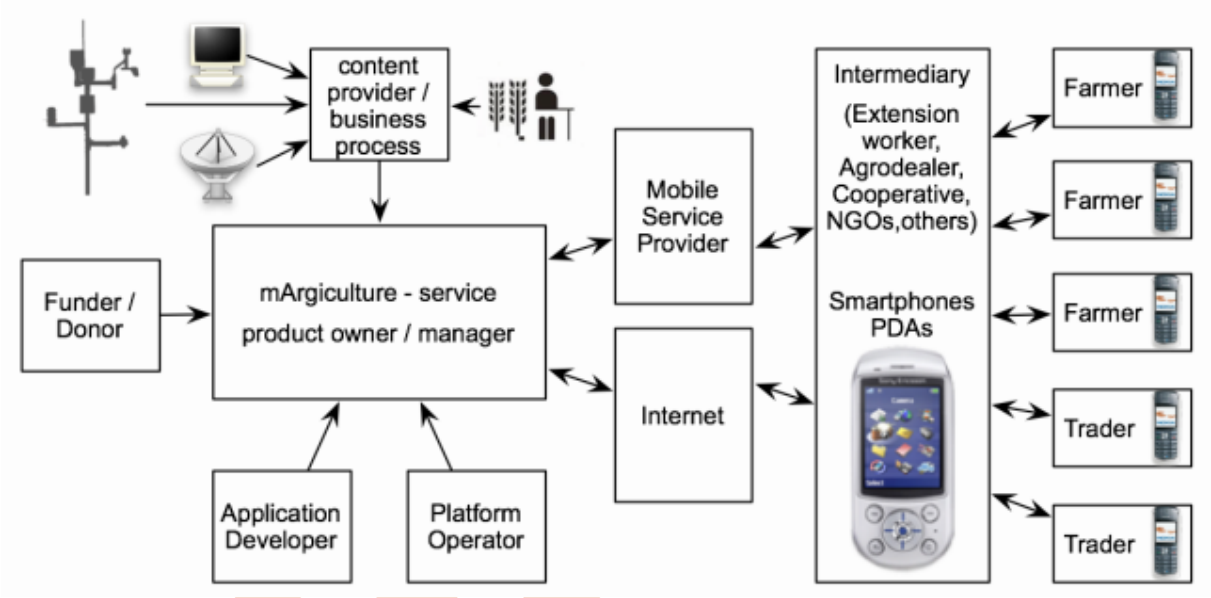
The monitoring process in a farm (whether chicken, cow, duck, fish, etc.) is very important, so that the costs used can be accurately recorded, so that the actual production costs can be obtained.

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

- Location and condition of the cage
- Seed selection
- Feeding and vitamins
- How to maintain
- Harvesting Process
- Analyze the efficiency of feed use
- Analyze the mortality rate of livestock
- Analyze the use of vitamins/medicine to the performance of livestock
- Analyze animal weight
- Analyze livestock sales

- Analyze expanse expense (use of petty cash)
- Record stock of feed, vitamins, medicine and livestock

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



9) Chicken 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.

Poultry Feed Production Process

Cleaning System

Feed raw materials: Corn, Beans, etc...

Receicing materials and clear away the impurities and iron in the material.
Major Equipment:
Cylinder Precleaner/ Permanent Magnet Sleeve/ Bucket Elevator/etc...

Grinding System

Raw materials powder

The raw materials are crushed into powder
Major Equipment:
Hammer Mill/ Impulse Filter/Rotary Distributor/etc...

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

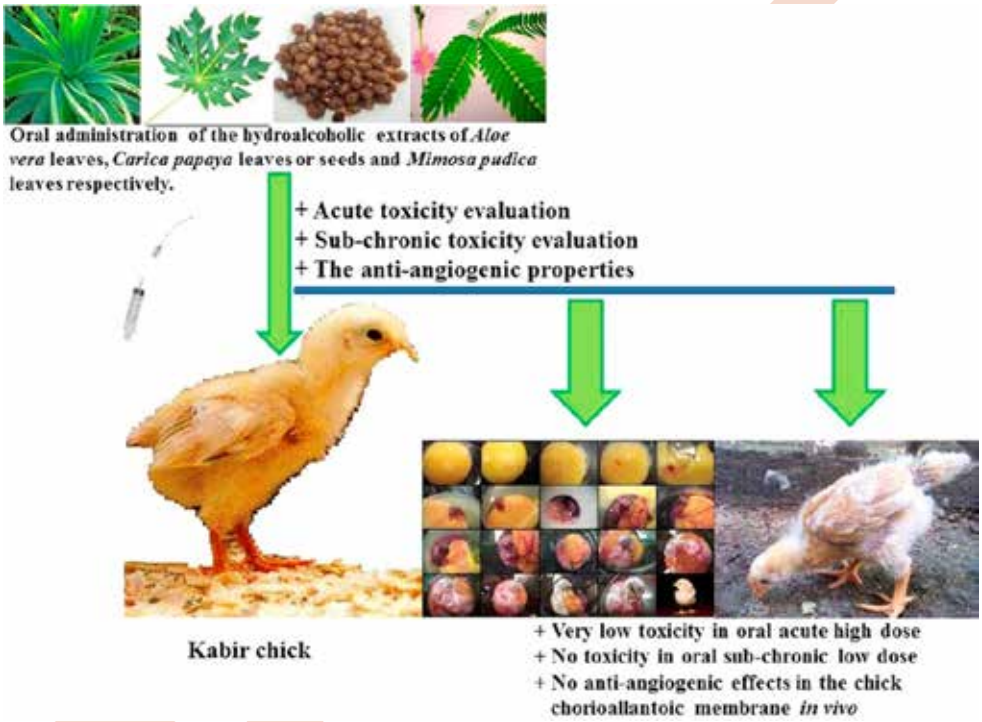
Pressing the powder feed into pellets, cooling pellets, and crumbling the pellets into smaller size if necessary
Major Equipment:
Pellet Machine/Vibrating Screener/Cooler/Crumbler/etc...

In the African context, making feed from locally available materials and pelleting will help in reducing the cost and wastage.

10) ethno-veterinary services in chicken 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 or irregular and expensive. At this

level, indigenous animal health systems are used for emergency purposes.



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

Feeders

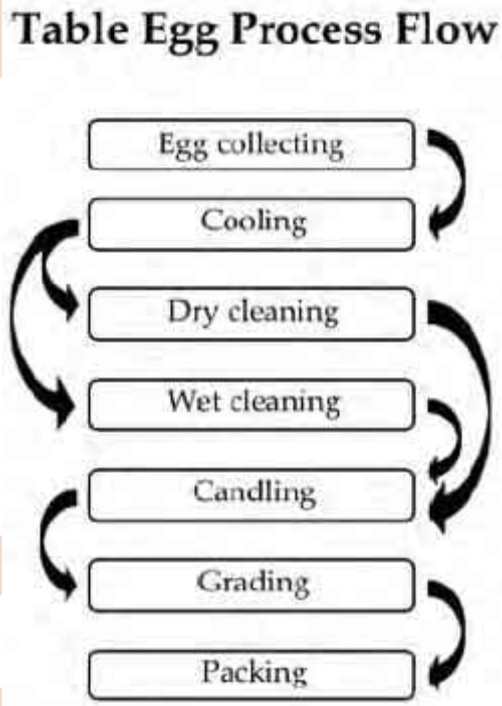
Drinkers

Brooders

12) Collection/ cleaning, grading, packaging

Egg Processing Line with Cleaning, Grading and packaging

The process is as follows



VIII- MARKETING AND DIGITAL INNOVATIONS TECHNOLOGIES

Innovation in poultry product marketing will include:

1) App to develop chicken 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

IX- CRYOPRESERVATION/ CRYOCONSERVATION OF AFRICAN CHICKEN GENETIC RESOURCES

1) Genetic diversity of local chicken

Chicken 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 chicken genetic diversity. These local breeds are well adapted to extensive husbandry systems or backyard chicken production. They are results of millennia of years of evolution and are therefore adapted to the local environment.

The decline in chicken genetic diversity and genetic variation are caused by the following factors:

- Substitution of local breed adapted by exotic breeds
- Uncontrolled crossbreeding
- consumer's preference

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

2) Conservation of chicken genetic resources

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

tal challenges.

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

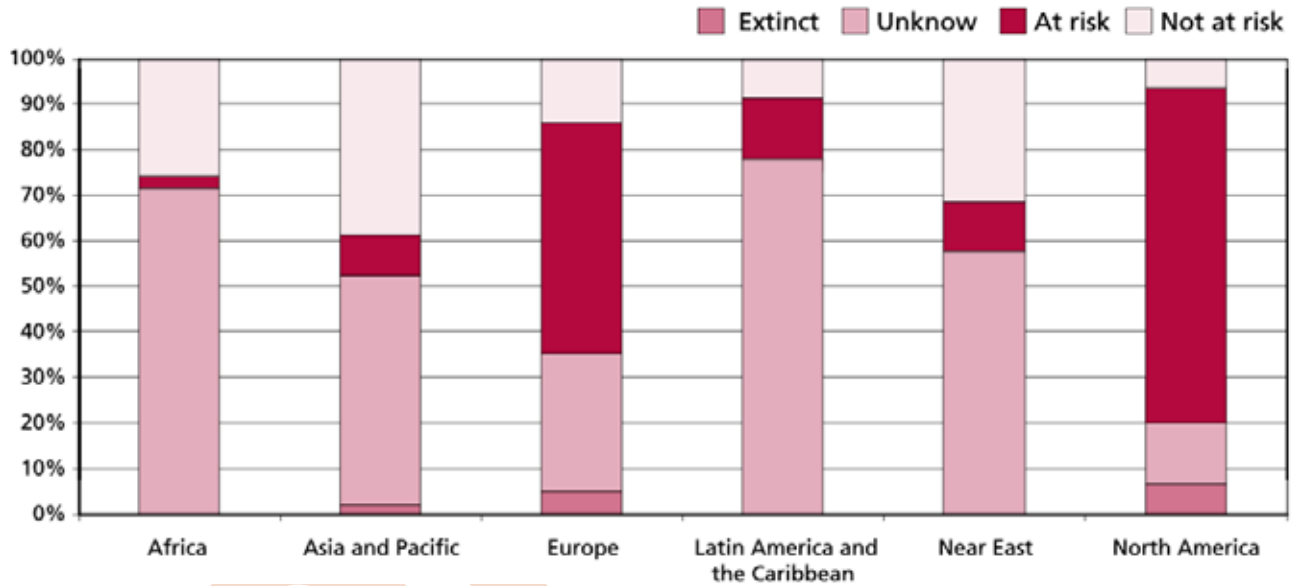


Figure: risk status of local and regional chicken breeds, by region

From the FAO database, it is estimated that about 25 percent of chicken 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.

3) Conservation in regional gene bank and database

Cryopreservation is an important complementary measure for the conservation of diversity in chicken 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 genebanks could play several key roles namely:

- provide cryoconservation facilities for countries lacking national genebanks;
- provide back-up storage for national genebanks (i.e. a second location f or security purposes); and
- store material fr om trans-boundary breeds.

Regional animal genebanks 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 ger-

mplasm; and the long-term care, documentation and security of the samples.

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

- Inventory and characterization of livestock populations with special attention to indigenous types
- Identification of priorities and mobilization of resources in support of conservation
- Development and support of genebanks for threatened populations
- Development and maintenance of genebanks
- Evaluation and utilization of diverse genotypes, including those imported from other countries
- Collaboration with other national and international programmes.

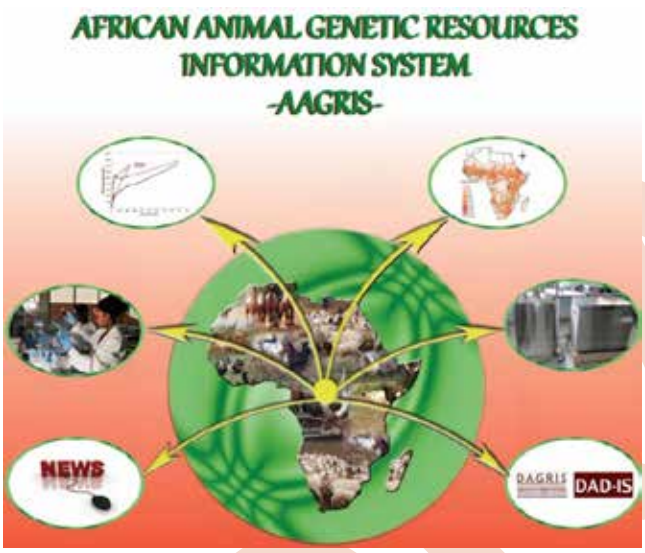
An important lesson from experiences with the plant genetic resources genebanks is that good documentation and good organization are critical. Otherwise, the task of accessing accumulated materials of which little is known regarding genetic characteristics or environmental background becomes formidable, and genebanks 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 genebanks over time.

Design and management of data banks should be done in harmony with genebanks to ensure that essential data are available. This implies that the same institutional infrastructure supports both data and genebanks. Data banks not associated with genebanks 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 aware-

ness 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/	AAGRIS has **FIVE** main categories • Species and breeds • Inventory, monitoring and surveillance • Conservation and breed improvement programmes • Capacity development • AnGR Institutions

4) Collection of eggs from the field

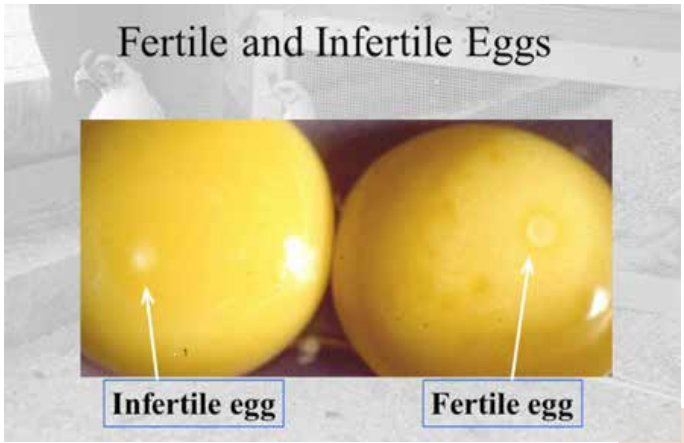
5) Primordial Germ cell (PGC) technology

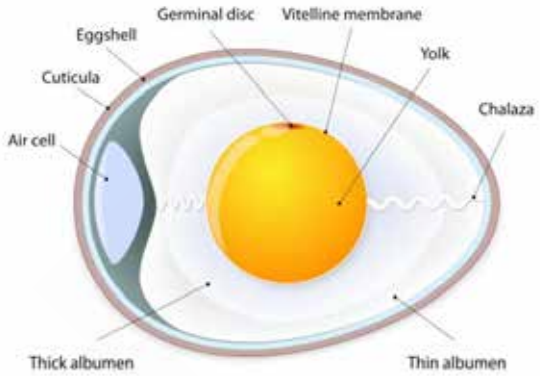
a) The basic knowledge of Avian Primordial Germ Cells

Day by Day Chicken Embryonic Development:

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

Fertilized eggs





Migration of PGCs in the chick embryo

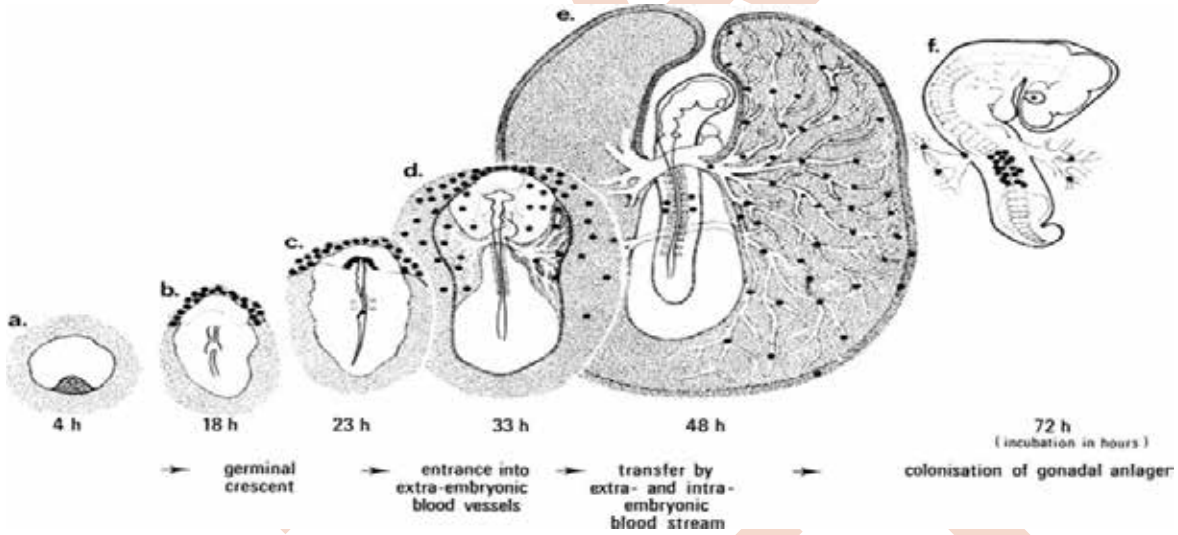
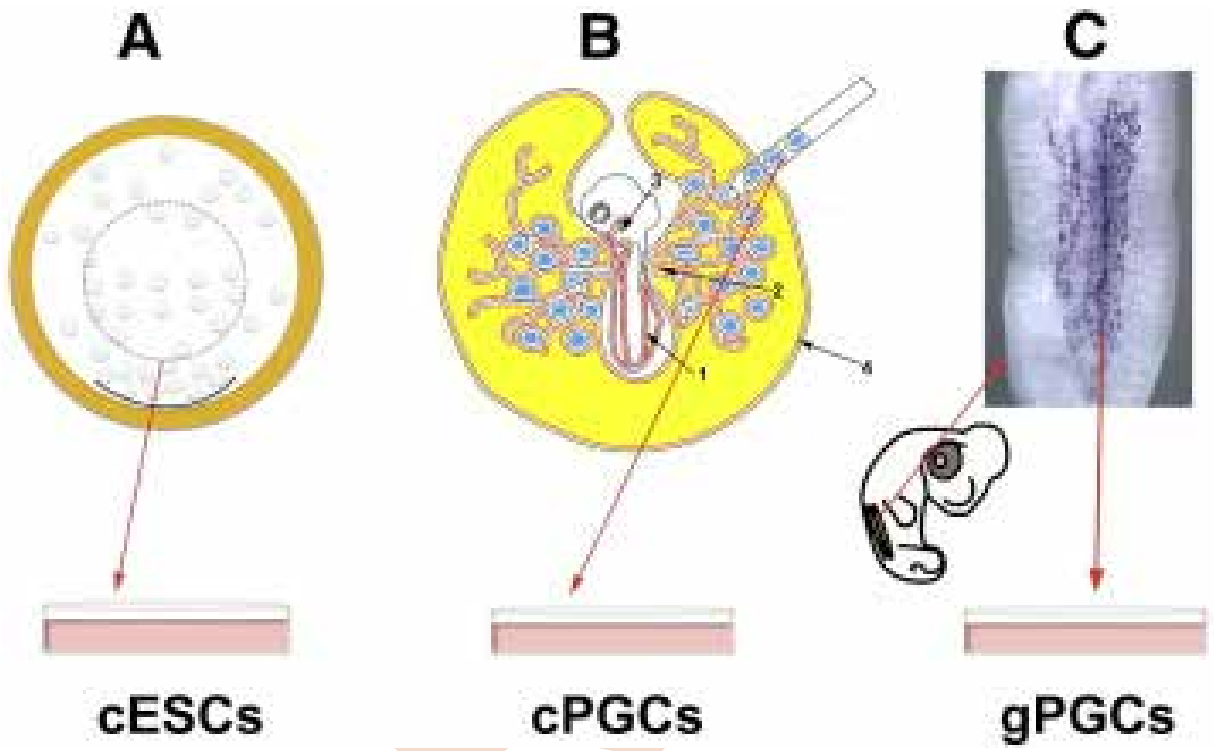


Figure. Migration of PGCs in the chick embryo. (a) Absence of easily identifiable PGCs prior to primitive streak formation (b) and (c) accumulation of PGCs in the germinal crescent (d) penetration of the PGCs into blood islands (e) circulation of PGCs through the vascular system (f) colonisation of the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

b) Isolation PGC cells form different stage of Embryo



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

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 chickens (economic traits, morphological features)	Finished /ILRI
	Example questionnaire to be filled during sampling (Breed questionnaire, Production environment descriptors)	Finished /ILRI
	Collection blood from chickens 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 chicken 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 Chicken 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 chicken Embryos	In processing /Roslin

Isolation of PGCs from chicken 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)
- Chicken farm

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




Astell





A











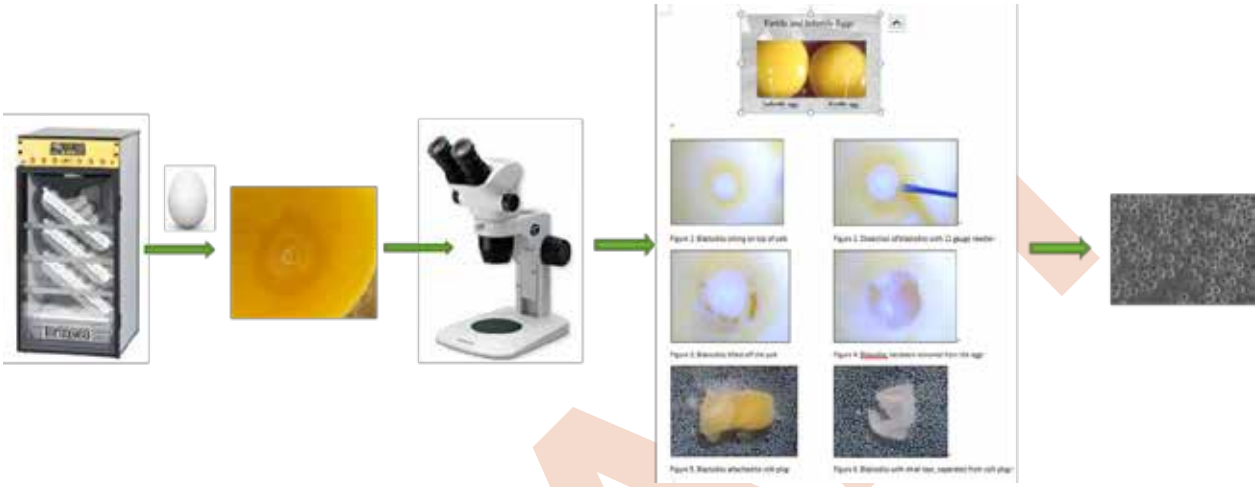







Isolation of PGCs from chicken embryo gonad

Isolation of PGCs from chicken embryo Blastodisc

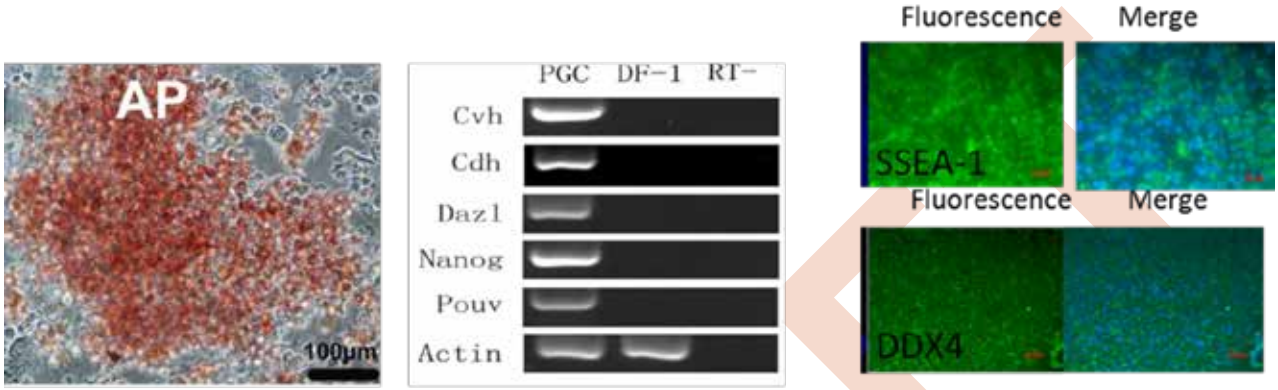


Isolation of PGCs from chicken embryo blood

Sexing of Chicken embryos（PGC）

Characterization of primordial germ cells

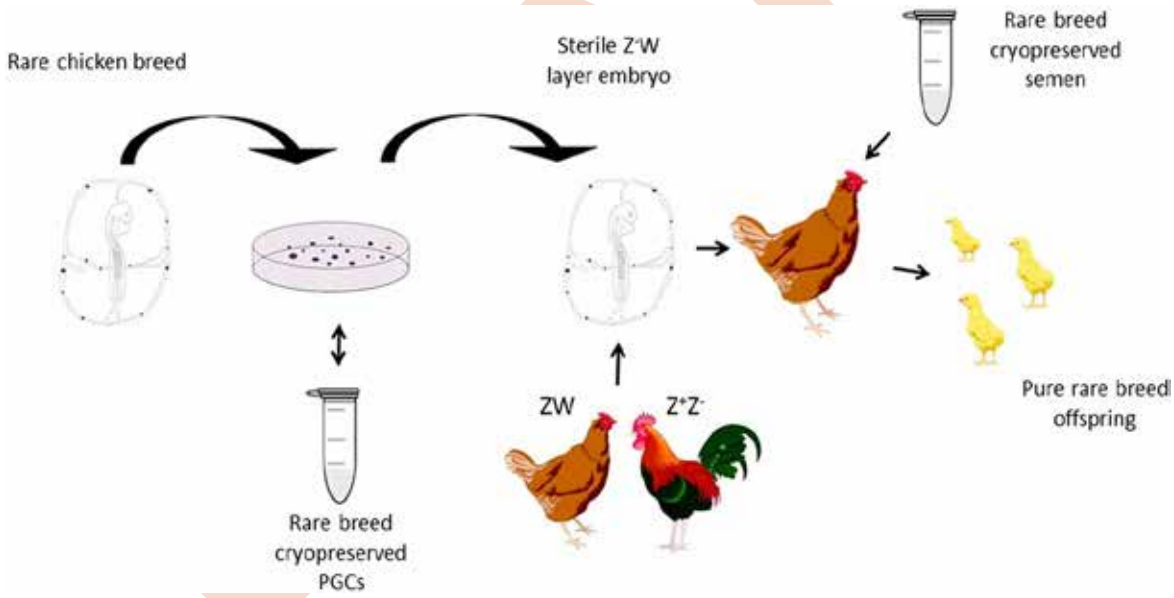
- *Alkaline Phosphatase Staining*
- *Immunocytochemistry*
- *RNA Isolation, Reverse Transcription, and PCR*



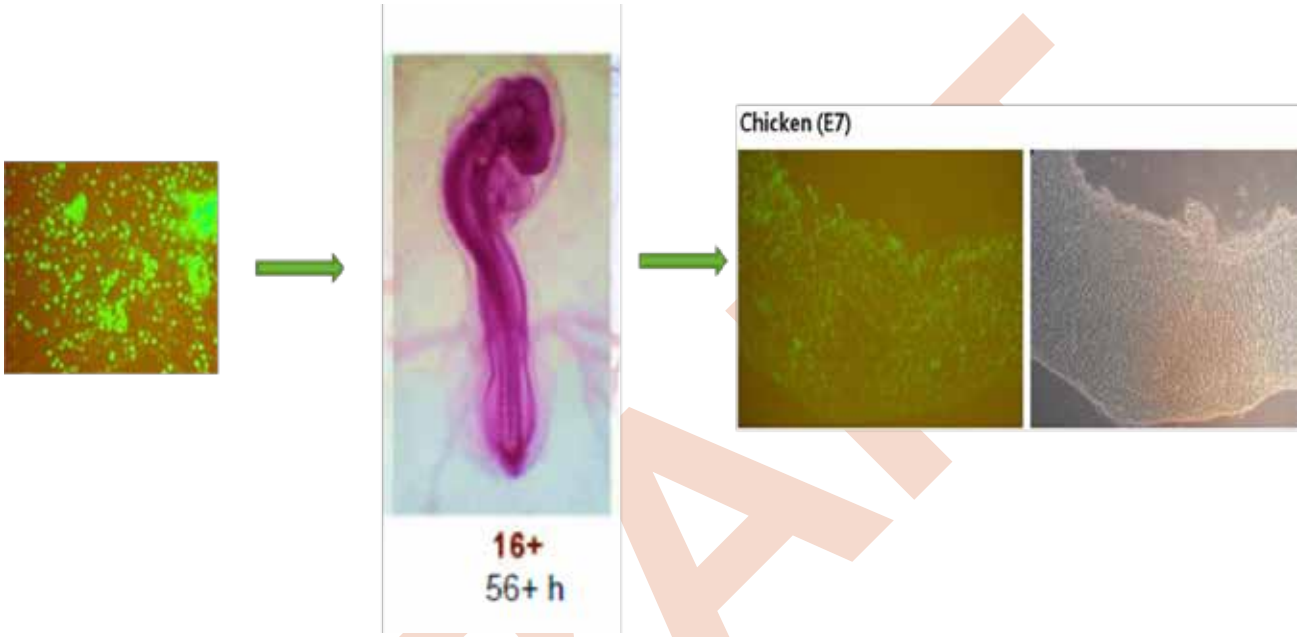
Cryopreservation of PGCs serum-free in liquid nitrogen

c) Culture free technique of cryopreservation of PGC

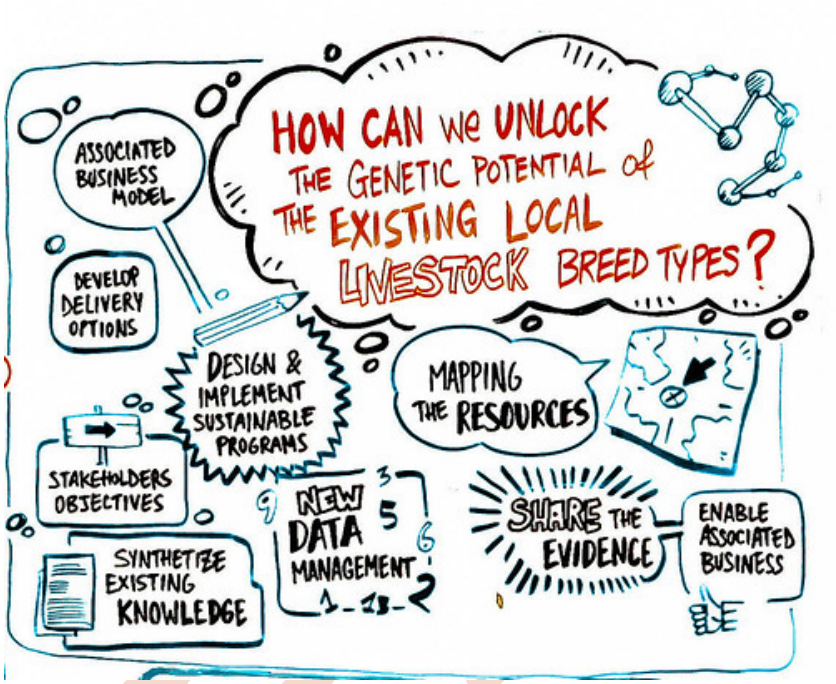
d) Recovery of chicken population from cryoconserved PGC



Woodcock et a., 2019



e) Cryoconservation to support local chicken value chain



6) Cryopreservation procedure

- Check for contamination
- Media preparation
- Freezing cells in a controlled-rate chamber
- Recovering cryopreserved cells
- Post thawing considerations

Contamination

Sources

- Contaminated cell lines
- Improper aseptic technique

Types

- Microbial – Bacteria, mycoplasma, fungi, viruses
- Cellular – Cross contamination

Signs

- Turbid media
- Rapid decline in pH – color change
- Morphological changes
- Filamentous structures

Freezing Cells

-70°C

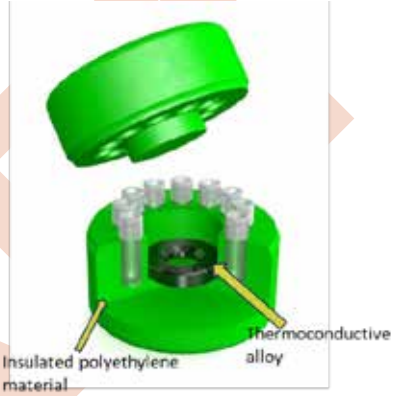
Controlled rate freeze chamber

-1°C/min cooling rate

A few hours to 24 hours

-140°C

Liquid nitrogen tank

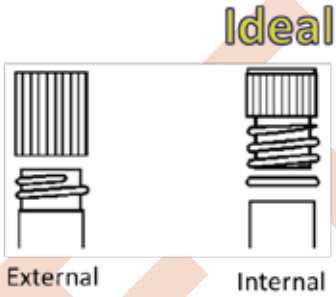


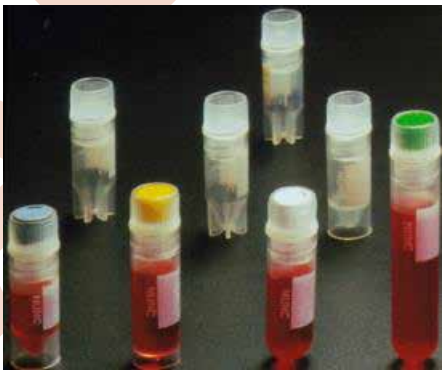
- Reliable -1°C/min cooling rate
- 4 Hours in -70°C Freezer
- Comfortable to touch
- No alcohol use or maintenance

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)



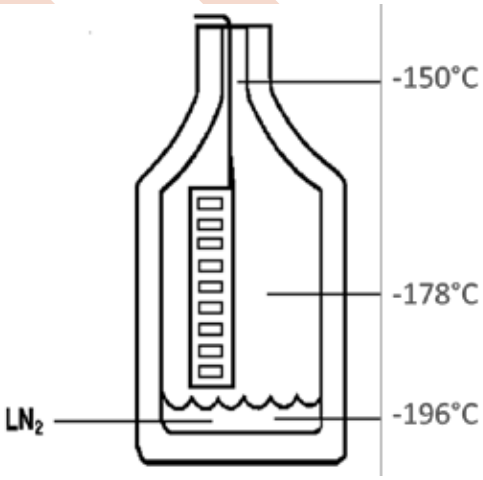


Considerations for vial type selection

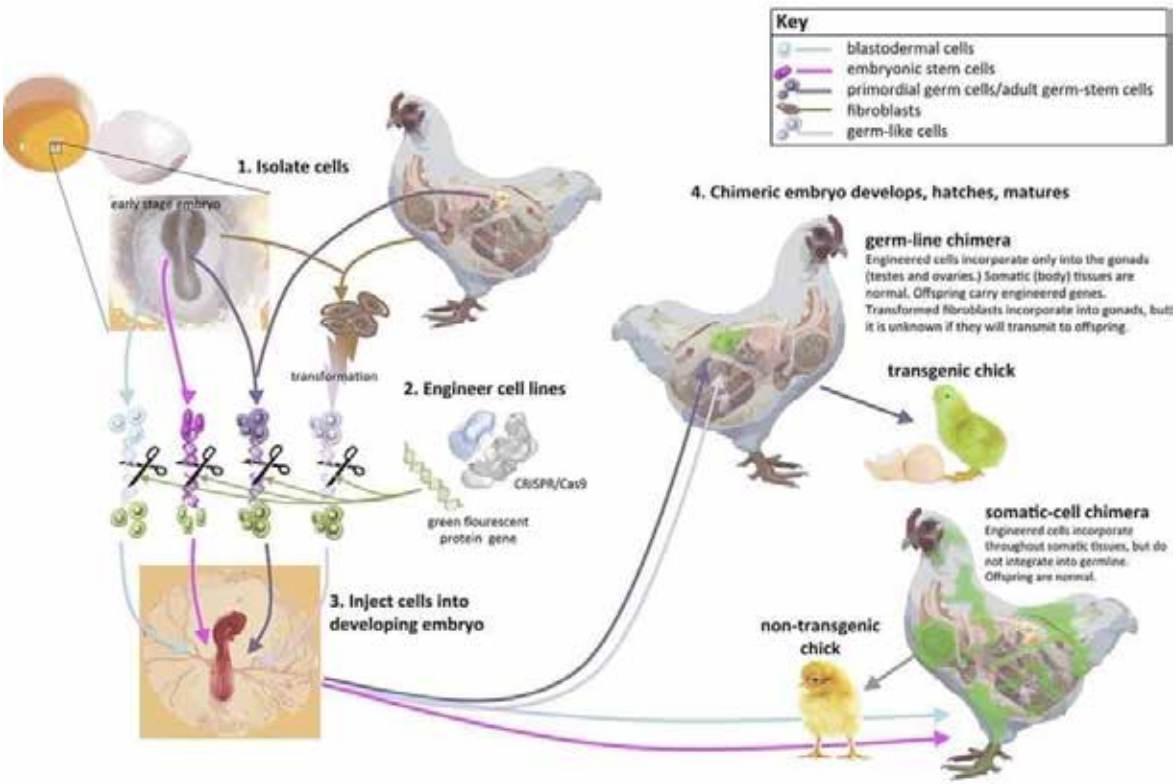
- Storage temperature
- Liquid submersion
- Head space
- Effect on warming
- Material stresses

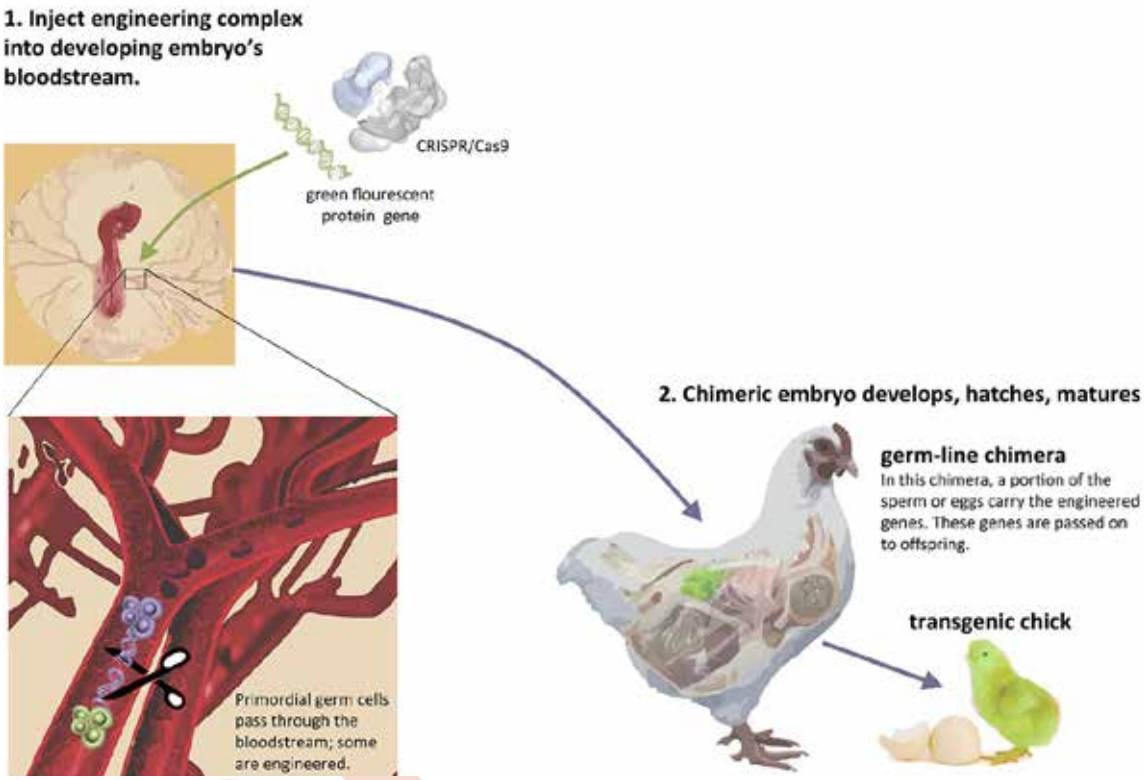
Low temperature storage

- 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**



Methods of creating transgenic chickens





X- VALUE ADDITION, PROCESSING AND BIOSECURITY IN LOCAL CHICKEN VALUE CHAIN

1) Value addition and processing

This is still at a very nascent stage but both the quantity and value of the exported processed chicken

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.

a) **Advantages of Value Addition.**

- Adding value to chicken especially to meat and eggs increases its life span
- Increasing value increases the convenience to consumers
- It mitigates losses that you can go through while trying to sell such as meat going stale
- Value addition creates a more significant market opportunity and can easily satisfy the demand for products

b) **When to Add Value**

If you want to have a competitive edge from your business rivals, then it's time to add value to your chicken. It will benefit you in reducing losses from chicken meat going bad and your eggs breaking. Moreover, Value addition will also reduce waste tremendously. You will be able to make money from simple things including feathers and chicken waste.

c) **State of the art Post-harvest technologies**

Egg processing sector is still in infancy stage in India in spite of 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.

The Many countries in Africa have begun exporting local chicken 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 chicken products are preferred by many buyers

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

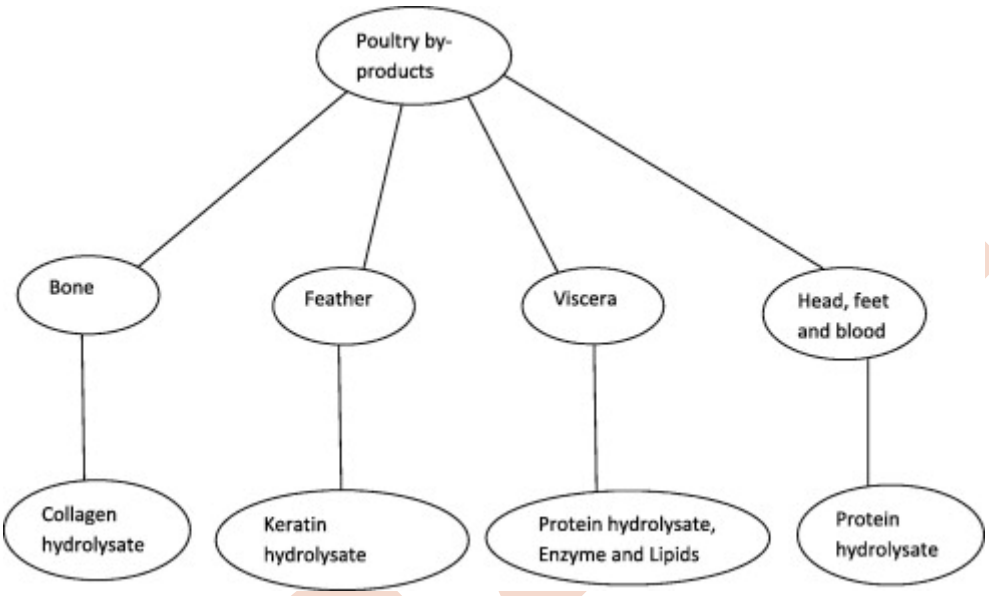
Industry must come forward to create awareness about processed products. This will not only help in the improvement of production lines but will also promote consumption of healthy, safe, and hygienic meat products among African populations.

Chilled chicken is said to be gaining more rapidly than frozen, but both are a very small share of the total market.

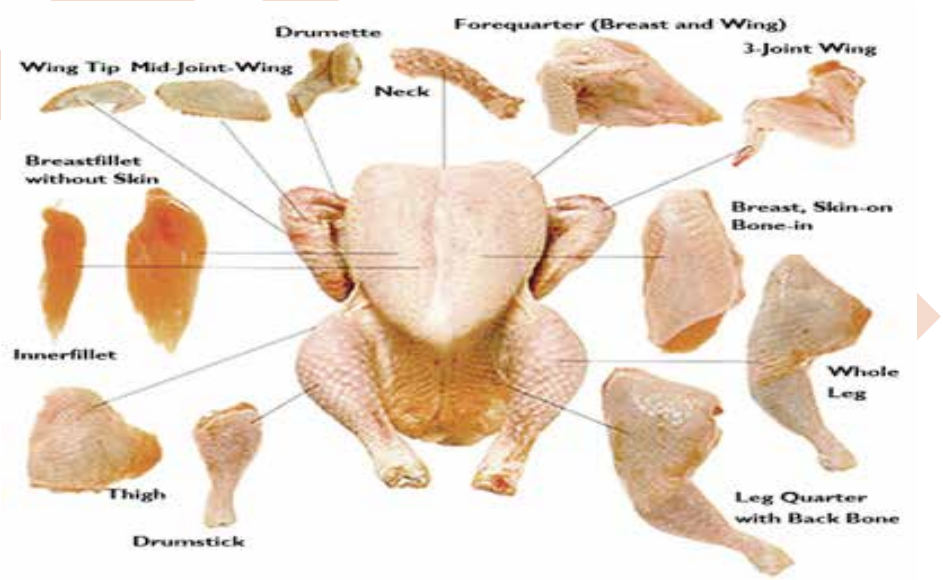
d) **What Chicken products can you Add Value to?**

- 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, you 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 you need to do is mix it with water. Bakers are increasingly embracing the use of powdered eggs in their trade.

- By-products: You can add value to chicken by-products such as feet and head by packaging it and selling it as pet food. You can get an extra coin by drying chicken feathers. They are a good fiber source and can be used to make pillows and cushions. Chicken excretions are a good source of manure. You will not miss a farmer or two who will buy the organic fertilizer from your chicken farm. You can dry chicken blood and make money from selling it as fish meal.



- Chicken Meat Parts: Give your customers a wide range of choice. You can give them chicken parts including gizzards, drumsticks, necks, thighs, wings, and breasts. You can pack them and get them to the shelves as either fresh or frozen cut-ups.



-  ***Semi-Cooked chicken***: You can spoil your consumers for choice by putting semi-cooked chicken strips on the shelves. Just ensure that they are flavored and seasoned. Your market will include hotels, schools, hospitals, and supermarkets.

-  ***Fully cooked chicken***: You will need to be an owner of choma joint, eateries or restaurant to be able to serve your customers thoroughly grilled chicken

-  ***Marinated chicken parts***: Marinated chicken parts have increasingly become popular. Most customers especially the chefs from restaurants like marinated chicken. They find them juicy with a great aromatic taste. You will have saved the chefs lots of time in marinating the chicken because it takes up to 72 hours.

-  ***Boneless chicken products***: Boneless chicken is popular among the middle class. It is an extensive market, and you need tap it. You can also package the bones and sell them. They are great in making certain dishes especially soup.

e) **Value-added Chicken Business Ideas**

-  ***Chicken restaurants***: As earlier mentioned, the best way to sell fully cooked chicken is by starting a restaurant. It is a great chicken business idea. You will have a direct market for your chicken all year round

-  ***Hatchery***: Developing a hatchery is another great business idea. Instead of buying chicks from other hatcheries you hatch your own and even get to sell the day-old chicks. You can also decide to teach other farmers how to rear chicken. You will have extra cash in your pockets

-  ***Chicken parks***: Another great business idea is when you choose to establish a chicken park. You can rear ducks, layers, and broilers and have people pay to come and see your chicken park. You can choose to venture into value-added chicken business or to add value to your chicken. Both if executed well, will make you a profit. Be prepared to dedicate yourself fully and work hard to achieve your dreams. Nothing comes easy!

f) **Specific Chicken 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 Chicken Eggs: A simple technique for preparation of intact salted chicken 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 growing 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 growing fast food outlets. Egg roll filled with 80% scrambled egg and 20% chicken meat mixture (shallow pan fried) was rated best in flavour, texture and overall acceptability. Egg roll had 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 growing 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 growing fast food outlets. Egg Waffles prepared from 65% liquid whole egg with 10% wheat flour and 5% granulated wheat are most acceptable and has an ambient shelf-life of 4 days in vacuum and 3 days in air packs, while at refrigeration temperature, it can keep well for 10 days in vacuum and 6 days in air packs with satisfactory microbiological quality.

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

-  ***Chicken patties***: This is a value-added, comminuted chicken 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.

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

- 

Intermediate moisture chicken meat: It is self-stable product developed by immersion of diced chicken 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.

-  ***Chicken 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.

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

- 

Vinegar based chicken gizzard pickle: Vinegar based chicken gizzard pickle is a low cost protein rich, chicken 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 chicken stock*** (One-minute curried chicken): This is a cost-effective fast food for instant use by working couples, old people and highly useful at times of instant need.

g) **Requirements for setting up your chicken products value addition plant**

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

i. Decide what product you will sell and how you will make it.

ii. Develop a plan for your business.

iii. Register the name of your business with your city

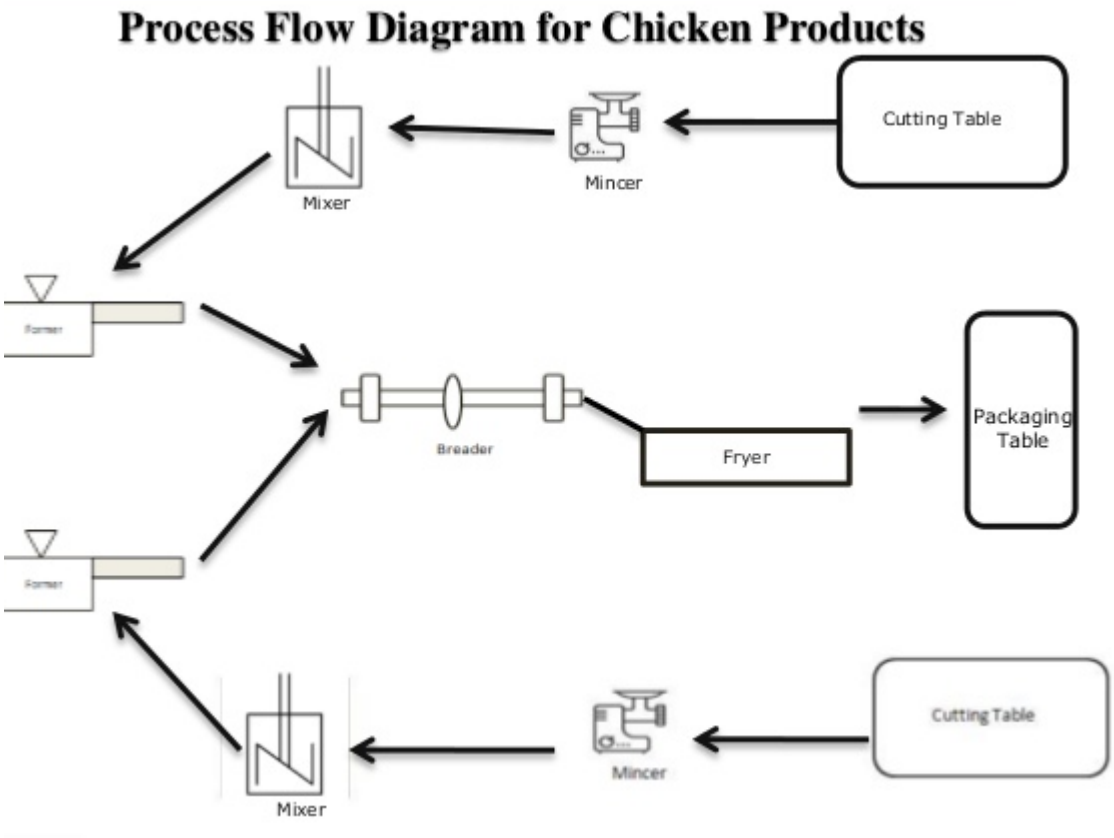
iv. Take a food safety certification course

v. Apply for a food business license

vi. Complete state and federal tax forms

vii. Determine your business risks and obtain insurance

viii. Start selling your product



h) **Processing of chicken products**

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

Certified inspectors are support to be in every plant monitoring the processing line to ensure the chicken you eat is safe and meets safety standards.

- Receiving and Slaughter

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

Workers trained in huma
carefully place chickens on a movi

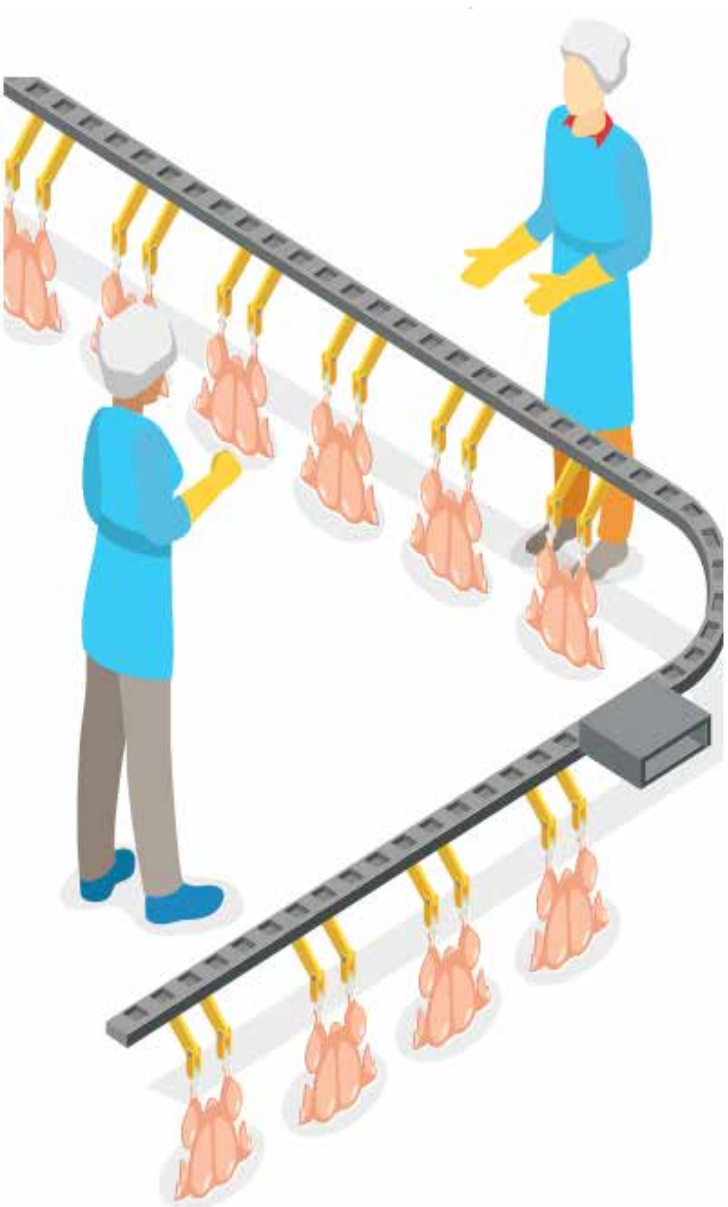
The chickens are calmed b
and by “rub bars,” which provide
sensation on the chicken’s chest

Birds are stunned (rendered unconscious
and unaware of pain) and then slaughtered with
a quick, single cut to the throat

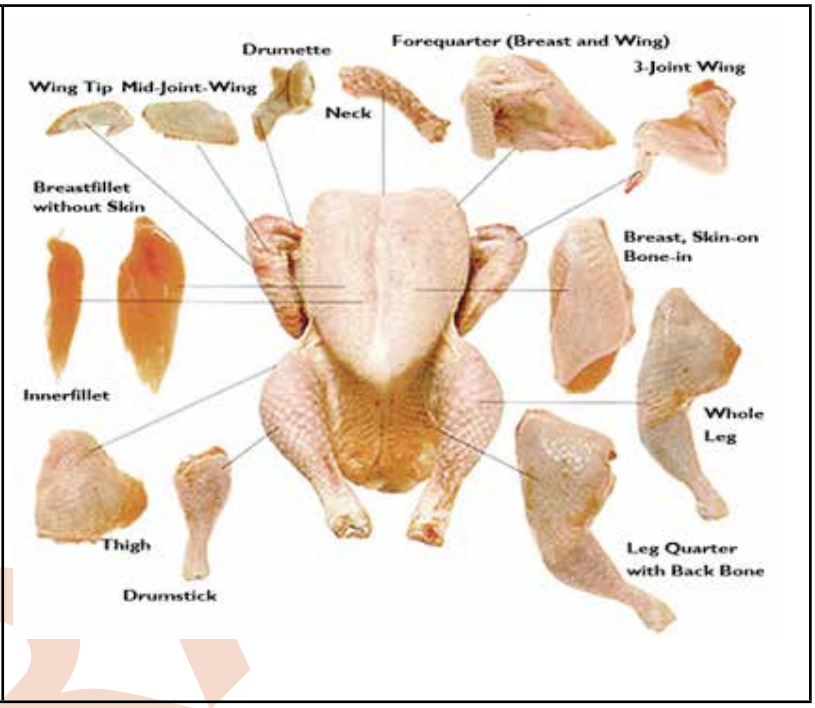
Trained workers ensure that each bird
is properly slaughtered before feather removal,
evisceration and cleaning

- **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 chicken is tested for any potentially dangerous bacteria, like Salmonella	

- **Processing and preparation**

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

- **Packaging and shipping**

Once the chicken is cut up into parts, it is packaged, bagged, and/or boxed

The chicken products should not leave the plant without being inspected and getting the seal of approval by the certified veterinarian.

Finally, the chicken is shipped in refrigerated containers of truck to grocery stores, restaurants or distribution centers.

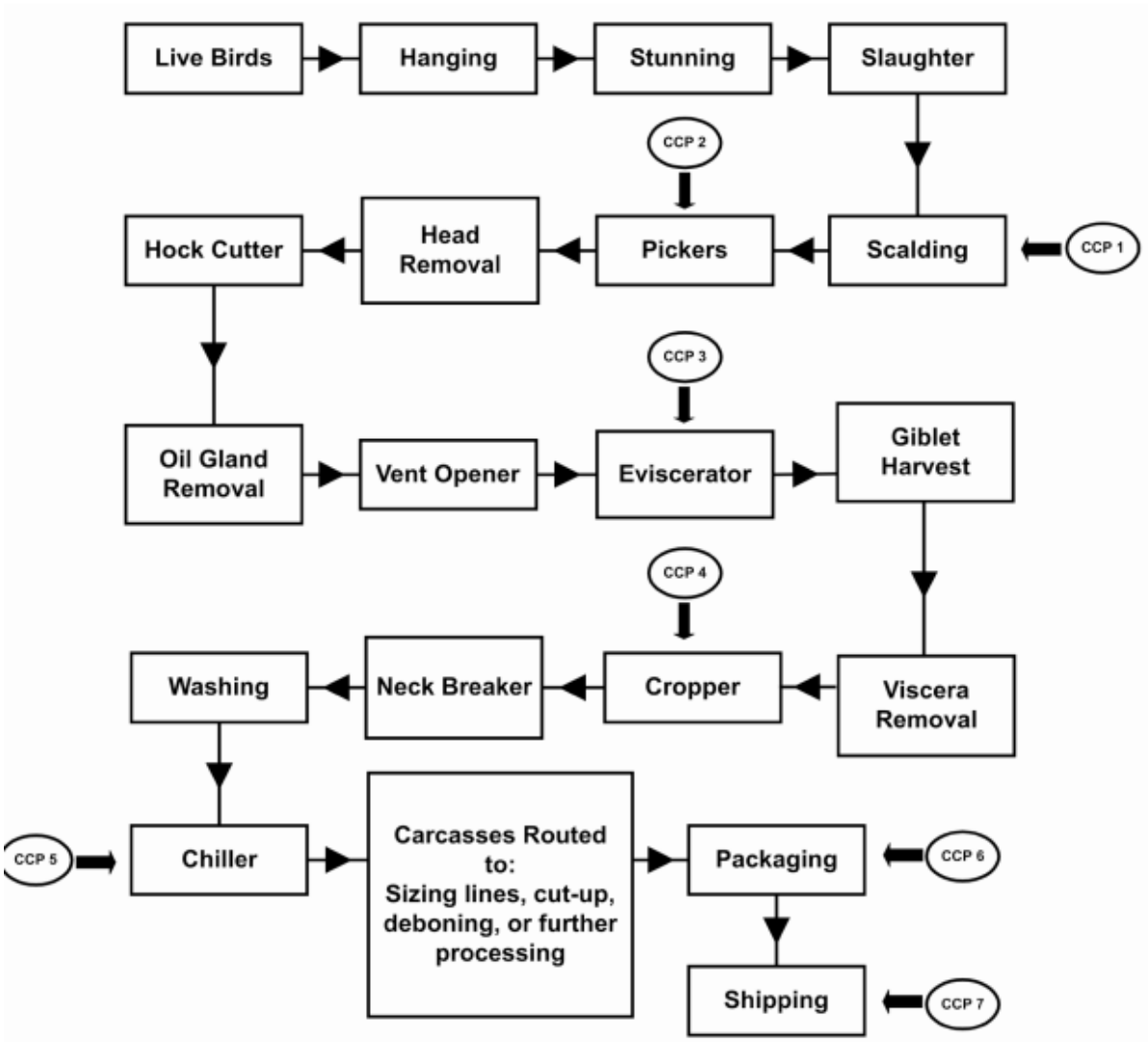


Figure. Example of Chicken Processing hazard analysis critical control point (HACCP) Flow Diagram.

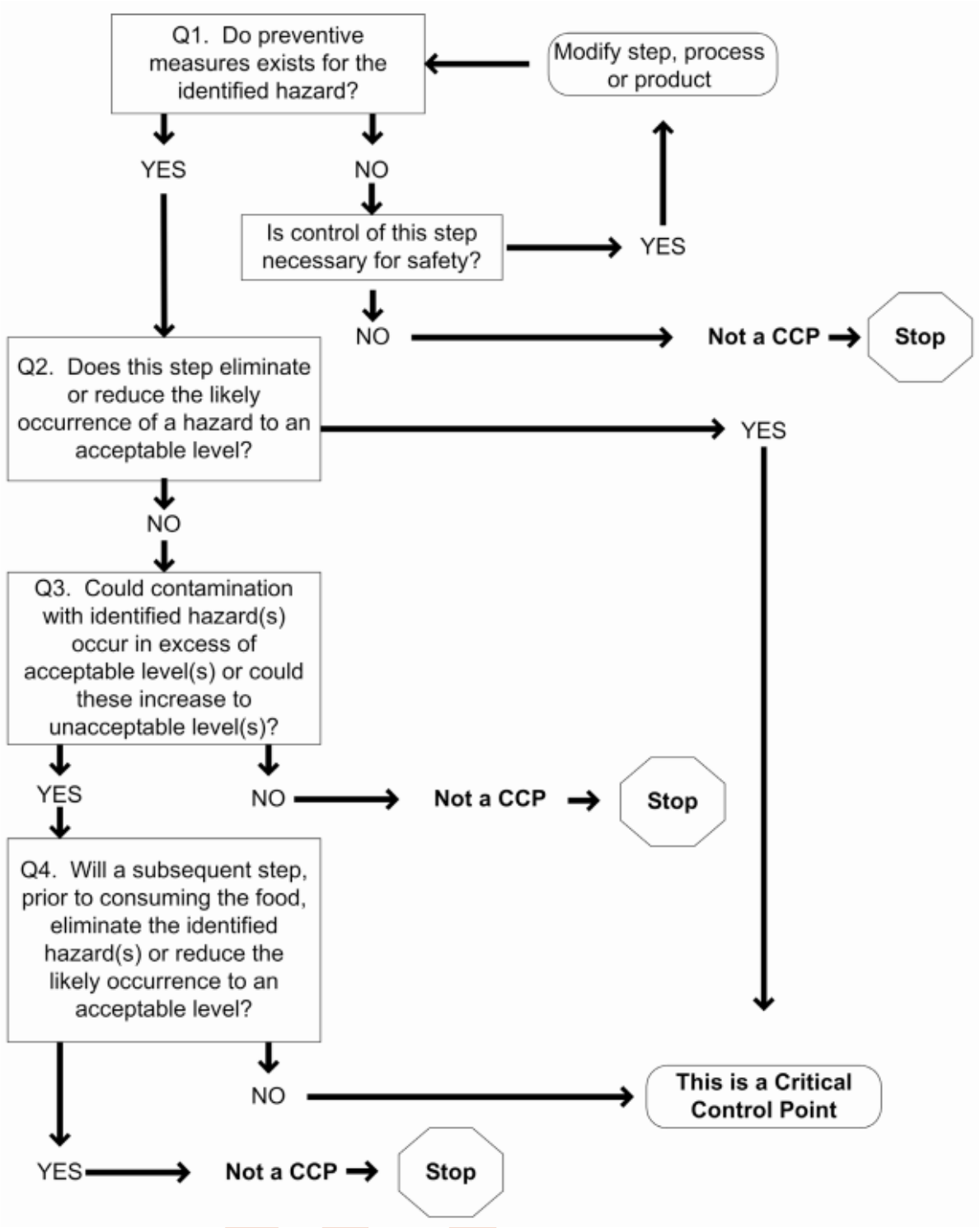


Figure 2. critical control point (CCP) Decision Tree (Stevenson and Bernard, 1995)

2) **Biosecurity**

a) Personnel changing, showering and sanitary facilities

b) Receipt, storage and transfer of eggs

c) Incubation and hatching

d) Sorting, sexing and other handling of day-old birds

e) Storage of egg boxes and boxes for day-old birds, egg flats, chick box liners, chemicals and other items

f) Equipment washing

g) Waste disposal

h) Dining facilities for personnel

i) Office space.

3) **Potential of African local chicken products and suggestions for their globalization**

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

- Availability of different meats and egg in abundance for processing.
- Value addition to low value meat cuts and trimmings
- Low investments for production.
- Ease of processing using simple technologies.
- Increasing demand due to better standards of living and changes in lifestyle.
- High consumer response for variety, 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.
-

CONCLUSION

ANNEXES

ANNEX 1: Chicken parts

Chicken Breasts	One of the most popular chicken par ts, the chicken breast, can be purchased in many different forms. Chicken breasts are considered white meat and are available fresh and frozen in various cuts, such as whole breasts, breast quarters and breast halves.
Chicken Wings	Chicken wings, another very popular chicken product, are available in many forms. They are considered white meat.
Chicken Cutlets	Cutlets are boneless chicken 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
Chicken 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.
Chicken Fillets	Fillets are slices of meat from the chicken breast.
Chicken Breast Strips	Chicken breasts are cut into strips.
Chicken Tenders	Tenders, which are part of the chicken breast, are full pieces or chunks of chicken tenderloins.
Giblets	The giblets consist of the neck, liver and heart.

ANNEX 2: **Simplified diagram of the various operations performed in chicken processing**

Annex 3: Biosecurity Procedures In Chicken Production

(2019 © OIE - Terrestrial Animal Health Code - 28/06/2019)

Recommendations on the location and construction of chicken establishments

1. **All establishments (chicken farms and hatcheries)**

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

b) Chicken 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) Chicken 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 chicken 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 chicken 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) Chicken 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 chicken 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:

i. personnel changing, showering and sanitary facilities.

ii. receipt, storage, and transfer of eggs.

iii. incubation.

iv. hatching.

v. sorting, sexing, and other handling of day-old birds.

vi. storage of egg boxes and boxes for day-old birds, egg flats, chick box liners, chemicals and other items.

vii. equipment washing.

viii. waste disposal.

ix. dining facilities for personnel.

x. office space.

Recommendations applicable to the operation of chicken establishments

1. **<u>All establishments (chicken farms and hatcheries)</u>**

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

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

c) Traceability at all levels of the chicken 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 chicken 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 chicken 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 chicken, chicken waste, or chicken processing plant(s). This time period should be based on the level of risk of transmission of infectious agents. This will depend on the chicken 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 chicken.

2. **Additional measures for all chicken 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 chicken 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 chicken house.

d) Animals, other than chicken of the appropriate (resident) species and age, should not be permitted access to chicken 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 chicken 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 chicken house is empty.

f) Birds used to stock a chicken 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 chicken house should be kept dry and in good condition.

i) Dead birds should be removed from chicken 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 chicken 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 chicken 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 chicken house and equipment should be done.

n) For chicken flocks that are allowed to range outdoors, feeders, feed and other items which may attract wild birds should be kept indoors. Chicken should not be allowed access to sources of contamination, such as household waste, litter storage are as, other animals, stagnant water an d water of unknown quality. The nesting area should be inside the chicken 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 chicken

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) Chicken 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 an d 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 chicken 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 chicken.

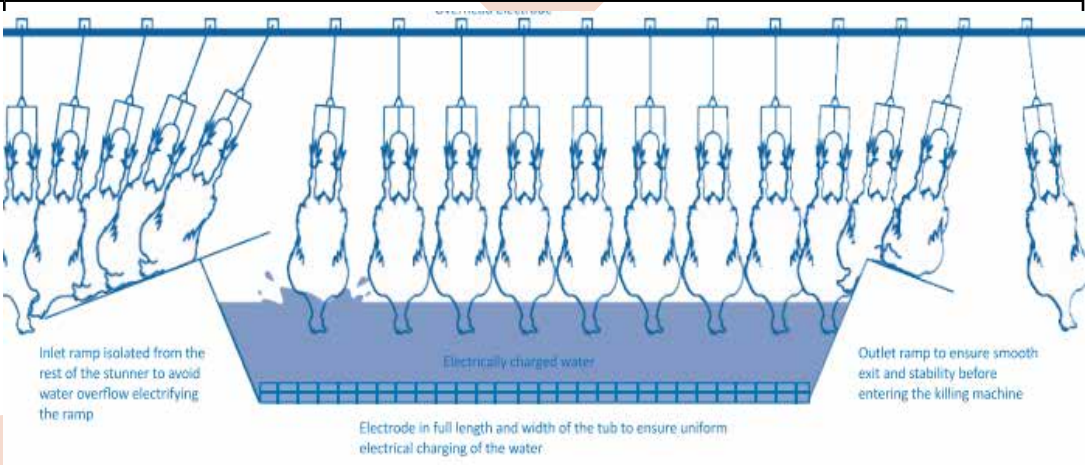
6) Periodically the market should be emptied, cleaned and disinfected. This is of particular importance when an infectious agent of chicken deemed significant by the Veterinary Services has been identified in the market or the region.

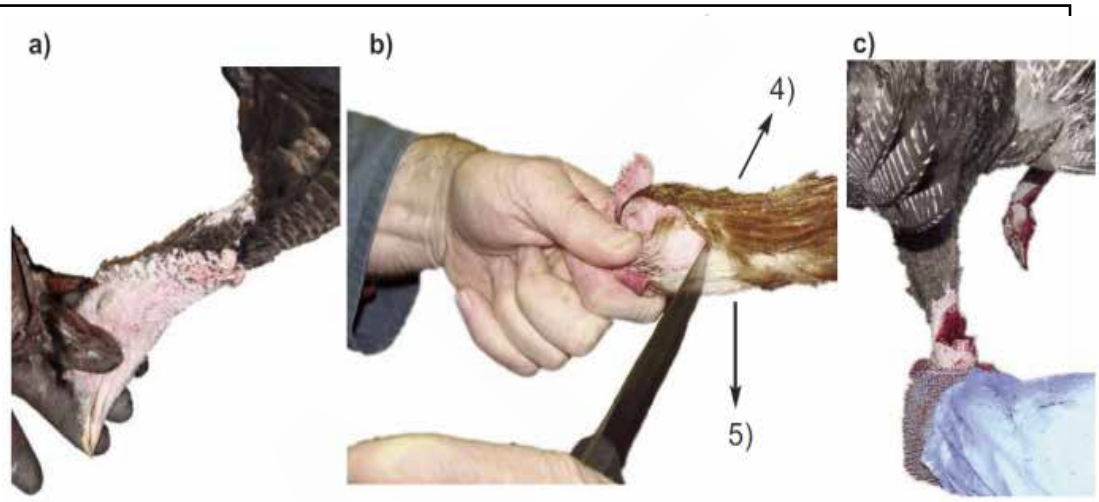
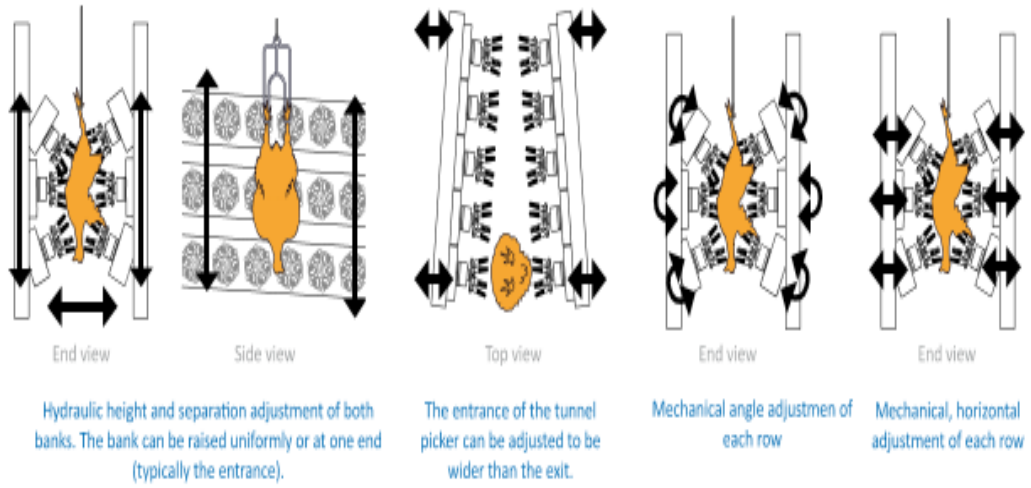
7) Where feasible, surveillance should be carried out in these markets to detect infectious agents of chicken. The surveillance programme should be determined by the Veterinary Services, and in accordance with recommendations in relevant chapters of the Terrestrial Code.

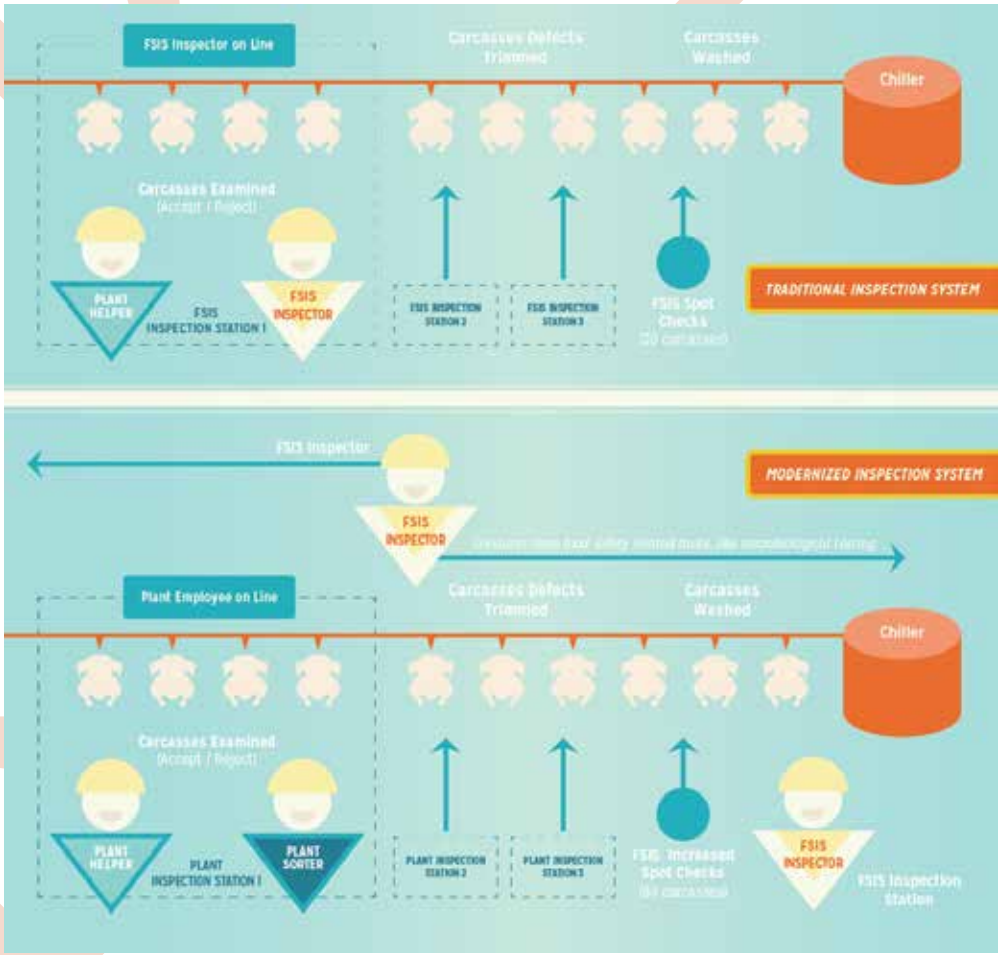
8) Efforts should be made to ensure the possibility of tracing all birds entering and leaving the markets.

Annex 4

PROCESSING STEPS

Step 1	Activity	
1	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	

12	Packaging	

ANNEX 5

EQUIPMENT FOR CHICKEN 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 vaccum 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.

- Drainage fittings
- Heavy duty grilles cast iron.
- Ceiling fans:
- Heavy duty (industrial) variable speed control, water resistant.
- Office equipment:
- Standard furniture, heavier duty preferred.
- Changing room equipment:
- Industrial quality.
- Laundry equipment.
- Industrial quality.
- Boot wash:
- Heavy duty, locally fabricated to fit chosen site.

ANNEX 6

EQUIPMENT FOR CHICKEN PROCESSING UNITS

Model 2 200 Birds/day: Chilled whole chicken carcases

1. Chicken 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. Carcase 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	Eviscerator	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

Chicken 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. Carcases 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 carcase 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 chicken 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 carcase 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.

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

Sink unit/sterilizer: For cleaning and sterilizing chicken 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 chicken carcases. 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 prechill the water in readiness for production. May be supplied with an auger to assist passage of carcases.

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 chicken carcases 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 chicken carcases 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 CHICKEN PROCESSING UNITS

Model 3 350 Birds/hour: Chilled whole chicken carcases and portions

1. Chicken 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. Carcase 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. Carcase 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 carcases(optional)
25. Packing table × 2, 2 × 1m

26. Chicken 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 carcase	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	١

5	Inspecting inside the carcase, removing remainder of lung tissue, removing head and placing in evisceration trough. Removing neck and placing into the appropriate giblet tray	٢
6	Cutting off feet and hanging carcase 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 carcase	1
2	Tying down, banding or trussing	1
3	Putting bird inside bag	1
4	Weighing and placing preprinted 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, Carcase 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 chicken 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 chicken shackle to steady it as the chicken 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 chicken 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 chicken.

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 chicken 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 galvanished steel. The container is supported on a trolley of four wheels, a handle and a tap at base to drain liquids.

Carcase washer

To wash the carcase 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 carcase. 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 carcases.

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 chicken carcases. 5 × 1.4 × 1.4m

Refrigeration (optional)

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

Packing table:

As holding table

Chicken 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 carcases or

1500kg chicken carcases.

- 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 chicken 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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