Hatchery Management Manual

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Ethiopian Institute of Agricultural Research

Hatchery Management Manual

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About the manual

This manual covers scientific background and procedures for the successful hatchery operation and artificial insemination in poultry. In view of current expansion of hatcheries in the country, such a material will serve as reference material and guide. The lack of appropriate hatchery guides in the country is the motivation behind the preparation of this material. The manual covers all processes: the formation of hatching eggs to the production of day old chickens.

1. Egg

An egg is a vessel that contains an ovum – the reproductive cell produced by a female that would nurture and sustain an embryo. A chicken egg is the egg laid by a chicken. In general, eggs are composed of several parts: they have a hard outer shell, which would help protect a growing bird embryo (if the egg is fertilized); and inside the shell is the ovum. In a fertilized egg, a chick grows inside the egg for about 21 days before it is strong enough to break out of the shell and become a "fully-fledged" chicken.

The different parts of eggs are described below.

Shell

- Egg's outer covering and approximately 9-12% of total weight of the egg. It is the egg's first defense against bacterial contamination. The Shell is made of mostly calcium carbonate.

- Shell strength is determined by a hen's diet (particularly calcium) and thickness by a hen's age.
- Each egg has up to 17,000 pores on the shell surface. A greater number are on the larger end and allow moisture and CO_2 to move out and air to move in to form the air cell.
- A protective covering called the cuticle or the bloom covers the shell to block the pores to keep egg fresh and prevent contamination.

Shell membrane

- There are the inner and outer shell membranes. These structures protect against bacterial penetration. The air cell forms between the two membranes.

Albumen

- Is also known as "egg white." It contains more than half the eggs total protein, potassium and sodium. It is more opalescent than white.
- The cloudy appearance comes from CO_2 which escapes as the egg ages, so older eggs are clearer than fresh eggs and tends to thin out with age.

Air cell

- This is the empty space between the albumen and the shell and found at the large end of the egg. When egg is first laid it is warm, as it cools, the content contracts and the inner shell. Membrane separates from the outer shell membrane forming the air cell.
- Air cell becomes larger with age and the size is used in determining grade of egg.

Germinal Disc

- The Slight depression on the yolk and is entrance leading into the center of the yolk.
- When the egg is fertilized the sperm enter through the germinal disc.

Chalazae

- Ropey strands of egg white and hold the yolk in place in the center of the egg white. It is more prominent when the egg is fresh.

Vitelline Membrane

- It is a clear seal which holds egg yolk also known as the yolk membrane. The main function is to protect the yolk from breaking. Is weakest at the germinal disc and weakens with age.

Yolk

- Yellow portion of egg and accounts 33% of the liquid weight of the egg. It contains all of the fat

in the egg and a little less than half of the protein. It also contains more vitamins than the egg white and serve as a source of food for the embryo.

1.1 Structure of an egg

- Albumin: 60% of the total egg weight.
- Chalaziferous, inner thin, outer thick, and outer thin albumen.
- Total solids content of albumen is about 11%.
- Yolk: accounts about 30% of the total egg weight which is coverd by vitelline membrane. The total solids content of yolk is about 50%.
- Shell accounts about 10% the total egg weight and largely consists of calcium carbonate (94%), magnesium carbonate (1%), calcium phosphate (1%), and organic matters (4%).

2. Formation of egg

The formation of an egg is a process that takes just over a day, from ovulation to oviposition. The reproductive tract begins with a mature ovum, which is only a yolk and germinal disc, and constructs a hard shelled egg, complete with its own protective membranes and the necessary nutrients for the developing embryo

2.1. Avian reproductive system—Female

Chicken lay eggs in clutches, a group of eggs laid by a hen on consecutive days. After laying a clutch, a hen rests for a day or more and then lays another clutch. The reproductive system of a chicken hen is made up of two parts: the ovary and the oviduct. Ova develop in the ovary. When an ovum (singular of ova) has matured, ovulation occurs. Glands in the oviduct secrete substances that form parts of the egg, such as the albumen (egg white) and the shell. The total

required to make a yolk into an egg and lay is about 25 to 26 hours. Ovulation generally occurs about a half an hour after the previous egg has been laid However, the female chicken reproductive system is sensitive to light exposure, especially the number of hours of light in a day. Ovulation usually occurs under normal daylight conditions and almost never after 3:00 p.m. In almost all species of birds, including poultry, only the left ovary and oviduct are functional. Although the female embryo has two ovaries, only the left one develops. The right one typically regresses during development and is nonfunctional in the adult hen.

Ovary

The ovary is a cluster of developing ova, located midway between the neck and the tail of the bird and attached at the back. The ovary is fully formed when a layer chick hatches but stays very small until

sexual maturity. At hatch, a hen chick has tens of thousands of ova that can be laid but most never develop to the point of ovulation. The maximum number of eggs a hen can lay is determined at hatch because no new ova form after the chick hatches. At ovulation, the follicle enclosing the ovum ruptures, dropping the ovum into the oviduct. Each ovum starts as a single cell surrounded by a vitelline membrane. As the ovum develops, additional yolk will be added. The word ovum refers to the yolk and blastodisc formed in the ovary. The color of the yolk comes from xanthophylls, obtained from the feed. Hens provided rations that contain yellow maize or grass produce eggs with dark yellow yolks. However, those provided diets with white maize, sorghum, millet, or wheat typically produce eggs with pale yolks. The ovum is enclosed in a sac that ruptures along the stigma, or suture line, during ovulation. At any time, an ovary contains ova in various stages of development, ranging from very small, white ova, many of which

will never be developed, to almost mature ova, ready to be ovulated.

Oviduct

This refers the system that receives the ovum (or egg) from the ovary and produces an egg, which is then laid. When ovulation occurs, the ovum (yolk) enters the oviduct. It is divided into five major sections: the infundibulum, magnum, isthmus, shell gland, and vagina.

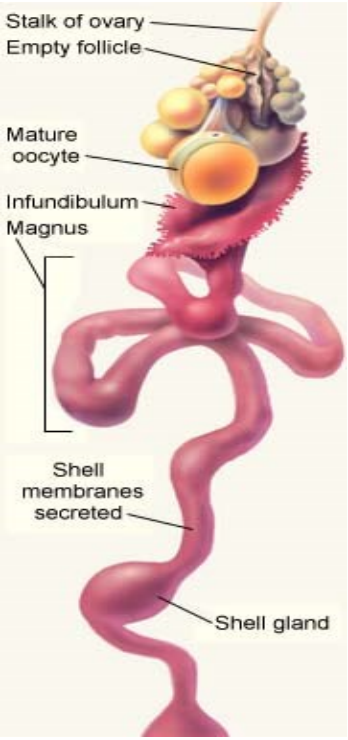


Fig. 2. Female reproductive tract

The first part of the oviduct is the infundibulum. It is 3 to 4 inches long and receives the ovum released from the ovary. The Once the ovum is released the muscular infundibulum moves to surround it. The yolk remains in the infundibulum for 15 to 17

minutes. Fertilization, takes place in the infundibulum if sperm is present and the first layer of albumin is deposited. The next section of the oviduct is the magnum. It is 13 inches long, and the largest section of the oviduct. Magnum is a glandular structure made up of layers of circular muscles. The yolk stays here for 3 hours and adds the majority of the albumen. The third section of the oviduct, the isthmus, is 4 inches long. The isthmus, is slightly constricted, and is where the inner and outer shell membranes form. The developing egg remains here for 75 minutes.

The next section of the oviduct is the shell gland (or uterus), is 4 to 5 inches long. In this section, the shell forms on the egg. The shell largely is made of calcium carbonate. The hen's body mobilizes body calcium to provide 47 percent of the calcium required to make a shell. The rest is obtained from the diet. The egg acquires salt and water before calcification occurs. The egg stays approximately 20 hours and

acquires its color during the last 5 hours. The last part of the oviduct is the vagina, is about 4 to 5 inches long. The vagina carries the egg from the uterus to the cloaca and does not play a part in egg formation. It is made of muscle that helps push the egg out of the hen's body. Here the bloom, or cuticle, forms on the egg prior to oviposition. The egg turns in the vagina and comes out with the large end first. Near the junction of the shell gland and the vagina are deep glands known as sperm host glands. It can keep sperm 10 days to 2 weeks. (One of the unique conditions in birds is that the sperm remain viable at body temperature.) When a hen lays an egg, sperm are squeezed out of these glands into the oviduct and then can migrate to the infundibulum to fertilize an ovum. Cloaca: The cloaca joins the reproductive tract to the digestive and urinary systems.

Vent: This opening serves both for egg laying and for excretion.

2.1 Fertilization

Fertilization is a union of the sperm and the ovum. This must occur prior to the formation of the egg. Thus, if the hen has mated and she lays an egg, then that egg is fertilized. In chicken fertilization can be achieved in two ways; artificially and naturally. Natural fertilization happens when there is no human aid for the fertilization to happen. Artificial fertilization occur when human intervention in the collection of semen from the cock and the deposition of semen into the hens happen.

Natural Fertilization

Under natural mating, the physical act of mating is often starts by courtship. The physical act of mating, or copulation, is the first step in the fertilization process. The cocks should show the desire to continue to mate throughout the life of the flock. When the mating process occurs normally, semen is deposited

by the male in the hen's cloaca. Approximately 200 million sperm cells per ejaculation are deposited. Frequently mating are needed to ensure that relatively fresh and viable sperm are available in the hen during ovulation. Avian sperm have an extended life span due to the presence of sperm storage glands located in the hen's oviduct. This allows for stored sperm to travel from these storage tubules to the infundibulum. The presence of these storage sites avoids the need for fertilization on a daily basis.

Artificial fertilization (Artificial Insemination)

Fertilization in commercial chickens is usually the result of natural mating. However, in some cases, artificial insemination is commonly practiced. Artificial insemination (AI) is the manual transfer of semen into the females' vagina. It is a two-step procedure: collecting semen from the male and

inseminating the semen into the female. Some steps such as semen dilution, storage, and evaluation may be required. The goal of AI is to produce a succession of fertilized eggs between successive inseminations. Therefore weekly inseminations are needed to replenish the sperm population in the uterovaginal junction (UVJ) sperm storage tubules (SSTs). Birds do not have an estrous cycle that synchronizes copulation with ovulation. Alternatively, about 7–10 days before their first ovulation, hens mate, sperm ascend the vagina and then enter the SSTs. At the onset of egg production, individual sperm are slowly released from the SSTs, transported to the anterior end of the oviduct, and interact with the surface of the ovum. Whether fertilized or not, over the next 24–26 hours the ovum is transported though the oviduct, accruing the outer perivitelline layer (PL) in the infundibulum, the albumen in the magnum, the shell membrane in the isthmus, and the hard shell in the uterus (also referred to as the shell gland) before

oviposition. If fertilized, the blastoderm in the first laid egg consists 80,000–100,000 cells in the chicken. The reason for applying artificial insemination (A.I.) in poultry are: It helps to keep few cocks. This usually important in genetic improvement programs in which higher selection intensity is applied to enhance genetic progress. AI is also important when heavy males are required to mate smaller hens. Additionally, if properly executed, better fertility results may be obtained by A.I., than with natural mating. In natural mating the cock is producing about 150 – 250 million sperm cells each time, but he will mate several times per day with different hens. The sperm cells will be stored in the hen's genital tract, and will keep the fertilizing ability for more than a week. By manual collection the result of one ejaculation may show a variation between 500 – 5000 million sperm cells (0.2 – 1.5 ml in volume). By collecting 5 times per week a total of about 5 * 2.5 billion = 12.5 billion sperm cells can be obtained. For one insemination

about 100 million (0.1 billion) sperm cells should be sufficient, which means that with one cock about 125 hens can be fertilized.

Required equipment:

- Individual cages for cocks, which allow easy handling of the animals, to avoid stress
- Collection tubes
- Isolated container, depending on temperature
- Dilution fluid, depending on time lapse until insemination.
- Injection tube for insemination
- Cleaning and sterilizing equipment
- microscope, if semen should be evaluated

Fig 3.

Semen collection tools

AI Procedures:

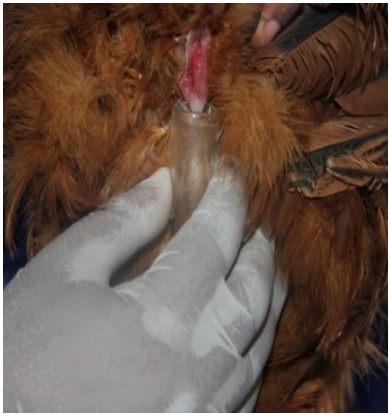
- The cock should be accustomed to the cage, and therefore they should be placed in the cages at least 2 weeks before starting with exercises for collection.
- The cocks should be trained at least two weeks, three times per week.
- For clean collection the cloaca should be cleaned using clean cloth and the surrounding feathers

eliminated.

- Semen collection (milking) should be done before feeding, or otherwise at least 3 hours after feeding, to minimize feaces contamination.
- Optimal semen collection can be done 3-5 times per week, but even daily collection is possible.
- After fixing the cock, the back and tail-bottom should be massaged 2 or 3 times, and when the tail is lifting, the same hand should be laid over the tail and the thumb and middle-finger should squeeze the cloaca gently, behind the exposed penis area.
- At the same time the other hand, keeping the collection tube in the little finger to be positioned under the cloaca, puts pressure with thumb and index finger under the cloaca, to support the ejaculation.
- Entrance of faeces in the collection tube should be

avoided.

- When no pedigree records are kept, the semen of different cocks may be pooled, to get a bigger sample of "mixed-semen".
- Quality of semen can be observed by:
- color: should be milky-white
- volume: 0.2 - 1 ml
- Concentration: 3 - 8 billion of sperm cells per ml.
- movement: sperm cells should be very active
- % abnormal cells: should be below 10 %



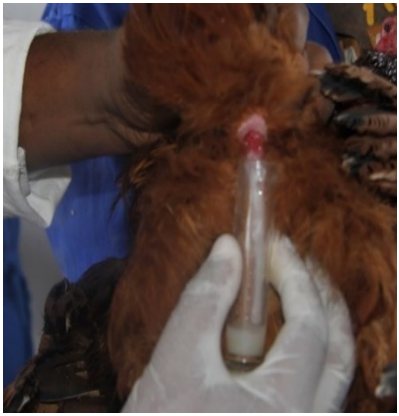


Fig. 4. Semen collection

Insemination procedures:

Undiluted semen should be used within half an hour. Diluted 1:1, with a dilution solution, it will keep about an hour without refrigeration. After dilution, it should be cooled until 2-5 °C, and can be used during 4 - 6 hours. With older semen the size of the doses for insemination should be increased.

- Insemination should not be done with an egg present in the oviduct, which means: better wait until after the time of laying.
- Insemination should be done twice a week for the first time; but once a week is enough afterwards
- Apply pressure on the belly area of the hen, the oviduct (left in the cloaca, the large intestines are seen in the right side) should be exposed,

- Deposit the semen about 1 cm. deep into the oviduct.

Fig. 5. Inseminating hens

3. From Embryo to day old chick

3.1 Selection and management of hatching eggs

Usually more eggs than required are produced. It is a common practice to set as many eggs as their breeders produce. If setter space is the limiting factor, it is more advisable to select the better quality eggs for incubating.

Selection

- Select eggs from breeders that are well developed, mature and healthy.
- Avoid eggs from very young and very old flock. Eggs from young flock are usually small and low in fertility, easily fragile and thin shelled in older flocks

- Avoid excessively large or small eggs. Large eggs hatch poorly and small eggs produce small chicks.
- Avoid eggs with cracked or thin shells.
- Avoid excessively misshapen eggs.
- Keep only clean eggs.
- Do not wash dirty eggs or wipe eggs clean with a damp cloth.

Egg size:

- The size of hatching eggs is important as there is a high correlation between the size of the hatching egg and the size of the chicks hatched. As a general guidelines it is desirable to use approximately 56.7 g each. Eggs that are large in proportion to the size of the hen producing them tend to hatch poorly. Eggs in which the proportion

of white to yolk is about 2:1 usually hatch better than eggs having wider or narrower ratios.

(a)

(b)

Fig. 6. (a) and (b) Different sized eggs are not suitable for hatching

Shell color:

- If hatching eggs are collected from white eggs layers, all should be free from tints, except for the first few tinted eggs laid at sexual maturity.

Fig. 7. Non uniform colored eggs

Cracked shells and tremulous air cells

- All hatching eggs should be tested for cracked shells. The easiest check would by tapping two

eggs together. If there is a resonant sound, both eggs are sound in shell; but if there is a dull sound, one of the eggs is cracked and should not be used for incubation. Outmost care should be takes in shipping or delivering eggs to a hatchery to avoid excessive shaking which sometimes results in a condition known as tremulous air cells, a condition that tends to lower hatchability. Hatchability of eggs will not be affected negatively by higher altitude which usually has lower air pressure.

Soiled eggs

- Soiled eggs can be washed, though it is may cause problems. If it has to be done washing water should be warmer than the eggs.

V

Fig. 8 soiled egg

Management of hatching eggs

All hatching eggs should be uniform in shape, size and sound in shell. For excellent results in the hatching, the proper care of the eggs before they are set in the incubator is very important. Even before incubation starts the embryo is developing and needs proper care to active the maximum possible hatchability. Egg storage is the time between oviposition (laying) and the start of the incubation process for hatching eggs. Storing eggs beyond two days leads to loss of hatchability and reduced chick quality. Below are tips to help maintain hatching egg quality.

- Collect eggs at least three times daily. When daily high temperatures exceed 30 degrees centigrade, increase egg collection to five times daily. Collect two or three times in the morning and one or two times in the afternoon.

- Slightly dirty eggs can be used for hatching purposes.
- Do not wash eggs. If it is necessary to clean hatching eggs, use a damp cloth with water warmer than the egg.

  Caution: Cleaning hatching eggs with water warmer than the eggs causes the egg to sweat the dirt out of the pores. Never use water cooler than the egg. Also, do not soak the eggs in water. If the egg is allowed to soak in water for a period of time, the temperature difference can equalize and bacteria has a greater chance of entering through the pores. Make sure eggs are dry before storing.

- Store eggs in a cool-humid storage area. Ideal storage conditions include a 13 degree centigrade temperature and 75% relative humidity. Store the eggs with the small end pointed downward. Never

store eggs at temperatures about 24 degree centigrade and at humidity lower than 40%. These conditions can decrease hatchability dramatically in a very short period.

- Store the eggs small end down and slanted at 30-45 degrees. Alter egg position periodically if not incubating within 4-6 days. Turn the eggs to a new position once daily until placing in the incubator.
- Do not store eggs more than 7 days before incubating.
- Do not use eggs stored for more than 3 weeks of storage, hatchability drops to almost zero.
- Plan ahead and have a regular hatching schedule to avoid storage problems and reduced hatches.
- Allow cool eggs to warm slowly to room temperature before placing in the incubator. Abrupt warming from 13 degrees to 37.7 degrees

centigrade causes moisture condensation on the egg shell that leads to disease and reduced hatches.

3.2 Embryo Development

Fertilization occurs in the infundibulum near the junction of the magnum. Several sperm penetrate the ova, only one can fertilize it. After the sperm cell has arrived at the site of fertilization a sperm cell, recognizes the appropriate sites on the outer surface of the ovum prior to its passage through this outer wall.

After recognizing the appropriate sites on the ovum, through enzymatic action (called an acrosome reaction) the sperm cell creates a hole through which it passes into the ovum (this process is referred to as sperm penetration). If the sperm cell passes through the outer layer of the ovum in the germinal disc region, it gains access to the female genetic material, or pronuclei. After gaining entrance into the egg, syngamy, or

joining of the male and female gametes, can occur. About 5 hours after ovulation, as the egg enters the isthmus, the first cell cleavage of the developing embryo occurs followed by a second one 20 minutes later. About 9 hours after ovulation, the blastoderm) cell division advances that by the time the egg is laid, the formation of the gut (gastrulation) is usually complete in the embryo. Normal cellular division continues in the developing embryos after egg laying as long as the egg temperature remains above approximately 26.8 degrees centigrade (Physiological zero).

When the egg is cooled below physiological zero, cell division stops and the embryo becomes dormant. Following these steps, the avian egg has been successfully fertilized; and, given the proper incubational conditions, embryonic development may begin. After lay, the development stops as soon as the egg temperature drops below $27^{0}C$.

When the temperature is raised again embryonic development continues, as long as the embryo has not been affected by long storage. From this stage, 4 extra embryonic membranes develop, to supply the embryo with oxygen, nutrients, water, and protect it from dehydration and shocks.

Table 2. Structures of a growing embryo

MEMBRANE	FUNCTION
Amnion	Prevention from shocks, dehydration. Absorption of albumen
Chorion	Respiration, (CO_2/O_2), Ca absorption
Yolk sac	Nutrient supply and position
Allantois	Storage of excreta (ureic acid)

Development of the embryo

The chicken embryo takes 21 days to hatch. During the 21 days different structures can be observed. Knowing these structures help understand the process and determine when a death has occurred during break out analysis. The following table shows major changes in the development of chicken embryo.

Infertile: the blastoderm (nucleus) is white and small and has an irregular shape.

Table 3. Embryo development stages

Day 2	Blood veins appear in the yolk sac, Amnion formation starts, Heart start beating
Day 4	The eye gets pigmentation
Day 5	Crop and sexual organs are formed
Day 6	Feathers, egg-tooth, beak, first movements.
Day 10	Beak gets harder, feathers can be seen by the naked eye
Day 14	Head turns to the blunt end of the egg

Day 18	Growth is almost complete
Day 19	Yolk gets absorbed in the body of the embryo. The embryo fills the whole egg, except the air space.
Day 20	Yolk completely absorbed, air space is pipped and start lung respiration. Chorio-Allantois stops its function and dries out. (blood is resorbed) Chicks pip the shell
Day 21	Chicks hatch (in about 9 hours). They dry after cracking the shell, and rest.

Table 4. Embryonic development in chickens

0 – 4 days	Early embryonic development	30%
5 – 17 days	Mid term embryonic development	10%
18 – 21 days	Late embryonic development	60%

4. Managing hygienic conditions

A major source of contamination within the hatchery arises from the poor sanitary condition of the hatching eggs. The sanitation of the hatchery depends on the hygienic standards of the breeder farm and, on the frequency of collection of eggs.

Good hygiene is required for higher hatching results (higher hatchability and chick quality). Therefore it is a priority to protect the contamination of hatching eggs and day-old chicks from vertically transmitting diseases. The hatchery should be designed in such a way that eggs can get into the facility easily from parent stock farms and chicks are distributed to the commercial farms.

To better maintain hygienic conditions the following procedure should be followed,

- Hatchery personnel should adopt routine sanitary procedures in the hatchery,
- All outside hatchery doors should be kept closed and locked to prevent unwanted visitors from entering.
- Staff and authorized visitors should shower and change clothes (putting on hair nets, overalls, boots, etc.) prior to entry.
- Vehicles and outdoor equipment must be disinfected before allowed into the hatchery.
- Washing and disposable area should be far enough to avoid molds and pathogenic bacteria being carried into the hatcheries due to poor ventilation systems,
- Ensure proper ventilation to avoid embryos and newly hatched chicks infected with bacteria and moulds during incubation.

4.1 Hatchery set up

- The building must be designed for ease of sanitation.
- Rooms should be large enough to serve their allotted purpose and should be designed initially to provide for easy and cheap expansion.
- A designated arrival area is essential. The area for truck docking and egg arrival must be designed for the type of truck used to deliver the eggs.
- This area can be purpose-built for a flat-bed truck or for a truck with a tail lift. Hatchery layout should include physical separation of each major operation within the building. Thus each operation should be integrated, but not centralized into one unit.
- The movements involved in the production of

chicks should be in one direction only.

- Cross currents of air must be reduced to a minimum. The best results are achieved in hatcheries which have separate rooms for reception of eggs, fumigation, setting, hatching and removal of chicks.
- Washing facilities, storage rooms and offices must be separate.
- Avoid contaminants that include the microorganisms present in soil, feathers, litter, egg boxes and other items of equipment, including the clothing worn by hatchery workers.
- Design the workflow to reduce the exposure of the newly-hatched chick.
- Move hatching eggs: from the receiving area, setting room, then to the hatching machines, and finally to the chick sexing room and the distribution (Fig. 9). Subsidiary to this main flow of

hatching eggs and chicks are secondary rooms or areas, for fumigation of eggs and washing of hatcher trays and movable equipment, and a room for storage of chick boxes and other equipment.

- All outside walls and the walls of the egg room should be well insulated to prevent sweating and condensation, which would provide fertile areas for bacterial and mold growth.
- Substantial lighting should be available
- Wall outlets should be vapor-proof, and cleaning and facilitate proper sanitation.
- All horizontal exhaust ducts should be of circular cross-section, and should possess an adequate number of clean-out doors. Circular ducts are much easier to wash out than rectangular ducts.
- Floor drains should be of the trough type, with floors properly sloped to the drains.
- Ceilings should be high enough to enable easy

cleaning of the top surfaces of all equipment. High ceilings also allow air systems to move air above chicks and machinery, avoiding direct draughts. As ceilings require regular cleaning, they should be constructed of waterproof material.

- Adequate ventilation must be provided in all areas, use mechanical air conditioning to avoid air-flow from one area to another section.
- Alternatively use roof-mounted heaters and evaporative coolers for more air conditioning.
- Install Air-moving equipment to avoid propelling air more than 45 meters in any direction. This will provide a more constant temperature throughout each room.
- Make sure each room is ventilated separately,
- Make sure incubators and hatchers ventilated with air which has passed through a dust filter.
- Make sure air from the hatching machines

expelled from the building at a point where it will not affect incoming air.

- Egg room temperature should be maintained at 19°C, with 25% relative humidity.
- Fresh air should be provided at a rate of 0.06-0.10 m3 /min per 1,000 eggs.
- Setting room temperature should be approximately 22-24°C), with a relative humidity of 45-60%. In this room, the air must be replaced in the setting machines at a rate of 0.15-0.20 m3 per miniute per 1,000 eggs.
- The temperature in the hatcher room should be maintained at 24°C, with a relative humidity of 50%, and the rate of air movement should be greater (i.e. 0.40-0.60 cubic meters per minute per 1,000 eggs).
- Make sure chick room temperature is controlled at 22°C and 50% RH.

- The chick processing room should be set at 0.60–0.70 cubic meters per minute of air movement per 1,000 chicks.
- During warm season and in the absence of mechanical cooling, more volumes of air (about four to eight times more) should to be moved out from chick processing room.

To facilitate hygiene control and ensure production of good-quality chicks, mechanical air conditioning is very useful because the air input and exhaust can be controlled accurately. The use of areas (setting machine rooms) with a positive air pressure facilitates correct air circulation and prevents entry of contaminated air from rooms or areas with higher microbial contamination.

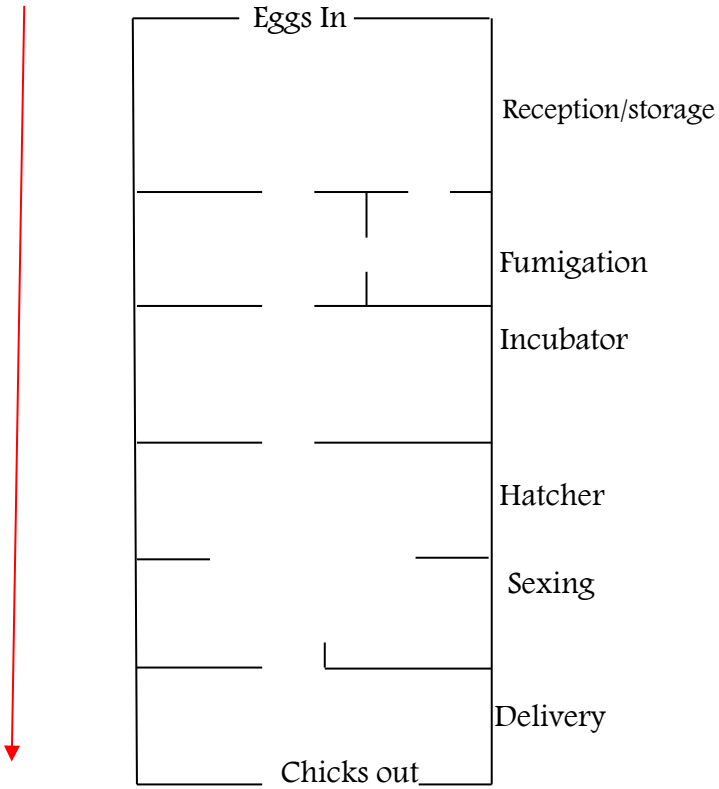

Eggs In
Reception/storage
Fumigation
Incubator
Hatcher
Sexing
Delivery
Chicks out

Fig. 9. A typical hatchery layout

4.2 Cleaning and Disinfection

Effective cleaning and disinfection programmes help control pathogenic organisms. The four key sources of contamination are the egg, surfaces which can contaminate the egg, air-borne contaminants, and movable equipment and personnel.

Therefore the following procedures should be strictly practiced

Washing

- Adequate supply of water is necessary for the cleaning of hatching areas and machines, the chick processing area, and some permanent and movable equipment.
- Incubators must be cleaned after each transfer of eggs that involve scraping, vacuuming and mopping the floors, and wiping down wall areas and fan blades at the same time.
- Exterior surfaces require damp mopping at least once a week.

- Never put any stuff on top surfaces and surroundings of incubators.
- all machines should be emptied and thoroughly cleaned at least once in year
- Transfer eggs before egg pipping starts (at day 18).
- Avoid transferring chicks and at the same time cleaning hatchers begin cleaning after all chicks are removed
- Replace humidity wicking after each hatching,
- Check and replace hatcher gaskets if necessary.
- Make sure the fan blades are always clean for required amount of air circulation. clean and disinfect all equipment properly
- Clean, disinfect and fumigate plastic egg trays and plastic chick containers with water and detergents, removed and cleaned washer nozzles should be frequently

- Washer pump motors should be switched off whenever filter screens are removed for cleaning, as running the pumps with the screens out allows debris to pass through the pump, blocking the nozzles.
- Water in the washer tank should be at 47–52°C and should be changed frequently during the day to prevent equipment from being washed in dirty water.
- All washed trays and racks should be thoroughly disinfected before leaving the wash area with a water hose fitted with a common domestic spraying nozzle.
- Clean trays and racks should never be put into a dirty hatcher room.
- Use formaldehyde (formalin) for fumigation as it is effective in destroying microorganisms on eggs, egg trays, setters, hatching machines and fibre chick boxes, once subjected to preliminary cleaning.

Caution:

To produce the fumigant, potassium permanganate should be mixed with formalin in a ratio (w/v) of 2:3. When the correct ratio of formalin and potassium permanganate is used, a dry brown powder remains after the reaction is completed.

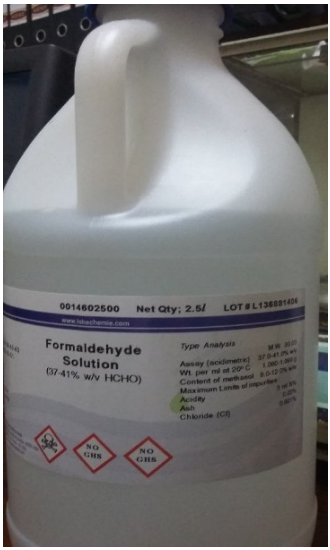


Fig. 10. Formaldehyde solution

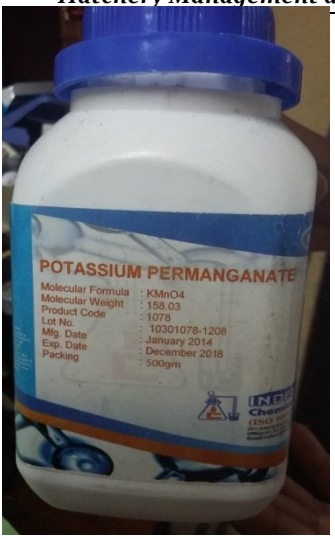


Fig. 11. Potassium permanganate

Recommended application rate for fumigation

- An application rate of 53 ml formalin and 35 g potassium permanganate per m3 of space is recommended.
- fumigate for 20 min at the temperature range of 24–38°C and a 'wet bulb' reading of 20°C or higher of humidity.

- Measure the internal dimensions (i.e. length x width x height) of the incubator, fumigation cabinet or fumigation room to calculate the amounts of chemicals necessary.
- Neutralize formaldehyde gas in 10-15 minute using ammonium hydroxide at an amount equal to half the volume of formalin used.
- Keep formalin at room temperature in a tightly sealed container to keep the strength. If stored for long period, a white precipitate (paraformaldehyde) will be formed. If this happens shake it thoroughly before use.
- If storage is necessary, formalin kept in small, completely filled containers.
- When mixing with potassium permanganate for fumigation, always add the formalin to the potassium permanganate, never the reverse.
- Formaldehyde at bactericidal concentrations is very irritating to the eyes, nose and throat. Therefore hatchery operators should use a

respirator to avoid unnecessary exposure to the gas.

- An appropriate positioning of container should be used to release the gas. The sides of the container should slope outwards to avoid an excessive build-up of heat, which could ignite the formaldehyde.
- The container should be made of heat-proof material, such as metal, and should be sufficiently large to prevent the chemicals from boiling over.

Fumigation of eggs in chambers

- Eggs should be fumigated immediately after collection, while they are still warm.
- The fumigation room or cabinet should be airtight, and should be equipped with a fan to circulate the formaldehyde gas during

fumigation and expel the gas from the building when fumigation is completed.

- The eggs should be placed loose in wire baskets or placed in plastic trays to allow air circulation and exposure to the formaldehyde gas.

Fumigation of eggs in setters

- Eggs should be fumigated within 12h after setting, when the temperature and humidity return to normal operating levels.
- The setter doors and vents should be closed, but the circulation fan should be on
- After fumigation has been completed with in20 minutes, the vents should be opened to the normal operating position to release the gas.
- To avoid embryo mortality eggs incubated for 24-96 hours should not be fumigated.

Fumigation of hatchers

- Following the removal of all chicks, the machine should be cleaning and disinfected, When fumigating the machine the doors and vents should be closed
- The machine should be fumigated for at least three hours,
- preferably the machine should be fumigated during night time
- Use standard concentration (37-41%) of formalin and potassium permanganate.

Neutralization of formaldehyde gas

- Formaldehyde gas should be neutralized using a 25% solution of ammonium hydroxide.

- The solution should be applied at a rate of not more than half of the volume of formalin used.
- The ammonium hydroxide should be spread on the floor of the machine and the doors closed quickly.
- All the time, fumigation and neutralization chemicals should be kept separate chemical room.

Use of Disinfectants

Ninety percent of hatchery sanitation is dependent on design of the premises, good management of the hatchery and of supply flocks, cleanliness, and a programme whereby dust is removed and prevented from reaching the hatching areas. The remaining 10% requires the additional hygienic measures provided by fumigation and disinfection.

A disinfectant, could be a solution, gas or aerosol.

Clean an item thoroughly before disinfecting it using chemicals

5. Incubation Conditions

Based on air circulation there are two types of incubators. These are forced air and still air incubators.

1. Forced-air incubators which have a built in fan to circulate the air.

2. Still-air incubators which have no fans, so the air is allowed to stratify.

The forced-air incubators are now commonly used. The advantage of the forced-air incubator is that it is easier to maintain humidity at a constant level because of air circulation. Still air incubators are smaller and air flow is harder to manage. There can be as much as a 5° difference in temperature from the

top to the bottom of some of the still-air incubators. Therefore air should be allowed to get in. It is very easy to overheat the eggs in still-air incubators and difficult to maintain proper humidity.

There are basically two types of incubators available, forced-air and still-air incubators. Forced-air incubators have fans that provide internal air circulation. The capacity of these units may be very large. The still-air incubators are usually small without fans for air circulation.

- Attain adequate air exchange by rising and escaping of warm, still air and the entry of cooler fresh air near the base of the incubator.

Note:

Setters can also be Single-stage or multi-stage Incubation. Single-stage means that all eggs within an incubator are set together. So all eggs are in the same embryonic stage.

This enables the user

- To adjust the temperature, humidity and ventilation set points according to the needs of the embryo, possibly leading to improved hatchability and chick quality.
- Improved biosecurity as provided by every all-in all-out system. The incubator can be easily cleaned, disinfected and also maintained after each batch of eggs.
- It can be more flexible if the amount of hatching eggs is not constant for each setting.

For this reason single-stage incubation are used many commercial layer hatcheries and all major breeding companies. In contrast a multi-stage incubator is usually filled with eggs of six different embryonic ages. Therefore the multi-stage incubation environment cannot, by its nature, create optimum conditions for every egg. Temperature, humidity and

ventilation are set at a fixed point throughout the whole incubation period.

The advantage of multi-stage incubation are

- Its simplicity both with respect to the control system of the incubator as well as the management of incubation.
- Energy efficiency. The difference between the two systems is only relevant for the first 18–18.5 days of incubation. After transfer the hatcher is always managed in an all-in all-out method.
- The size and type of incubator selected depends on the needs and future plans of each producer. Many different models are available. For continuous settings, separate incubator and hatcher units are recommended. If all eggs in

the unit are at the same stage of incubation, a single unit can be used.

Locate the incubator and hatcher units indoors to protect them from major weather changes. It is essential that the room has a good ventilation system to supply plenty of fresh air. Keeping the units indoors makes it easier to maintain uniform temperature and humidity.

Temperature, humidity, ventilation and turning very important factors when hatching eggs artificially. Of these, temperature is the most critical one. The optimum incubator temperature for hatching is 37.7°C with a relative humidity of 60 percent

Concentrations of oxygen should be above 20 percent, carbon dioxide should be below 0.5 percent, and air movement past the egg should be 0.34 cubic meters per minute.

5.1 Temperature

Temperature determines the speed of embryo development. The embryo temperature is more critical than the incubator temperature. The embryo temperature can be determined by measuring the eggshell temperature (EST) with an infrared thermometer at the "equator" of the egg and not at the top above the air cell.

- Measure the egg shell temperature by taking 10 – 15 eggs per trolley and from the middle of a tray.
- The measurement is expected to be between of 37.5 and 38°C during the first twelve days of incubation is acceptable.
- After the twelvth day, the embryo begins to grow more quickly and to produce more heat.
- If there are too many "clear" eggs that do not produce any heat, cooler areas on the trays will be created. At this stage, at an average EST of

37.7 °C, even eggs with living embryos constantly have an EST below 37.5 °C.

Note:

Embryo death occur if the temperature drops below 96°F or rises above 103°F for a number of hours. If the temperature stays at either extreme for several days, the eggs may not hatch. Overheating is more critical than under heating. Running the incubator at 105°F for 15 minutes will seriously affect the embryos, while running it at 95° for 3 or 4 hours will only slow the chick's metabolic rate.

- Do not adjust the heat upward during the first 48 hours after eggs are set.
- If power interrupts, keep the eggs as warm as possible until the power returns by placing a large cardboard box or blankets over the top of small incubators for additional insulation.

Table 5. Temperature requirements in incubators with and without fan

Days of incubation	Incubator without fan	Incubator with fan
0-18	37.8-39.20c	37.5-37.80c
18-21	37.2-37.80c	36.1-37.20c

5.2 Humidity

Humidity influences the incubation process. During incubation water vapor is lost through the pores of the shell. At a given temperature the water content of the air can be recorded as relative humidity or wet bulb temperature. Practically the moisture loss can be

determined by simple weighing, because any weight loss is solely due to the loss of water from the egg.

The procedure

- Mark and weigh 3 – 6 sample trays before setting and reweigh them at transfer.
- The same trays can be used for examination of embryo mortality and to measure chick yield.
- The weight loss until day 18 (transfer) should be 12 %, with an acceptable range from 11 to 13 %. This will ensure that the majority of the eggs experience a moisture loss that is high enough to form the air cell necessary for internal pipping without risking the dehydration of the chicks.
- If the weight loss differs from 12 % by more than 0.5 % the humidity set points should be adjusted for the next incubation period.

- The humidity set points during incubation should be increased by 2 % relative humidity, if the weight loss target is exceeded by 0.5 %.
- For eggs collected from old flocks a higher humidity set point is required to avoid excessive moisture loss. The opposite is often seen when dealing with very young flocks that are producing eggs with very thick shells.
- If you incubate eggs for the first time without having an idea about the necessary humidity set points it makes sense to re-weigh the sample trays during incubation, for example after 7 days. This leaves time to react, if the moisture loss is not on target on average 53 – 55 % relative humidity or 28.8 – 29.4 °C wet bulb reading is recommended. These adjustments works perfectly for batches of eggs.

- Eggs stored more than7 days require higher humidity settings as they have already lost more moisture during storage (0.1 % per day).
- Make sure that the humidity does not drop too far (35 % RH, 23.8 °C Wet Bulb) during the second half of incubation. Otherwise the cooling of the eggs can be impaired, because of the low heat capacity.
- The relative humidity of the air within an incubator should be about 60 percent.
- During the last 3 days of the hatching period the relative humidity should be kept between 65 and70 percent.
- The table below (Relative Humidity) will enable you to calculate relative humidity using readings from a wet- bulb thermometer and the incubator thermometer.

Table 6. Relationship between wet bulb reading and relative humidity

WET BULB READING °C	RELATIVE HUMIDITY %
33.5	76
33.0	73
32.5	71
32.0	68
31.5	65
31.0	63
30.5	60
30.0	58
29.5	55
29.0	53
28.5	51
28.0	49
27.5	46
27.0	44
26.5	42
26.0	40

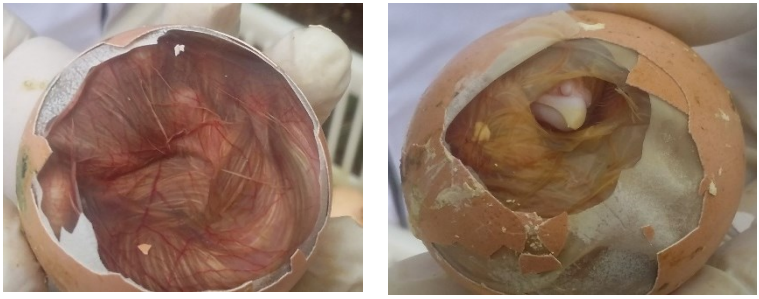


Fig.12. Dead embryo due to low moisture

5.3 Ventilation

The ventilation of an incubator supplies oxygen, the removal of CO2and the water vapor evaporated by the eggs. It can also be needed for cooling. The fresh air used for ventilation need to be conditioned according to the requirements of the machines.

- Create air pressure differences to avoid air flow from dirty areas of a hatchery (chick processing room, fluff chamber, waste) to clean areas (setter room, egg room).

Frequent air exchange helps to dilute aerial contamination and create good ventilation to provide suitable working condition for the hatchery staff.

- Follow the recommendations of the manufacturers as the ventilation systems differ from machines to machines.
- The ventilation of the individual incubator should be based on the oxygen requirements of the embryos. These are very limited during the first seven to ten days of incubation, rise rapidly after eleven to twelve days and reach a plateau after 17 days.
- Set the ventilation rate for different stages of incubation or let the damper be steered by a CO2 sensor to meet the oxygen demand. The latter has the advantage of automatically adapting the ventilation to the number of fertile eggs in the incubator. It should be advisable to keep the CO2 level between 0.2 % and 0.4 %.

- Monitor CO2 to avoid unnecessary ventilation and contribute to a stable incubation climate and help to detect ventilation problems.

There is probably no specific CO_2 value needed for good embryonic development but if the ventilation settings are correct for any one setter or hatcher, the CO_2 will be found to be correct.

- Ensure the normal atmospheric air (20–21 % oxygen) for the best hatching results.
- Adjust the ventilation holes should be to allow a normal exchange of air.

5.4 Turning

Turning is beneficial to prevent the embryo from sticking to the shell membrane and promoting the utilization of the albumen.

- Eggs are turned hourly by 45° throughout the setter period.
- Eggs set should be rotated at least 3 times daily.
- Turning should be stopped for the last three (3) days of the incubation cycle (at 18 days).
- The incubator should not be opened until the hatch is completed to insure a desirable hatching humidity is maintained.

6. Candling, transfer, hatchery analysis

Candling is used to identify infertile and early dead embryos by passing trays of eggs over a strong light source. Candling is a tedious work that requires extra equipment and labor.

- Candle a sample of each flock weekly to monitor the status of the breeders.
- If candling percentage exceeds 10 %, then all eggs should be candled, the clear eggs removed and hatcher trays refilled to 95 – 100 %.
- Candling should preferably done between day 9 and 10 or included in the transfer routine.
- If done at transfer often an automatic candling machine with egg remover is used for faster work.
- A candling table, which illuminates an entire setter tray from beneath can be used.

Ideal for candling small samples is a spot candler. It is by far the cheapest and most accurate method, but

requires some training and is more time consuming when doing big numbers.

If candling is combined with the breakout of clear eggs, it is the best method to identify fertility.

Eggs set upside down, cracked eggs and other second grade eggs can be also noted at this stage.

- Use candling and breakout analyses as part of the quality control program of a hatchery.
- Do not use setting trays for hatching to avoid falling through the trays.
- Transfer eggs after 18 – 18.5 days from setter trays to hatcher baskets and put in separate hatcher cabinets.

It should be noted to understand that the growing chick has used calcium from the shell for growth and shells are very fragile at this stage.

- Do not expect any chick from an egg that got cracked. The temperature in the transfer room should be at least 25 °C and no trolley should

be outside of an incubator for more than 30 minutes.

Fig.13. Mass candling

6.1 The Hatching Cycle

In the hatcher the eggs will stay for three days. During this time the embryo will develop into a chick. After 19 days of incubation it will penetrate the inner shell membrane and lung respiration will start. The

additional available oxygen enables the chick to break through the shell and hatch. Naturally not all the chicks will hatch at the same time. The time frame during which 99 % of the chicks hatch is called "spread of hatch" or "hatch window". Even under good conditions it can't be much shorter than 24 hours. The spread is caused by natural variation in egg quality, egg weight and by varying conditions during egg handling and incubation. The latter especially can cause a hatch window as wide as 2 days or more. By this, chick quality will greatly suffer, because the first hatching chicks will have to wait a long time in the hatcher, before they are pulled, processed, transported and finally get access to feed and water.

- Monitor the hatch window by taking out three hatcher baskets at several times during the hatching cycle and counting the number of chicks that hatched so far.

- 36 hours before pull there should be a maximum 1 % and 24 hours not more than 25 %.
- Twelve hours before take-off one should aim for approximately 75 % hatched chicks and six hours later for 99 %.
- Then there is still enough time for the last chicks to dry before they are pulled. Collecting this information and analyzing it helps to find the correct setting time according to egg and flock age.
- If early or late hatching occurs, examine the incubation conditions. Are the machines properly calibrated, are they evenly filled, is the temperature of the incoming air on target, is the spraying nozzle working properly and not too often, is the ventilation correct, did any delays occur during transfer, has the temperature been lowered too early in the

hatcher should be examined.

6.2 Hatch time and Hatchery analysis

It is not advisable to help the chicks from the shell at hatching time. If it doesn't hatch, there is usually a good reason. Also, prematurely helping the chick hatch could cripple or infect the chick. Humidity is critical at hatching time. As soon as the chicks are dry and fluffy or 6 to 12 hours after hatching, remove the chicks from the incubator. It is good practice to remove all the chicks at once and destroy any late hatching eggs. Hatching time can be hereditary and you can control the uniformity of hatching by culling late hatchers. If you keep every chick which hatches late, in a few years each hatch could last 4 days or longer.

- Conduct breakout analysis when possible.

- Eggs that are removed from setter and from hatcher should be broken and analyzed. Indicative features are shown below.

Table. 6. Different features seen during breakout

CATEGORY	DESCRIPTION	EMBRYO DIED…
Infertile	White and irregular shape nucleus	Not applicable
Membrane	Enlarged & circular nucleus	Between 0 & 2 days
Blood	Blood vessels on yolk sac	Between 2 & 4 days
Dark eye	Pigmented eye	Between 4 & 6 days
Egg tooth	Small white spot on beak	Between 6 & 18 days
Yolk sac absorption started	Yolk sac partly entered through navel opening	After 18 days

(a)

(b)

(c)

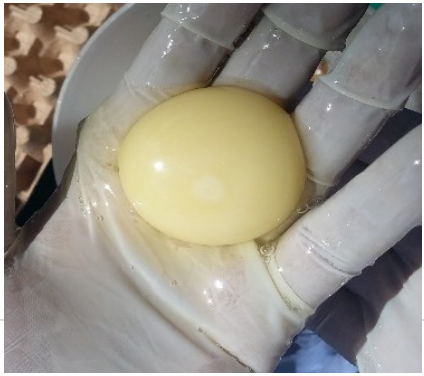


Fig.14. (a) Infertile blastodisc, irregular fertile

round, doughnut shaped blastoderm (b and C)

Fig. 15. A small incubator with poor hatching

Usually, at the end of each hatch, we carry out breakout analysis on embryos that failed to hatch. This will help to trace the problems of failed hatchability. Hatchability can be associated with infertility or problems during the hatchery process. Day old chicken should be grouped as either first grade (good quality) or second grade (bad quality). Only good quality chicks should be vaccinated and used for distribution.

Table. 7. Traits to select good and bad quality chicks

Good quality	Bad quality
• Active & lively, normal behavior • Normal size • Straight feet and toes • Two bright eyes • Straight, closed beak • Good, dry feathers • Normal color • Supple belly • Completely healed navel • Normal cloaca	• Weak and not lively, twisted neck • Too small • Curled feet and toes • Abnormal eyes, blind • Cross beak, open or dirty beak • Sticky and wet feathers, clubbed down • Too pale • Hard and swollen belly • Unhealed and /or navel • Thick navel cord • Closed cloaca

Conclusion

Effective hatchery operations and maximum hatchability can be achieved by applying scientific knowledge and practices. A standard procedures should be applied for successful outputs.

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