Poultry
SIGNALS©

BROILER MEAT SIGNALS

A PRACTICAL GUIDE TO IMPROVING POULTRY MEAT QUALITY

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Wim Tondeur and Piet Simons

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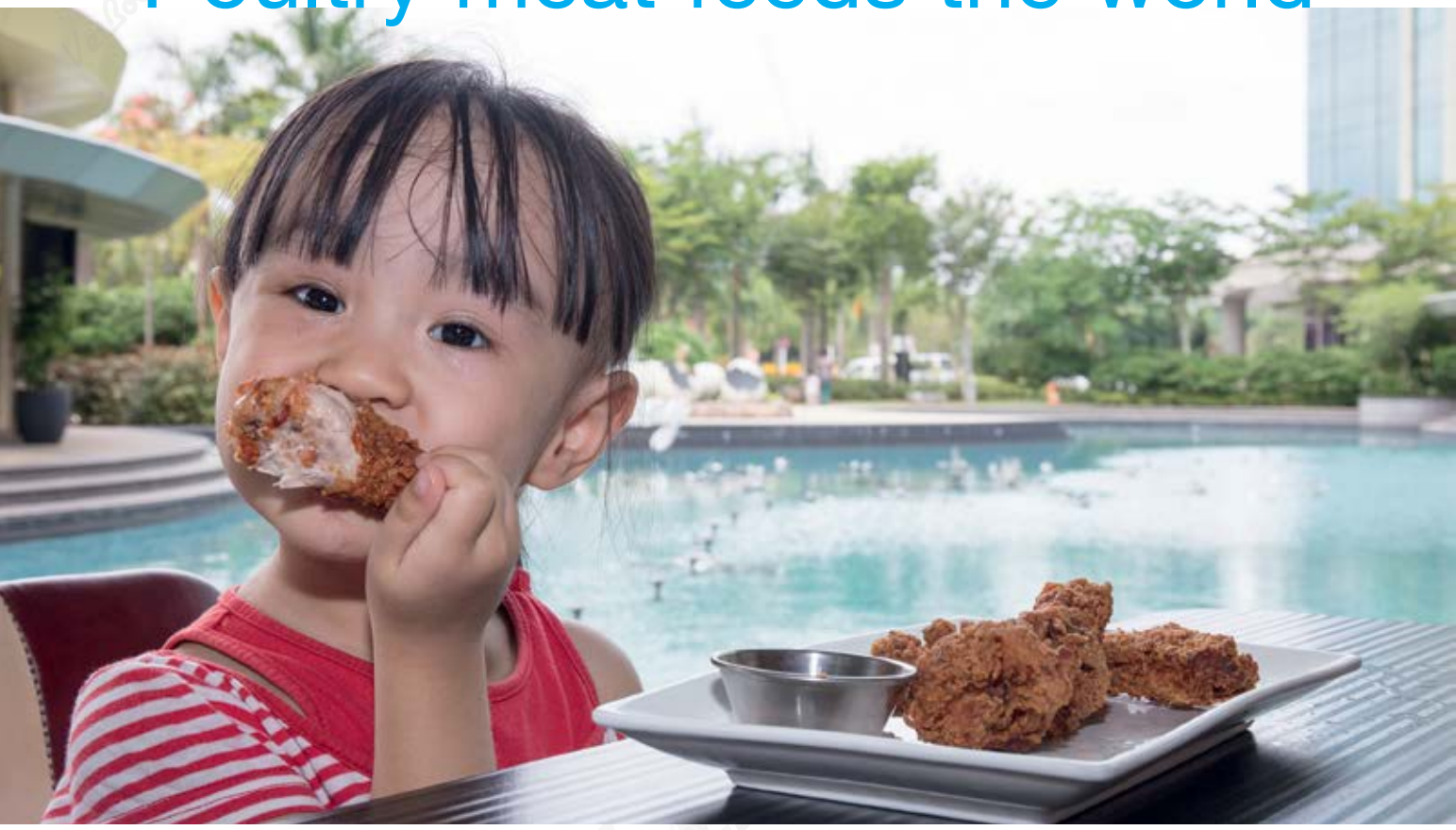
Contents

Poultry meat feeds the world



Poultry meat is a nutritious and affordable source of protein for most people in the world as it is lean and high in protein with low cholesterol content. It contains more unsaturated fatty acids than other meats. When you consider the efficient production systems available and the fact that it is accepted by almost all religions, you understand why poultry meat is a valuable product worldwide.

World production by meat type

	Millions of tonnes			Changes in 2017 in respect to 2016 (%)
	2015	2016	2017	
Cattle	67.6	68.3	69.6	1.9
Poultry	116.9	117.2	117.7	0.4
Pork	116.1	115.6	114.7	-0.8
Lamb/mutton	14.4	14.4	14.5	0.6
Total production	**320.5**	**321.0**	**322.0**	**0.3**

Source: WATT Global Media, FAO

Poultry meat and pork top the list of total production figures for various types of meat worldwide, but while there is a net decrease in pork production, you can still see growth in the production of poultry meat. In 2015, the poultry sector outpaced the pork sector in terms of production volume.

Poultry meat consumption has been growing steadily for many years. This increase has mainly been driven by Asia and Latin America. The cause is population increase and higher disposable income, which result in people consuming less grain and more meat. This will have a significant impact on demand for poultry meat in coming years. From a base of 70 million tonnes in 2000, production will have increased to 125 million tonnes by 2020. In 2025, poultry is predicted to be 37% of total meat consumption. Poultry meat consumption is growing faster than other types of meat.

Healthy

Chicken is a healthy type of meat. It is lean and its fat comprises mainly unsaturated fatty acids. The meat is full of essential amino acids that are the building blocks of proteins, as well as rich in vitamins and minerals. The fact that broilers are small animals and are relatively easy to keep also contributes to the popularity of poultry.

Sustainable

Poultry meat scores well on sustainability. It is economically efficient to produce, with a small Carbon footprint. In recent decades, the poultry industry has also been working hard on social acceptance, e.g. animal welfare and reduction of antibiotic use. Concepts like slow-growing broilers are a result of these efforts.

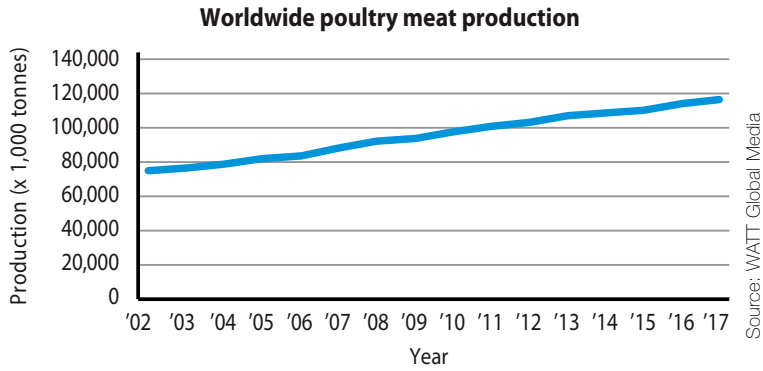
Positive characteristics of poultry meat

Poultry meat is very popular. This type of meat enjoys wide-ranging consumer acceptance. It is:

- tasty
- lean
- tender
- affordable
- easy to prepare quickly
- neutral in flavour
- free of associated religious or cultural impediments

and it also:

- works well in many dishes
- fits in a healthy diet



Poultry meat production worldwide between 2002 and 2017. This growth trend will continue in coming years.

Nutritional value of various meat products

Per 100 grams	Energy	Fat	Unsaturated fatty acids	Protein	Carbohydrates	Moisture content
Chicken breast fillet	463 kJ / 109 kcal	1.8 g	67%	23 g	0 g	65%
Beef steak	489 kJ / 116 kcal	2.3 g	61%	24 g	0 g	72%
Pork fillet	540 kJ / 128 kcal	3.9 g	62%	23 g	0 g	73%

Source: Voedingscentrum (Dutch Nutrition Centre)

Poultry meat is a healthy, low-fat type of meat with few saturated fatty acids.

CO_2 emissions, feed conversion and water consumption

Product	CO_2 (CO_2-eq / kg)	Feed conversion (kg feed/kg product)	Water consumption (m^3/kg product)
Beef	25	6	15
Pork	4.5	2.7	6
Poultry meat	2.6	1.5	4
Farmed salmon	2.1	1.1	-
Eggs	2.0	1.9	3

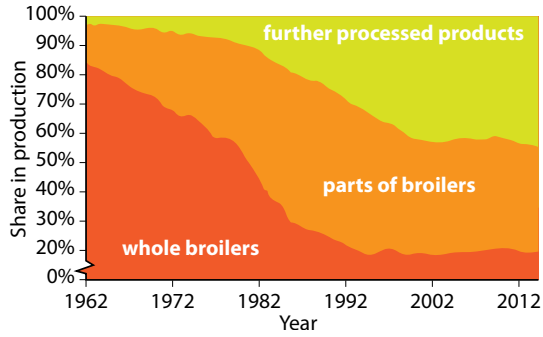
In comparison to other meats, the production of poultry meat has a lower impact on the environment. This is due to efficient use of feed and water for growth (good feed conversion).

The CO_2 footprint of beef is 10 times that of poultry meat.

The differences between countries

There are broad differences between countries in terms of poultry meat consumption. In the US, average annual poultry meat consumption per person is 48 kg/105 lb, in Brazil 40 kg/88 lb, in Europe 24 kg/53 lb, in China 12 kg/26 lb and in India 2 kg/4 lb. Consumption depends on income level, availability, tradition, religion and eating habits. In Europe, chicken fillet is in the greatest demand. Asian, African and South American consumers prefer chicken legs, thighs and wings.

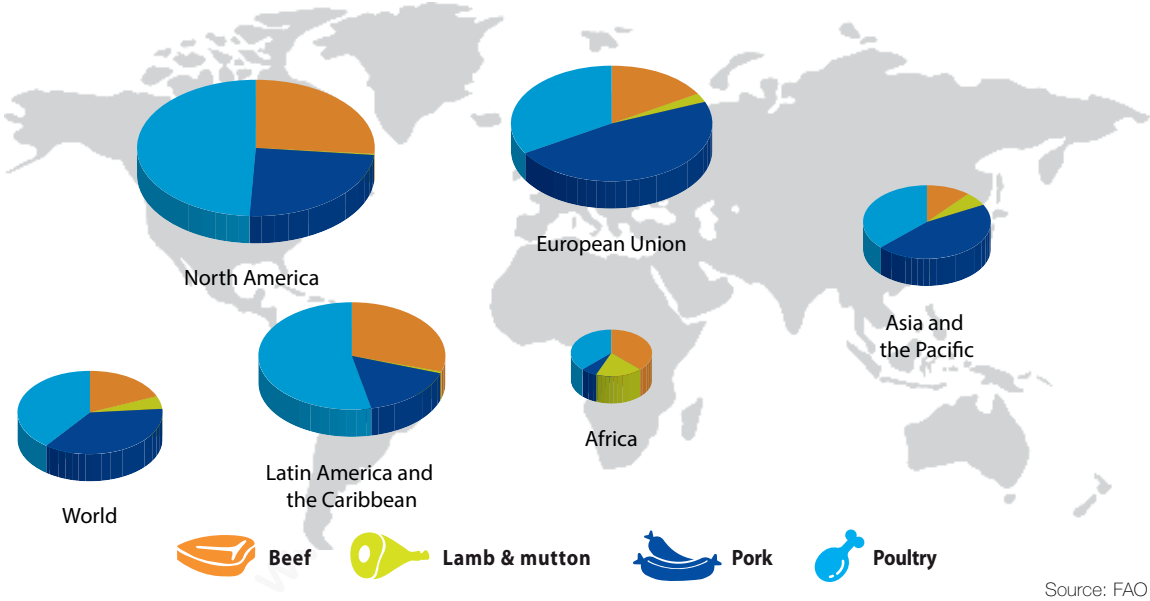
Market development in production of whole carcasses and cuts in the US market



Source: National Chicken Council USA (2014)

Not only in the US but worldwide there is a strong trend towards selling cuts and processed pieces rather than whole birds.

Regional meat consumption per capita



Source: FAO

Meat consumption per capita varies a lot in the world (size of the pie represents total consumption), as does the proportion of beef, pork and poultry.

The industry operates in most countries with a 'cold chain' and slaughterhouses supply refrigerated products. This sector of the industry is growing with increasing prosperity.

On the so-called 'wet market' animals are sold alive or slaughtered on the spot. Although a guarantee of freshness, it is not always hygienic.

Market differences

The value of the different broiler parts depends on the traditions of the country. In Europe the breast and leg fillet is worth more, but in Japan the neck meat has higher value than the fillet. Even the intestines have value in some markets, such as in Indonesia. Chicken feet are very popular in China.

Production, import and export

Local production costs, quality and the location of the market determine international trade flows. The feed price is the main determining factor for production costs. This is again determined by available agricultural area, climate and (increasingly) the availability of water. It is expected that production in China will grow the fastest in the coming decade. The occurrence of Avian influenza (AI) in the world markets has slowed growth down considerably overall. It is anticipated that there will be a shift to countries that grow raw materials for feed (grains) and have cheap labour available, e.g. Ukraine, Poland and Kazakhstan.

Chicken feet are popular eating in China, all parts of South-east Asia and Africa.

Edible organs like the liver, heart, spleen, gizzard and the neck go to specific markets.

Value of blood

In many countries, the blood is also used in local dishes. For example, it is used to make 'blood bread', 'blood pancakes' or 'blood cakes' in Scandinavia. In France, blood is mixed with vinegar or brandy to create a dip for bread. In China, the blood is mixed with a stiffener and calcium chloride. It looks like a jelly pudding and is called 'black tofu'. In Spain, certain tapas are made from chicken blood. According to certain religions, blood is unclean (Islam: haram, Jewish: non-kosher).

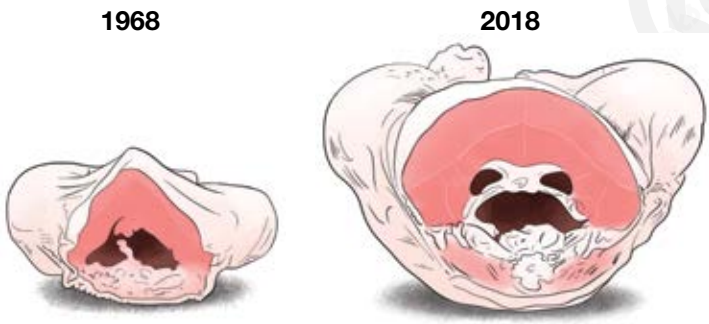
Buffalo Wings are the traditional snack when watching the Super Bowl in the US (beginning of February). At that time, there are 1.3 billion wings eaten.

The daily feed intake of the broiler chicken has risen by 55% over the past thirty years, while the digestive system has changed much less. This means there is a big load on the stomach and intestines. It only needs something small to go wrong and the balance is upset. The birds' vulnerability makes optimal management essential.

Improvements in production between 1925 and 2015

Year	Slaughter age (days)	Slaughter weight (kg)	Gross feed conversion	Mortality (%)
1925	112	1.13	4.70	18
1945	84	1.37	4.00	10
1965	63	1.58	2.40	6
1985	49	1.90	2.00	5
2005	48	2.44	1.95	4
2015	42	2.95	1.55	2

Broilers reach higher slaughter weights in ever shorter times with less and less feed, while mortalities decrease.

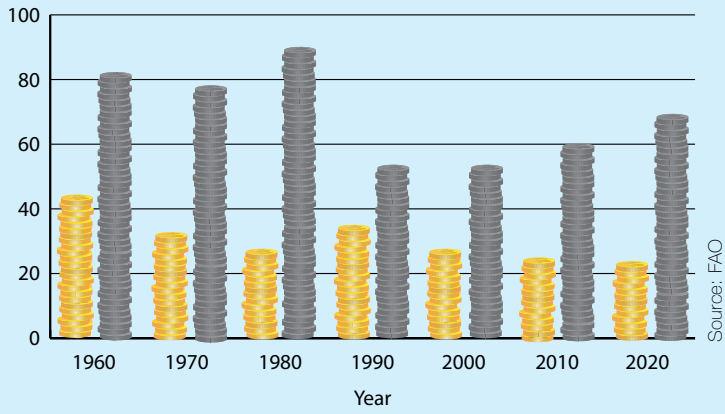


The difference between a broiler breast of 50 years ago and of today. This is the result of years of genetic selection, focused on the most appreciated part, namely the breast fillet.

Becoming more specialized and more efficient

The growing demand for poultry meat has led to increases in scale, specialization and efficiency in the production chain. In 1920 the same breed was used for both egg and meat production. After the Second World War, the prevalence of specialized breeds for egg or meat production arose. One of the factors that played a role here was the need for a reliable meat supply for soldiers stationed in Europe. The scale of production grew during the 1960s. This led to an enormous advance in technical and financial results. In 1925 it took 112 days to get a broiler to slaughter weight (1.13 kg). Farmers today achieve a final weight of 3 kg in 42 days. The ratio between daily growth and feed intake has improved considerably. Feed conversion rate (kg feed/kg growth) decreased from 4.7 to 1.5. The short cycle, rapid growth and good feed conversion combine to make production costs low compared to other meats, e.g. pork and beef.

Price development of meat, corrected for inflation



Poultry meat price development

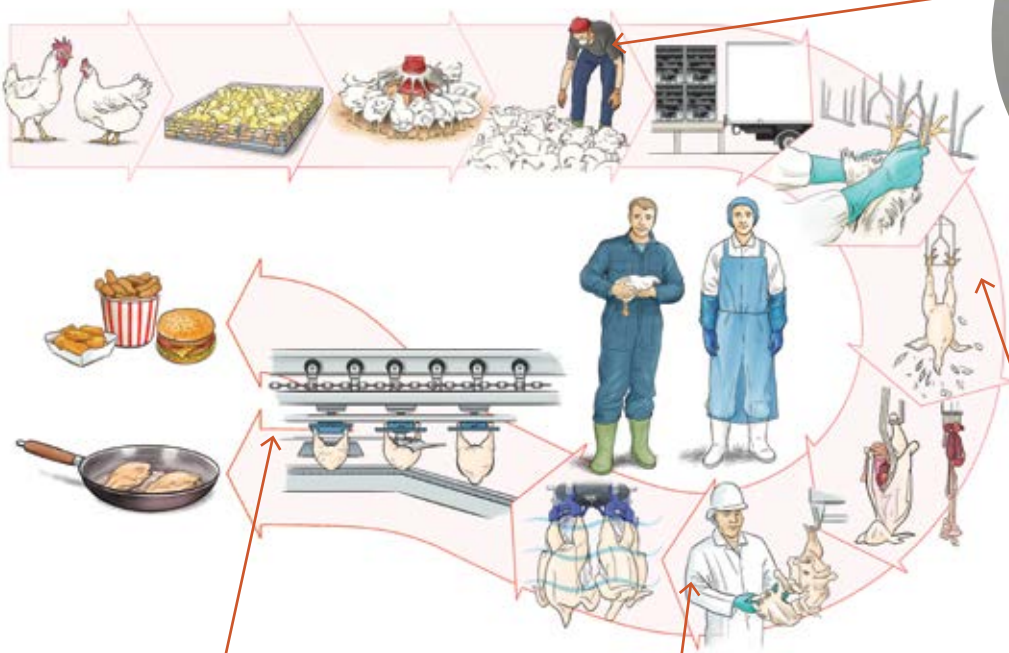
Consumer prices of poultry meat have risen much less in recent decades than those of beef. Broiler meat has become about four and a half times more expensive since 1960, while the price of beef became 7 times more expensive. Based on inflation figures, you would expect meat prices to have increased more than eight-fold. You could say that the price of poultry meat is actually almost fifty per cent less in real terms than it was in 1960.

poultry meat beef

Meat quality = chain quality

Meat quality is the general term covering all the product's characteristics that influence consumer acceptability. You must therefore stay alert every day and properly monitor and interpret signals that can affect it. This applies throughout the chain. Broiler farmers lay the foundation for good quality meat. The slaughterhouse can produce good or bad meat from a good broiler but only poor quality meat from a substandard one. That is why quality assurance must be of paramount importance in all parts of the chain.

Critical check points in the chain



A paper or digital record in the unit provides vital daily management information.

Final inspection of the meat.

Veterinary inspection.

Slaughterhouse arrival inspection (ante-mortem).

From breeder to consumer, every link in the chain has influence on meat quality. The success of poultry meat is due to long-term scientific research in many fields, including genetics, hatchery, feed and animal health, and significant advances in slaughtering, cooling, cutting and further processing (yields and speeds).

A slaughter line runs very fast. How many animals can one person evaluate per minute for abnormalities? A person can manage 125 per minute but the slaughter line speed is often around 12,000 per hour, i.e. 200 per minute. Therefore the line is split to allow inspection from two platforms. Furthermore, the workplace must be illuminated optimally for proper assessment.

In view of such high line speeds, it is good if the slaughterhouse also has people performing general observation without being driven by the high throughput speed.

SI-units

In this book the International System of Units (SI) is used. In many countries the imperial system is more common. For clarity in some cases both units are mentioned, especially when it concerns temperatures.

The most often used units:

Temperature:	°F = (9÷5 °C) + 32
Mass:	1 kg = 2.2 lb
	100 g = 3.5 oz
Length:	1 m = 3.3 ft
	10 cm = 3.9 inch

Signals concept

This book follows the Signals-concept. This means that we mainly emphasize things connected with meat quality aspects that you can perceive in a very practical way, what that information means and what you can do to improve things. Therefore good broiler chicken husbandry and processing meat well at a slaughterhouse both start with critical observation. Observe conscientiously. Take a step back, sometimes literally. You cannot observe properly if you are occupied with other tasks. Take your time to recognize the signals.

Structured observation

By structured observation, we mean that you really take the time to detect the signals. This works as follows:

1. Observe when not doing any other task.
2. Regularly stand still during work. For example, observe the slaughter line at different moments. Assess the end product, looking at B-grades and rejected broilers in particular.
3. Look at the whole situation from a distance but also pick up a carcass or piece of meat from the line occasionally and look in detail. They often show you a lot.
4. Look at the averages and the extremes.
5. Observe at different times and under varying conditions.
6. Identify risky times, animals, and locations.

Look-think-act

The guiding principle in *Broiler Meat Signals* is LOOK-THINK-ACT. The three basic questions that you must ask yourself time and again are:

1. What do I observe (see, hear, smell, feel, taste)?
2. Why is that?
3. What should I do?

In this book, we often challenge readers to first consider matters themselves, using the look-think-act boxes. Always try to answer the question yourself before reading further.

Aim and target group

This book follows the broiler from a day-old-chick until its meat is in a package for the consumer. Every link in this process has its own check points. In this way you look at the signals that are detectable on the poultry farm, during loading and transport, and during broiler slaughter and processing.
Broiler Meat Signals is a valuable practical tool for everyone involved in the broiler industry, i.e. for broiler farmers, veterinarians, inspection services, catching teams, slaughterhouse employees, advisers, students, etc.
Broiler Meat Signals is not a manual stuffed with standards and criteria, and it is not intended to be the complete solution. But it does provide useful pointers on good broiler and meat observation, and how to convert the signals into actions that will ensure better results.

LOOK-THINK-ACT

When did this bruising occur?

This bleeding is only a few hours old, so it occurred after catching. The blood is not coagulated, fresh red in colour and localized. It must have arisen shortly before death – during shackling or when tipping the container. Check the employees' working method or how the system is operating.

LOOK-THINK-ACT

What are these?

Black discoloration (litter spots) on the skin are caused by wet, sticky litter. These abnormalities are preventable by improving litter condition.

Breast blisters are subcutaneous swellings on the keel bone due to contusions on a hard surface.

CHAPTER 2:

Poultry meat

If you are involved in meat quality, basic knowledge of poultry meat helps you to understand how you can influence it. The market is international and preferences vary enormously, so quality criteria can also differ in different countries. There are a variety of meat cuts from a broiler and they have their own value in each country.

Flavour assessment

Flavour is an important quality factor. Tasting panels assess meat on factors such as flavour, tenderness, moisture content and the number of chews required before swallowing. For a good assessment, the determining aspects are described in as much detail as possible. Consider the smell, fat content, temperature, flavour sensation (salt, sweet, sour, bitter), texture, elasticity, mouth-feel, moisture content, colour, shape and the sound when eating. Chicken meat does not have a strong taste naturally but that has the advantage that you can give it a variety of flavours with seasoning.

The flavour test uses cooked chicken fillet without skin, which is brought to a core temperature of 72°C/162°F, cooled and cut into portions. The portions are often served under red light so that colour differences are masked.

Examples of structure assessment

Attribute	Definition
Wetness	Degree of moisture on surface
Springiness	Degree that sample returns to original shape after partial compression
Initial cohesiveness	Deformation before rupture
Hardness/Rigidity	Force required to rupture the sample
Initial juiciness	Amount of moisture in the meat
Rate of breakdown	Rate that sample mass breaks down to individual components
Hardness II	Force required to bite through the sample completely
Chewiness	Amount of work to chew the sample (Hardness × Cohesiveness × Elasticity)
Persistence of moisture release	Degree that moisture release persists or continues during chewing
Cohesiveness of mass	How sample holds together during chewing (LOW = fibres break easily, wad dissipates to HIGH = wad grows in size, resists breakdown)
Saliva produced	Amount of saliva produced in the mouth during sample manipulation to mix with sample to ready it for swallowing
Particle size and shape	Description of size-shape of particles as sample breakdown continues on chewing
Fibrousness	Degree of fibrousness or stringiness
Chew count	NUMBER of chews to get sample ready to swallow
Bolus size	Size of wad at point of swallowing
Bolus wetness	Amount of or feel of moisture in wad at the point ready for swallowing
Ease of swallow	EASY to HARD
Residual loose particles	Amount of loose particles left in mouth after swallowing
Mouth coating	Amount of moisture-fat coating the oral cavity after swallowing

Source: Shai Barbut

Influence of age on taste

The flavour of the chicken is mainly determined by the broiler's age. When broilers mature, the fat, protein and concentration of flavour components in the meat change. However, you cannot detect an age difference of one week by flavour. Yet it came to light that male Label-Rouge free-range broilers in France gained flavour around the 14th week of life - when the broilers mature. However, birds are slaughtered well before that time in most husbandry systems. There is little difference in taste between the main broiler breeds (Ross and Cobb), but their meat tastes different from that from backyard, heritage or bantam chickens and laying hens.

In general, getting a small flavour variation deviation requires a big change in the feed ration. The exception is fish oil or fish meal. A small amount of fish meal (> 5%) gives the meat a fishy flavour. This also applies to certain fats or medicines. Fish oil promotes better bone development and meat tenderness in broiler chickens. Using deodorized (refined) fish oil is a good alternative.

The muscles in a broiler

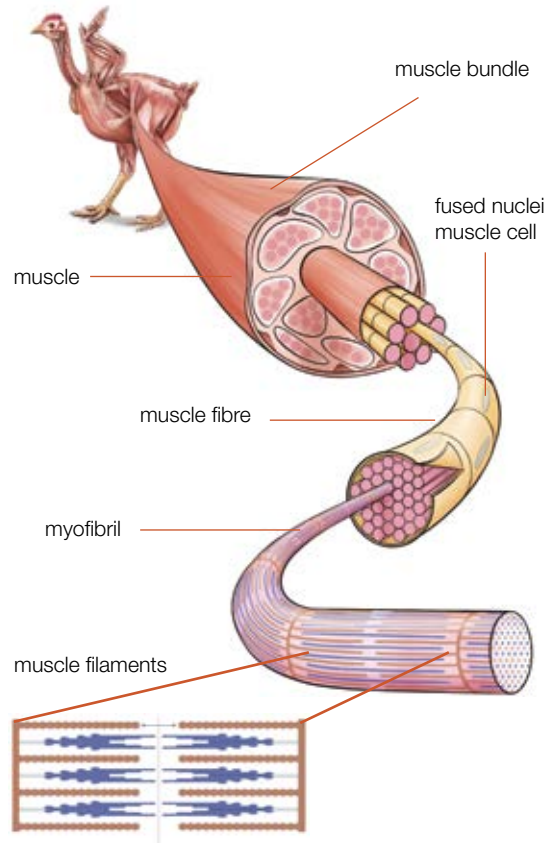
A broiler has two hundred muscles and each has its own function and therefore individual characteristics. As the muscles become the meat that we consume after the bird is slaughtered, you will find the characteristics of the various muscle types in the meat cuts.

There are various types of muscle tissue: striated (also called skeletal muscle tissue), smooth muscle tissue and cardiac muscle tissue.

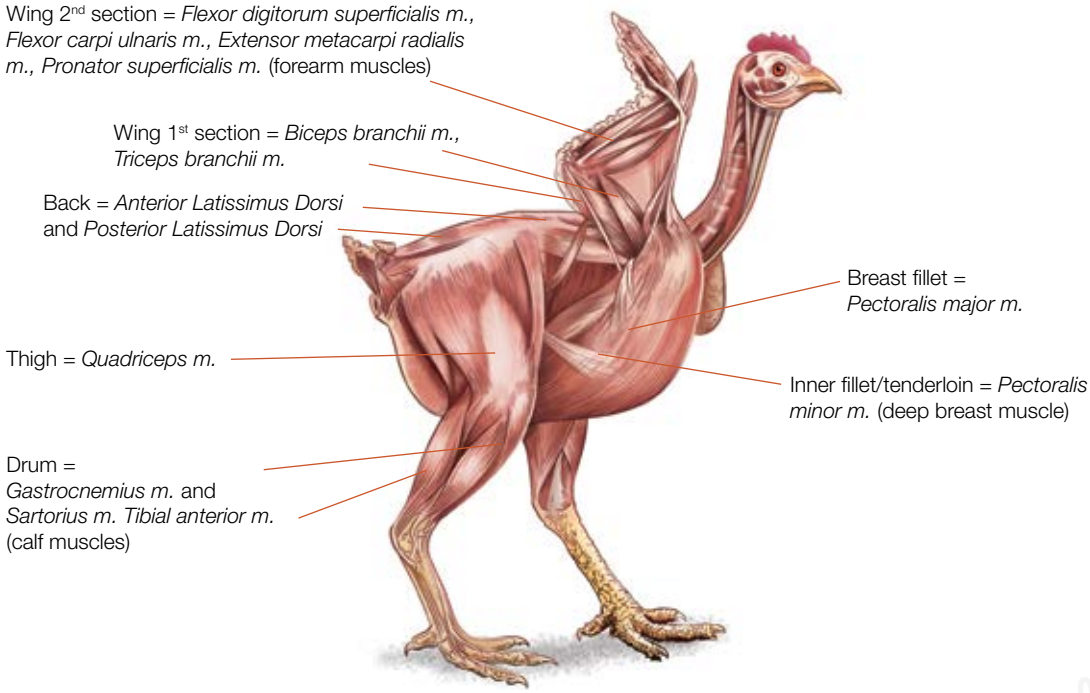
Smooth muscle tissue such as the muscles of the gastrointestinal tract and the walls of arteries is not under conscious control. The contraction of these muscles is slow but also almost indefatigable.

Skeletal muscle (voluntary muscle) has clear transverse streaks when you look through a microscope. An animal can consciously stretch and relax them. Skeletal muscles allow movements of the limbs and the entire body.

The heart muscle has a combination of the characteristics of smooth and striated muscles. It has cross streaking but has autonomous movements.



The skeletal muscles are made up of cells that contain multiple cell nuclei and thus form muscle fibres. A combination of a number of muscle fibres forms a muscle bundle. Multiple muscle bundles form the muscle. This progressive muscle build up also gives the meat its specific structure.



Important muscle groups in a broiler. The large breast muscle (Pectoralis major) is the most valuable of these – that is the chicken breast fillet.

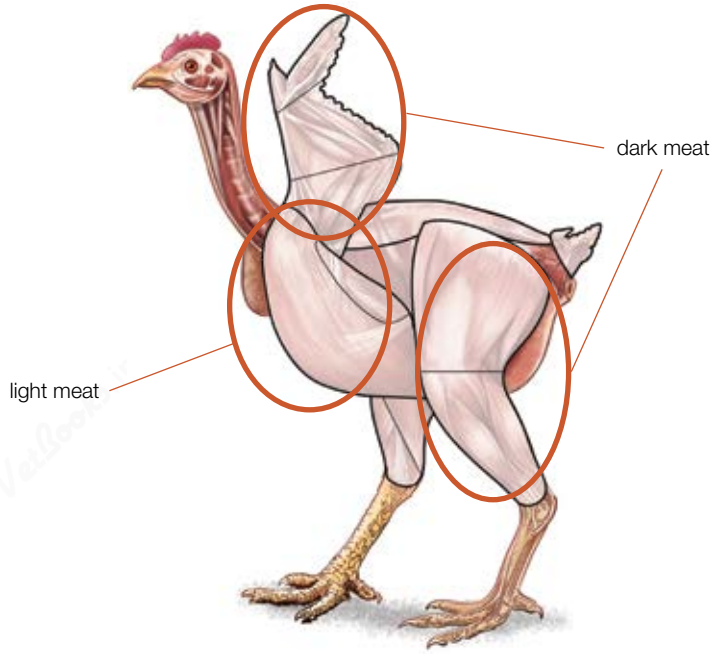
Light and dark meat

White muscle tissue ('light meat') makes up a broiler's breast muscles and is suitable for short-term efforts and actions in emergency situations (e.g. to fly away from a predator). The dark muscle tissue is in the legs and is suitable for the broiler's long-term muscular efforts – such as running. In chickens, the dark meat is pinkish-red, not as red as beef, for example. Dark muscle tissue contains little glycogen (rapidly released energy) and it contracts slowly (low shortening velocity) with little force (small fibre diameter). Dark muscle tissue can sustain such movement for a long time (many and large mitochondria/energy factories). Light muscle tissue can contract quickly and vigorously (fast shortening velocity and large fibre diameter) and it contains a lot of glycogen (rapidly released energy), but this type of contraction results quickly in fatigue (few and small mitochondria/energy factories).

Broiler breast fillet comprises mainly light muscle tissue. In migratory birds (ducks, geese, pigeons), the breast fillet will actually have dark muscle tissue, because it has to sustain flight movements for lengthy periods.

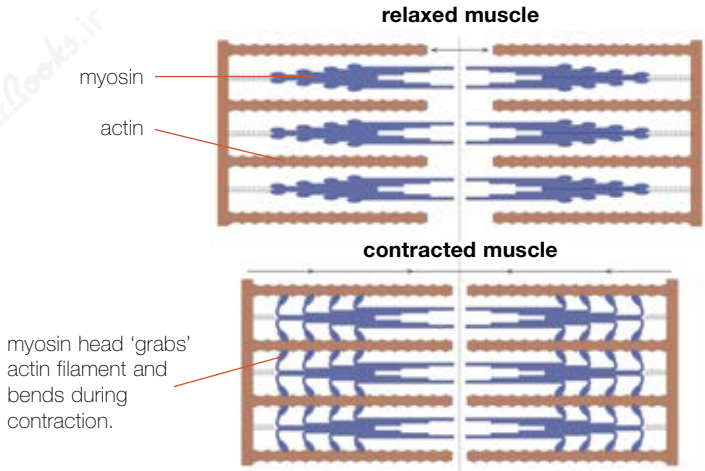
Comparison between dark and light muscle tissue

Characteristic	Dark muscles	Light muscles
Colour	Red	White
Fibre diameter	Small	Large
Shortening velocity	Slow	Fast
Energy burning rate	High	Low
- 'fast' energy supply (glycogen)	Low	High
- 'slow' energy supply (fat)	High	Low
Oxygen supply (myoglobin)	High	Low
Energy processing (number and size of mitochondria)	Much	Little

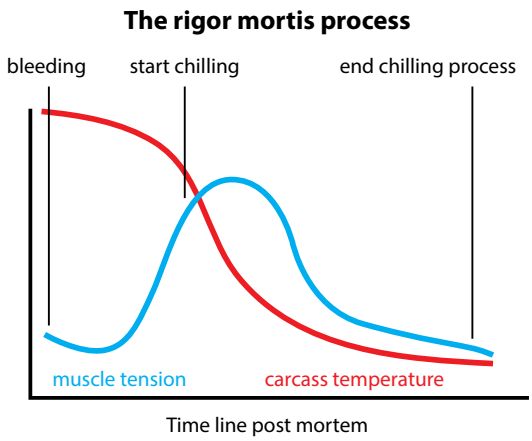


The main locations of light and dark meat on a chicken carcass.

Dark meat contains two and a half times more saturated fat than lean light meat. Thigh meat (left) is tender, slightly fatter and has more flavour than the chicken fillet. It is sometimes referred to as the 'chicken steak' or 'chicken chop'. That is why thigh meat continues to gain value.



The long (striated) muscle fibres contain the protein filaments actin and myosin alongside each other. Muscle contractions slide these filaments together. Calcium is released into the muscle cell here. Pumping this calcium out of the cell and thus breaking the actin-myosin complex requires energy (glycogen). When there is rigor mortis, the actin-myosin complex remains intact (cramped). Proteolysis (protein breakdown) releases these bonds again.



The formation of lactic acid in the process of rigor mortis decreases the pH. Lactic acid accumulates in the muscles until the glycogen stores in the muscles are depleted or the pH becomes too low for glycogen conversion by enzymes. At this point the tension is at a maximum. After this it decreases again due to muscle protein breakdown.

Factors that affect rigor mortis:

- Rapid cooling/freezing has a negative effect on the tenderness of the meat, because the glycogen has not yet fully decomposed and the rigor mortis process is still incomplete.
- Chronic stress before slaughter can cause exhaustion, lowering the glucose/glycogen level, which causes less pH decrease after death (pH > 6.2). This meat becomes dry, dark and firm. The resulting lower acidity makes it more perishable – bacterial growth is less inhibited.
- Electrostimulation immediately after bleeding causes the muscles to contract actively, which speeds up the rigor mortis process. Glycogen is consumed faster.

Rigor mortis

Meat has to mature to become tender, i.e. it has to age. The process of rigor mortis (body stiffening) is the basis for this. The rigor mortis process works as follows: at slaughter you interrupt the blood circulation, and thus there is no more oxygen supply. The metabolism then switches to a different method of energy supply, i.e. production of lactic acid from glycogen (anaerobic metabolism). The glycogen runs out and the muscle remains in a cramped state, i.e. rigor mortis. The light muscles go into rigor mortis faster than dark muscles. And small muscles do that faster than large ones. The course of the maturation process is not even throughout a flock. And that leads to meat quality variations. Broilers have differences in glycogen supplies, feed withdrawal times, stress levels (slower digestion) and panic (high glycogen use). Lactic acid decreases the meat pH from 7 to 5.8. This largely determines meat quality and colour development. Sufficient pH decrease is important for achieving tender, nicely-coloured meat with the right texture. In the following period, during maturation, enzymes break down muscle proteins (proteolysis), making the meat tender again. The proteins in the connective tissue around the muscles (collagen) are also broken down so that the muscle is easy to cut away from the skeleton. This process works best at a temperature between 15 and 20°C (60-70°F). The stiffness disappears after three to eight hours (with no electro-stimulation), and the meat can be processed further.

This device allows simultaneous measurement of pH and temperature. And you can follow the maturation process very well. In this case the pH is too low.

Water-holding capacity (WHC)

Consumers do not like chicken meat that releases a lot of water during preparation. The presumption is that water has been deliberately added in the slaughterhouse. But this is, in fact, forbidden in many countries, including those in the EU. This is referred to as brining and promotes unfair competition. A carcass will not normally absorb water if the skin is intact. The main reason for moisture release is poor water-holding capacity in the meat. A distinction is made between moisture loss during storage (drip loss) and during preparation (cooking loss).

Factors that influence water-holding capacity

The water-holding capacity depends on:

- protein content and quality (the collagen/muscle protein ratio)
- the electrical charge of protein (this is related to pH – isoelectric point at pH = 5.0-5.5)
- changing protein structure through acidification, freezing and thawing, etc.
- firmness of membranes (drip loss)
- salts and other ingredients added to meat products

The water-holding capacity has an effect on:

- meat processing efficiency (weight loss during cooling, cooking, etc.)
- sensory characteristics (juiciness and tenderness)
- nutritional value (the minerals, vitamins and proteins that are lost with the moisture)
- shelf life (escaping moisture promotes bacterial growth)
- the appearance of pre-packaged products (moisture in the package)

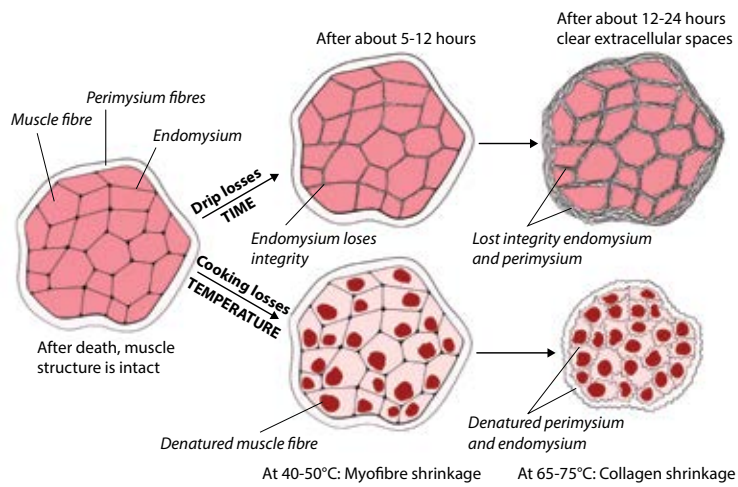
Slow-growing

A slow-growing broiler has more, but thinner muscle fibres (hyperplasia). This increases the water-holding capacity.

A fast-growing broiler often has shorter cells in the muscle fibres with a larger diameter (hypertrophy). This results in lower water-holding capacity. On the other hand, free-range broilers have more exercise, so lower glycogen reserves and higher pH, resulting in darker carcass and higher water-holding capacity.

The result of a cooking workshop in which broiler meat was prepared. The liquid that was released during preparation (cooking loss):
Left – free-range chicken 59 days (max. growth 45 g/day).
Centre – slow-growing chicken 49 days (max. growth 50 g/day).
Right – conventional chicken 42 days (growth 60 g/day).
A slow-growing free-range chicken releases significantly less water during preparation.

The difference between drip loss and cooking loss.



Drip loss *– the cell membranes weaken after about 5 to 12 hours in the process, allowing water to release from the cell. After a longer time (12-24 hours) the connective tissues between muscle fibres deteriorate. This allows moisture release from the muscle.*
Cooking loss *– the raised temperature shrinks the muscle tissues first and then the connective tissue.*
The extents to which these two processes occur determine the full water-holding capacity.

If the meat pH falls too little and too slowly, from 7 to 6.3 or higher, the result is DFD meat, i.e. dark-purple red, very tough and dry, with a firm and sticky surface and it has high water-holding capacity.

A good piece of poultry meat: pink, with a pH of 5.8 and slightly moist.

If the meat pH drops too quickly and too much, from 7 to less than 5.6, the result is PSE meat. PSE meat is pale, pinkish-grey, very soft and exudative (with fluid release: drip loss and cooking loss).

Water-holding capacity and pH

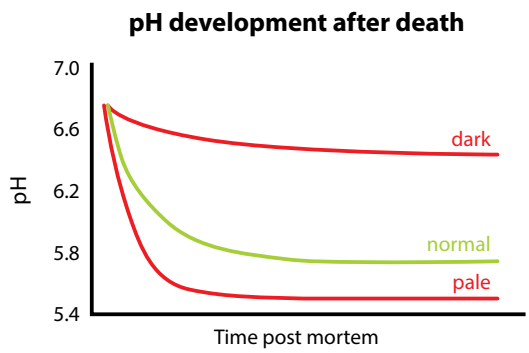
For good water-holding capacity, it is important that the acidity of the meat has dropped sufficiently after slaughter. The glycogen content in the muscles at the time of slaughter is important for this. Normally, after slaughter, the pH of the meat decreases from 7 to 5.8 in a gradual manner due to the formation of lactic acid from the glycogen stocks. This is called 'ultimate pH' or 'pH after 24 hours'. Two types of problems could occur.

Insufficient pH drop

Broilers who have already used up their glycogen supplies due to stress, an excessive feed withdrawal period, low glycogen reserves in the muscle and liver or muscle/wing flapping activity will produce much less lactic acid. This causes insufficient pH drop and that results in dark, tough meat. The water-holding capacity increases (DFD-like – dark-firm-dry). A piece of meat will stick on a wall and not slip off like normal meat will do.

Excessive pH drop

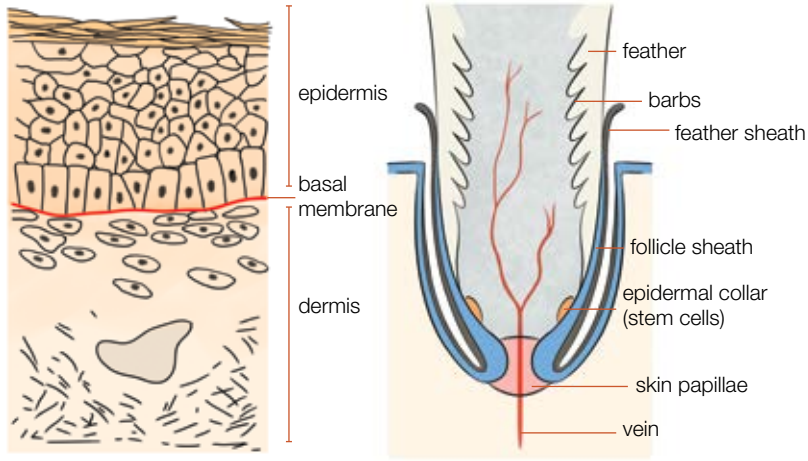
If there is too much acute stress before slaughter, adrenaline causes glycogen conversion into glucose, eventually resulting in more lactic acid. The result is a strong drop in pH in the meat while the meat temperature is still high. This changes the muscle proteins, which in turn results in less water-holding capacity. The meat is wet, pale and soft in structure (PSE-like – pale-soft-exudative). From 1 to 3% of the moisture can be lost during storage.



The development of pH after death. When this doesn't follow the ideal curve, the meat quality drops.

Feathers and skin

The skin forms a barrier between the body and the outside world. It prevents micro-organisms from entering the body and protects the body from environmental factors such as dehydration and damage. The skin also provides insulation and temperature regulation. The plumage forms an important part of a broiler's skin. A chicken has about 8,000 feathers that protect the epidermis. And naturally, feathers have other functions such as heat regulation and load bearing capacity for flight.

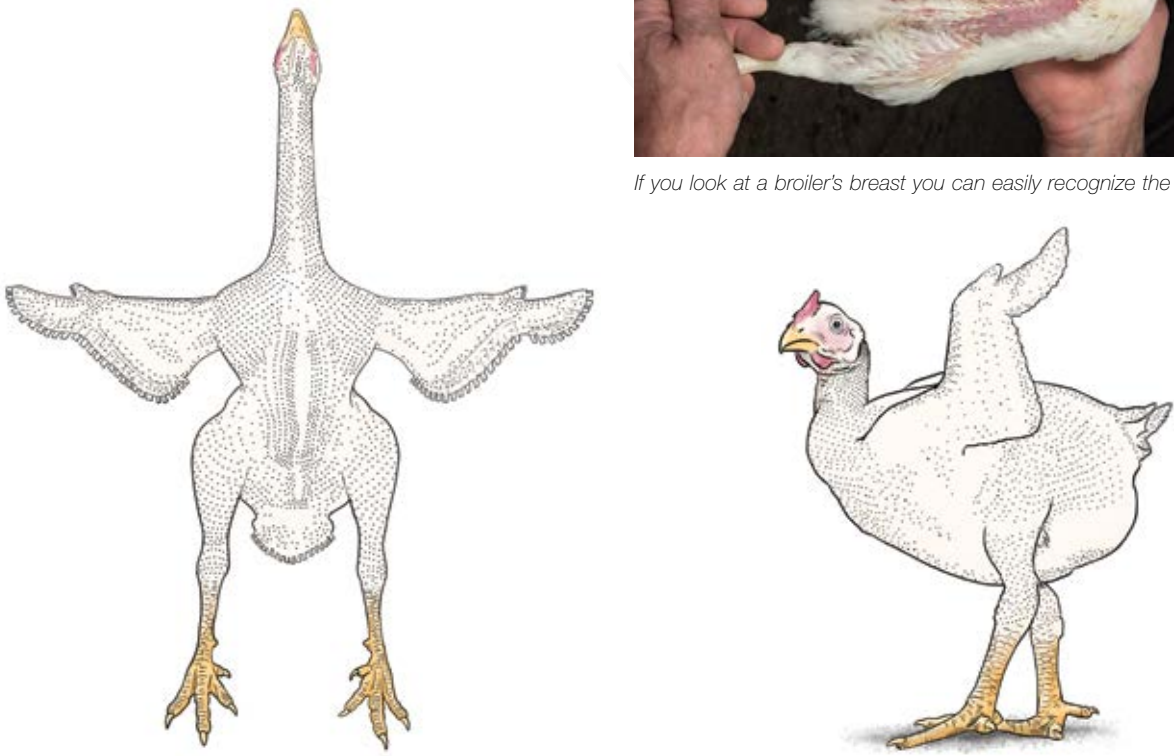


The skin comprises various parts, including the epidermis and the dermis. The feather grows out from a feather follicle. The feather comprises different grades of dermis to the hardened (keratinized), markedly flattened epidermis. On the carcass, we find feathers in different stages of growth, also related to broiler age and moult. This will also determine how easy they are to remove.

Summer and winter

Good plumage ensures skin protection. If broilers have few feathers, there are more visible skin scratches and skin inflammations. Broilers have more plumage in winter. Temperature settings, feed and management can all affect the plumage. For example, the plumage will be thinner with a higher ambient temperature.

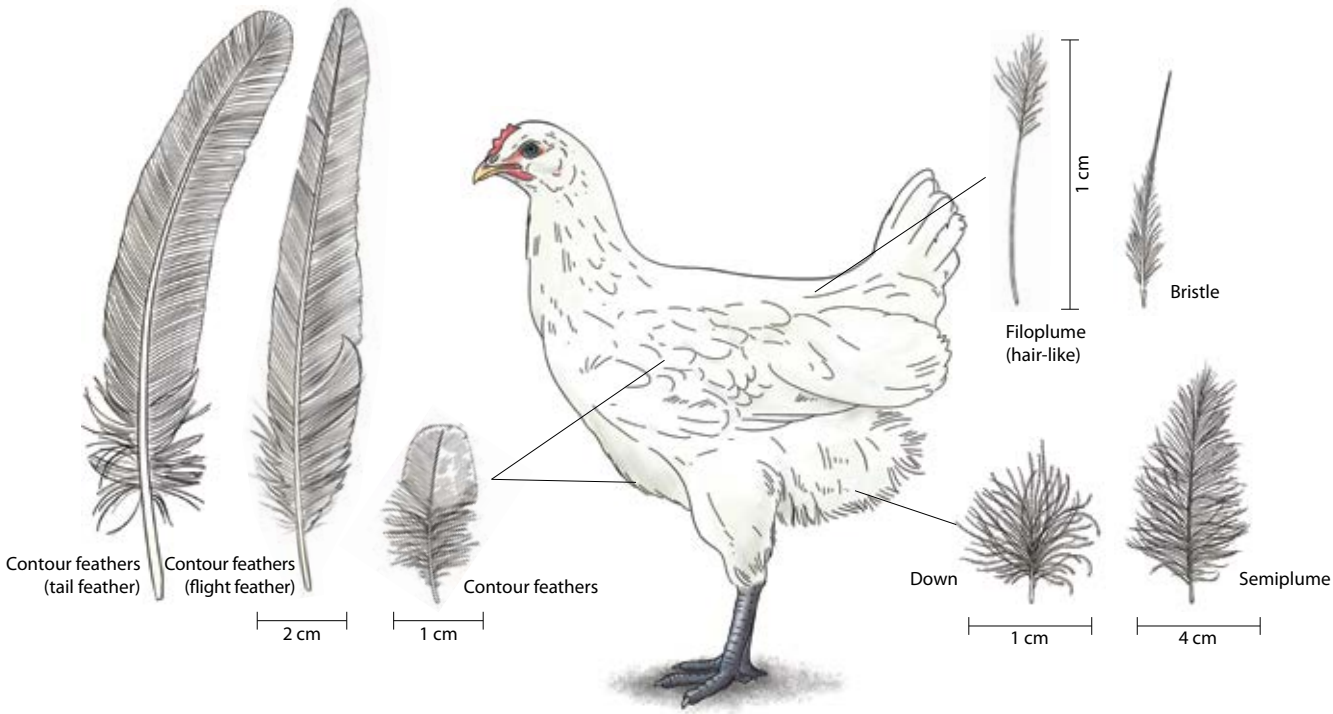
If you look at a broiler's breast you can easily recognize the rows.



Feathers grow in rows on the body, so that there are also parts where there are virtually no feathers, such as on both sides of the breast. There are feathers with different functions, and there are more follicles in the places where the feathers are softer.

Types of feathers

There are various types of feathers. They each have their own characteristics in terms of the degree of anchoring in the skin. This makes some more difficult to remove during the scalding and plucking process.



Contour feathers

Contour feathers are the most common, and they are composed of a flexible, strong shaft with rows of interlocking barbs. The barbs are in turn connected to each other with hundreds of minuscule hooklets, and the combination forms a kind of zip. The contour feathers give the bird its shape and they are mainly primary feathers on the wings and tail.

Filoplume feathers

Long, thin filoplume feathers grow distributed between the contour feathers, and they cover the broiler's entire body. Filoplume feathers have a signalling function for the broiler, to indicate any disruption of cover feathers. They feel draughts, for example.

Down feathers

In addition, the broiler has down feathers. These are very short and have thick and soft barbs, which make them an effective insulator. The areas with softer feather cover have more feather follicles. Down feathers are replaced, step-by-step, with definitive feathers, and are therefore an aid for estimating age.

A naked broiler in a flock of feathered ones. You see the difference between carcasses after slaughter and plucking – the feather follicles are missing in a naked chicken.

Israeli naked chicken

Israeli scientist Prof. Avigdor Cahaner succeeded in breeding a chicken without feathers from a natural mutation discovered in 1954. This featherless breed is less sensitive to heat and is therefore well suited to hot countries where climate control is not yet optimal. The results are a lot better in such cases. The amount of breast meat is higher, because a proportion of the protein in the ration is not required for plumage and it seems to go into the breast meat. They can therefore work well with less protein content in the feed. It is even claimed that naked broilers have better meat quality.

Skin integrity

Good skin integrity is important for skin damage prevention. The skin strength is important when the birds crawl over each other in the house, when catching and feeding for example. Otherwise, skin scratches (scabby-hip) develop quickly. Skin damage then causes infections, and parts of the broiler have to be trimmed off or even a whole carcass has to be rejected at the slaughterhouse. Feather pluckers cause skin breakages on the chest and thigh. The actual amount of damage depends on the skin strength. The skin strength is determined by the fibrous protein collagen. The collagen fibre forms a matrix structure in the skin. There is also elastin in these protein fibres, which handles stretching.

It ensures that the skin always returns to its original shape. Side branches create a very strong bond between the collagen fibres. The amount of side branches is partly hereditary, but is also influenced by nutrition: amino acids, enzymes and minerals such as zinc, manganese and copper.

Differences by gender

The skin of a cockerel is thinner, but contains more proteins (collagen and elastin) than those of a hen and it comprises less fat. This makes a cockerel's skin stronger than a hen's and it breaks less quickly. The skin on the breast is stronger than on the thigh. As a bird ages, the protein content decreases, but the collagen fibres are stronger. The older a hen becomes, the thicker the subcutaneous fat content becomes. This is why a hen's skin breaks easier. This applies in particular to birds that are offered a lot of energy in their ration.

The hips are a vulnerable position, since animals crawl over each other, with their sharp nails.

Slow-growing broilers have more feathers and a stronger skin. The plucking fingers have to be adjusted tighter, but since the skin is stronger, it can handle the increased forces.

Structural proteins

Collagen is a structural protein that provides string-like, strong and non-elastic structures. It ensures that the skin anchors well onto other tissue. There is a lot of collagen fibre and little elastin in tendons. Elastin is in connective tissue. Elastin provides elasticity, so that tissue quickly regains its original shape after deformation. A tendon's purpose is to transmit the force of muscle contractions when walking and flying.

The colour of broiler meat

Broiler meat is normally light pink. Many consumers base their purchase choices on their preferred chicken meat colour. For example, yellow skin colour is often required in Asia and Mexico. The colour of the chicken meat can be influenced through feed, but also by genetics (selection of breeds). The skin colour is particularly easy to influence.

A different skin colour can be caused by the following:

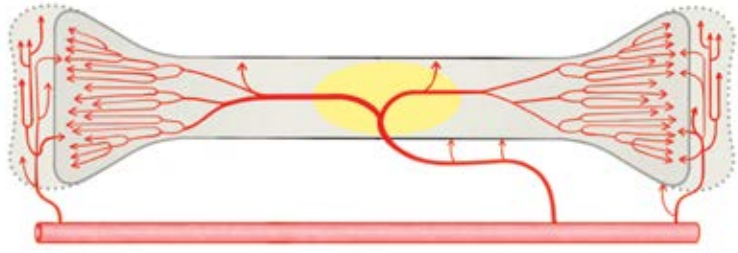
1. **Hereditary** - breed-related. Some chicken breeds naturally have pigments in their skin, causing them to turn yellow, brown, dark coloured or even black. Often, yellow broilers also have yellow plumage.
2. **Nutrition** - carotenoids. These are pigments from the feed and they are stored in the skin and the fat tissue. A carotenoid such as xanthophyll (e.g. from yellow corn) colours the skin and legs yellow. It is also in lucerne (i.e. alfalfa), paprika and gluten. The yellow-orange colour is achievable with synthetic colours with the advantage that you can control its intensity. There is no difference in taste between yellow and white chicken meat. By adding the red-coloured yeast *Phaffia rhodozyma* to chicken feed you get reddish coloured muscle tissue, and by removing yellow corn and other coloured raw materials from the feed you get white meat.
3. **Infection** - jaundice from liver inflammation. This rare disease is often a farm-related flock problem. You see yellow skin colouring and fat yellowing in some birds in the flock. You also see that the bird has yellow mucous membranes. This is caused by bile pigments that spread around the body through the blood. These broilers are rejected in their entirety because the liver inflammation is caused by bacteria such as Salmonella, Clostridium, E-coli and Campylobacter. These bacteria can produce toxins that spread throughout the broiler.

Chickens from differently fed broilers. On the left, a corn-fed chicken.

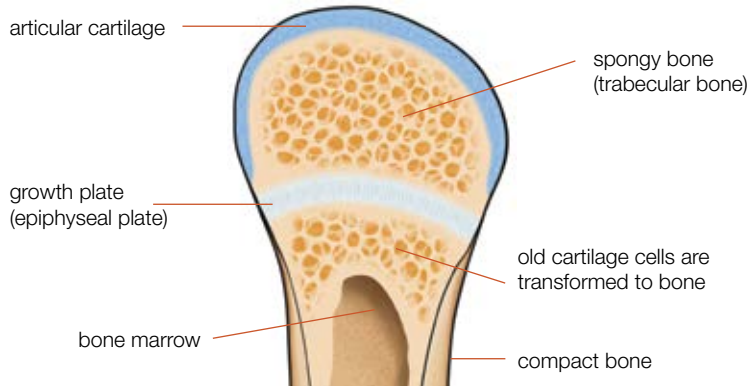
Through genetic mutation, every part in the Indonesian chicken breed Ayam Cemani's body, including organs, meat and blood is black. This chicken has a mythical status in Indonesia. It is considered a lucky charm and used for medicinal purposes. Chinese and Vietnamese people also like to eat black chicken meat.

Bone development

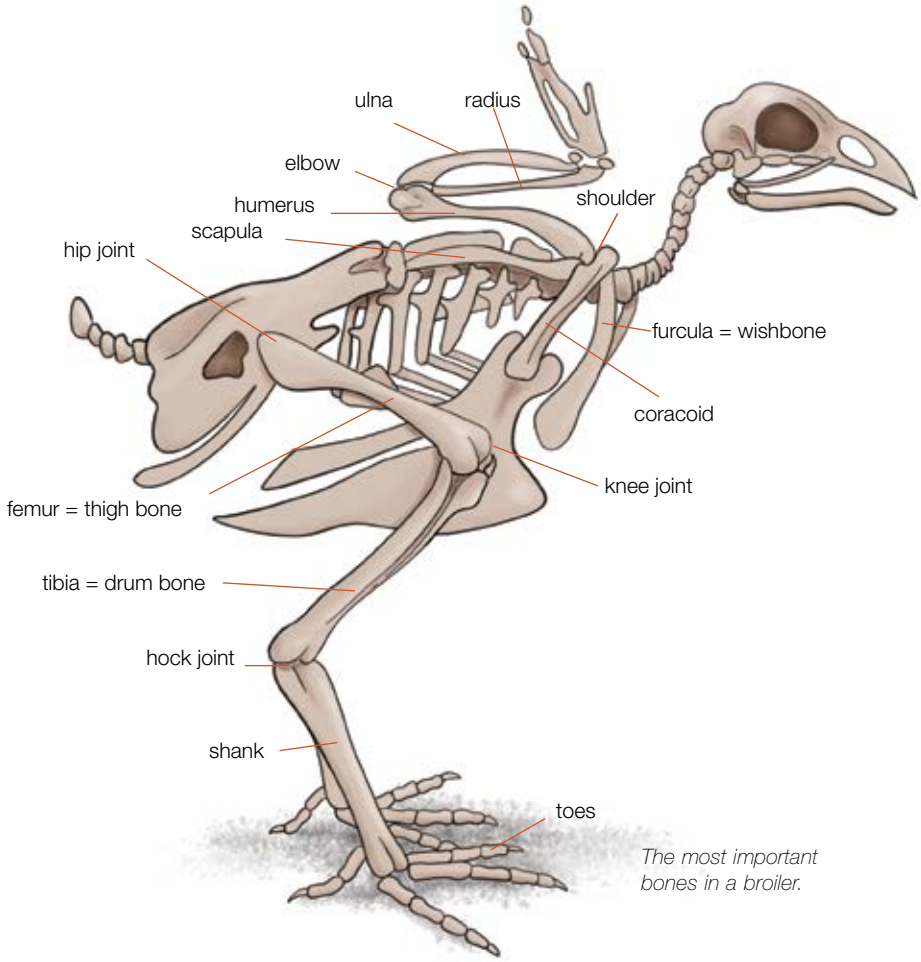
Feed composition plays an important role in healthy bone development, i.e. calcium, phosphorus, vitamin D3, vitamins A and C, and minerals such as copper, manganese and zinc. These nutrients must be properly absorbed, therefore poor bone development can occur following digestive problems and intestinal disorders. In addition, rapid growth and the large pectoral mass play a role, because the young bone has to carry increasingly heavy weight. That is why there are more leg problems with cockerels than with hens. Bone growth cartilage (epiphyseal plates) provide linear growth. Cells of these plates (chondrocytes) divide and calcify and build up bone length. Osteoblasts provide thickness growth. Bones that are subject to a lot of mechanical forces in certain places form extra bone tissue to make them stronger.



Only a few blood vessels supply blood to the bone. This makes the bones very vulnerable.



Longitudinal growth of young bone comes from the growth plate. This is a vulnerable part of the bone in immature animals. A broiler is of course still a growing, immature animal.



The most important bones in a broiler.

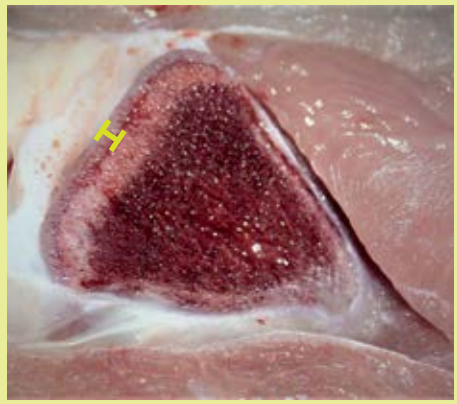
The growth plate reveals bone strength

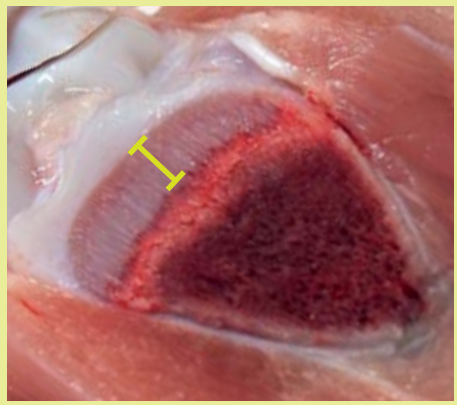
You can check the level of skeletal development of a broiler by looking at bone formation around the growth plate (where cartilage is replaced by bone cells and mineralization begins). To do this, you make a cross section through the top part of the upper shin bone (tibia), just below the knee. The growth plate should look like a thin grey pencil line. If the grey line is wider, it is a signal that the bone development is insufficient. In that case, the cartilage cells have not yet been replaced sufficiently by young bone cells. And that means the bone will be less able to bear the broiler's weight. Local damage will occur, and the broiler will be in pain and reluctant to walk.

LOOK-THINK-ACT

What do you see here?

This is the image of a section of the shank bone (tibia), just below the knee. A normal growth plate with the thickness of a pencil line (top) and a thickened growth line (bottom).





To see the growth plate properly, make a cut at an angle of 45° through the bone, about 3 cm below the knee joint.

Weight ratios

Every part of a broiler has a different value and that varies by country, season and in the way the bird is cut up (the types of cuts). So the value of each cut and its proportion of the bird's meat determine the final return. The percentages the cuts represent differ by breed, age and live weight. The slaughtered carcass of a 2,500 g broiler weighs 1,750-1,800 grams (slaughter efficiency approx. 70-72.5%). This carcass renders 450-500 g fillet, 650 g thigh + drum, 170 g wing and over 500 g other meat.

Difference in ratios between fast-growing and slow-growing breeds

Although the taste is not very different, there is a difference in the percentage of breast meat from slow-growing broilers (growth < 50 g/day) and fast-growing broilers (growth > 60 g/day). With slow-growing broilers and a market weight of 2.5 kg, 17-21% of the body weight consists of breast meat, depending on the growth rate and nutrition. A fast-growing broiler has 21-23% breast meat at a body weight of 2.5 kg. This can even reach up to 25% of the body weight for heavy broilers, depending on the feed ration. So, slowing down the growth rate of slow-growing broilers by decreasing dietary protein will result in less of the valuable breast meat.
Besides higher costs for the husbandry (feed and housing), the revenues will be lower when the meat price would be the same. This must be corrected through a difference in consumer price between the two types. As the breast meat is more desirable than dark meat from the legs in the markets where slower-growing birds are sold, this difference in consumer price is normally disproportionately attributed to the breast meat. This is done in order to encourage a balanced consumption of all parts of the carcass: the dark meat remains at the same price to the consumer.

Source: Schothorst Feed Research

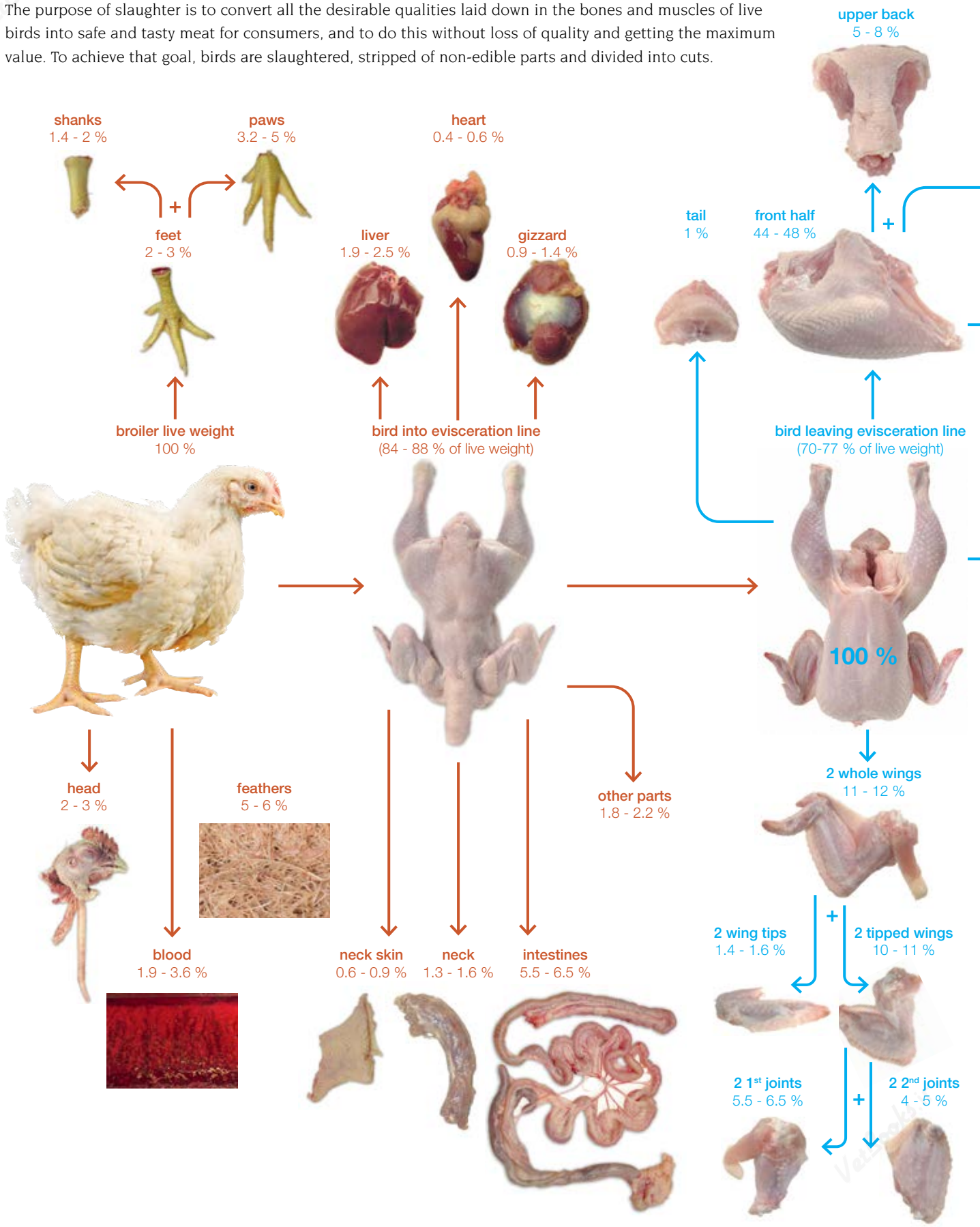
Value per cut

Below is an example of value structure in Europe. In this example, the highest value lies in the fillet (about 60%). These prices are constantly evolving and vary by region. In Asia, the leg has the highest value. This value is also increasing in the Western world.

	% based on live weight	Weight with a 2,600 g broiler	Value per kg	Value per bird
Live weight	100%	2,600	€ 0.87	€ 2.26
Whole carcass (live weight minus feathers, blood and intestines)	72.4%	1,882	€ 1.65	€ 3.11
Giblets = visceral organs	5.8%	151	€ 0.75	€ 0.11
Offal = guts, fat, blood, feet	21.8%	567	€ 0.10	€ 0.06
Breast fillet (complete)	**19.9%**	**517**	**€ 3.75**	**€ 1.94**
Leg (one complete)	15.6%	406	€ 0.90	€ 0.37
Thigh (one part) without back	10.1%	263	€ 1.50	€ 0.39
Drum (one part)	5.5%	143	€ 1.20	€ 0.17
Wing (one complete)	4.2%	109	€ 1.20	€ 0.13
Upper arm (one part)	2.8%	73	€ 0.20	€ 0.01
Lower arm (one part)	0.7%	19	€ 0.20	€ 0.00
Back + pelvic part	13.0%	338	€ 0.20	€ 0.07

Cutting up the chicken

The purpose of slaughter is to convert all the desirable qualities laid down in the bones and muscles of live birds into safe and tasty meat for consumers, and to do this without loss of quality and getting the maximum value. To achieve that goal, birds are slaughtered, stripped of non-edible parts and divided into cuts.



breast cap
36 - 41 %

whole fillet (incl. tenderloin/inner fillet)
29 - 31 %

+

2 half fillets
24 - 26 %

2 tenderloins / inner fillets
4- 6 %

whole fillet (incl. tenderloin/inner fillet)
30 - 33 %

+

2 half fillets
24 - 28 %

2 tenderloins / inner fillets
4 - 6 %

saddle (without tail)
39 - 44 %

+

2 leg quarters
39 - 44 %

lower back
7 - 8 %

2 anatomical legs
31 - 36 %

+

2 drumsticks
12 - 15 %

2 drumstick meats
7.5 - 8.5 %

+

2 thighs
18 - 21 %

thigh fillet
12 - 12.5 %

2 drums
12 - 15 %

+

2 chops
27 - 29 %

Broiler by-products

Apart from meat, a broiler renders a lot of by-products, each with its own use. Parts that are less suitable for human consumption, such as lungs, head, crop, proventriculus, intestinal tract and bones, are used for animal feed (if allowed). They are heat treated at well over 100°C/212°F to kill micro-organisms and prevent disease. The broiler fat can be used in animal feed, and other uses include waterproofing clothing or soap manufacture.

Feathers represent about 7% of the live weight and they are used in mattresses, as a base material for animal feeds and as a filler in artificial fertilizers.

For example, a breast cap with breast fillet removed still has some meat. This is removed from the carcass under high pressure, often by a specialized company. A type of minced meat is created, i.e. mechanically recovered meat or MRM (Mechanically Recovered/Reclaimed Meat). This meat is used in products such as hamburgers, chicken nuggets and frankfurters.

The broiler skin

Broiler skin is a high-quality product. The skin contains fatty compounds (phospholipids); heating the skin gives the typical aroma of roast chicken. There are also many omega-3 fatty acids in the skin, the consumption of which is good for those with high blood pressure or high cholesterol levels. The skin itself gives a lot of flavour to dishes such as soups and it is used widely in meat products, for its binding effect.

Slaughter age

Broilers are slaughtered at varying ages in different countries. In the greater part of the world, broilers are kept up to 6-8 weeks of age but there are also countries where it is up to 10 or even 22 weeks. French Label Rouge broilers are often slaughtered at an age of 96 days or more. This is related to tradition, animal welfare, flavour preferences, culture, infrastructure and climate. So the delivery weights and sizes of broilers also vary by country.

Fast-growing breeds have a high percentage of breast meat.

Chicken as sold on local markets in Indonesia. It has relatively little breast meat but it is highly valued.

Change of carcass composition with slaughter weight

kg	Breast %	Thigh %	Drumstick %	Eviscerated %
1.6	20.5	12.1	10.2	71.0
1.8	20.9	12.3	10.2	71.3
2.0	21.2	12.5	10.2	71.7
2.2	21.5	12.7	10.2	72.1
2.4	21.8	12.8	10.2	72.4
2.6	22.0	12.9	10.2	72.8
2.8	22.3	13.0	10.2	73.1
3.0	22.5	13.1	10.2	73.4
3.2	22.7	13.2	10.2	73.7
3.4	22.9	13.3	10.2	74.0
3.6	23.0	13.4	10.2	74.3

With the increase in weight, there is a shift in percentages of meat types on the carcass. The heavier the birds, the higher the percentage of carcass weight and breast meat. On the other hand, the broiler production naturally costs more. So it is essential to find the right balance.

Slaughter weight difference in various countries

Area	Weight	Background
Indonesia	Average 1.6 kg live weight (1.1 - 2.0 kg)	Consumers buy a chicken that is sufficient for a family, because there is not always a refrigerator available.
South Africa	1.6 kg - 2.2 kg live weight	Chicken is generally sold whole. Only 20% is divided into cuts and sold in supermarkets, but this percentage is increasing rapidly.
Southern Europe (Spain, Greece), Eastern Europe	1.7 - 2.2 kg live weight, 2.2 - 3.0 kg for cut-ups	Griller is very often sold whole (80%). The remaining 20% are grillers which are cut up. Grillers with any defect are generally cut up anyway.
The Netherlands	1.8 - 2.2 kg live weight, 2.0 - 2.7 kg for cut-ups, 2.5 - 3.2 kg for breast fillet production (more favourable yield)	There are virtually no whole carcasses sold (mostly at halal outlets, market poulterers and shops for immigrants). The primary demand is for breast fillet.
Brazil, Thailand, USA	2.8 kg - 3.5 kg live weight, aiming for 5.5 kg live weight in the future	Production and marketing are mainly for breast meat. Legs and wings are frozen and sold for a dump price to African countries, Central Asia or as food aid to emergency areas. People in these countries like eating from the bone.

Consumer perception in the USA

Perception	Reality
78% think that poultry is genetically modified.	Poultry is heavily bred for meat quality but birds are not genetically modified.
77% think hormones are added to poultry meat.	No growth hormones are used in poultry farming.
73% think that poultry meat contains antibiotics.	There are withdrawal periods for antibiotics, so there is no longer any residue in the meat at the time of slaughter. Furthermore, use of antibiotics has been decreasing rapidly during recent years.
68% think that broiler chickens are kept in cages.	Worldwide, most broilers are kept on floors with litter. Cages are prohibited in the EU.

Action poster from the United States to inform consumers clearly that there are no hormones used in broiler chickens.

In many countries, GMOs in food are not appreciated at all. It is explicitly stated on the packaging here.

Consumer perception

Consumers' perception can have a very decisive influence on their buying behaviour. But consumers do not always have a correct picture of the sector. They are influenced by sources such as civil society organizations and the media, and sometimes by various persistent rumours ('urban myths') too.

Animal welfare

Animal welfare plays a role in livestock farming in many countries (especially in Northwest Europe). In response to this negative image, many supermarket chains have switched to slower-growing and more robust chicken breeds. This has allowed various alternative concepts, using free range, to develop.

Injecting water

Addition of water to chicken meat is a common misapprehension among consumers. This is not applicable in fresh products and is even banned within the EU. In some countries it is legal to inject up to 15% water with salt and some additives (brine), meant to add flavour. For example, it could be in a marinade with herbs. The additive must be mentioned on the packaging.

Hormones

Many consumers think that chickens are fed growth hormones but this is not the case and is actually not interesting at all for farmers. Genetic potential has been brought to the optimum by breeding and cannot be improved by administering (growth) hormones.

GMOs in the feed

In many countries there is discussion about GMOs (genetically modified organisms) in the feed. GMOs are micro-organisms and plants (maize, soya, wheat) that have a certain property in their DNA (e.g. more protein or resistance to certain diseases). There are an increasing number of companies that do not want this anymore. This discussion plays a lesser role in the USA, because social acceptance there is greater.

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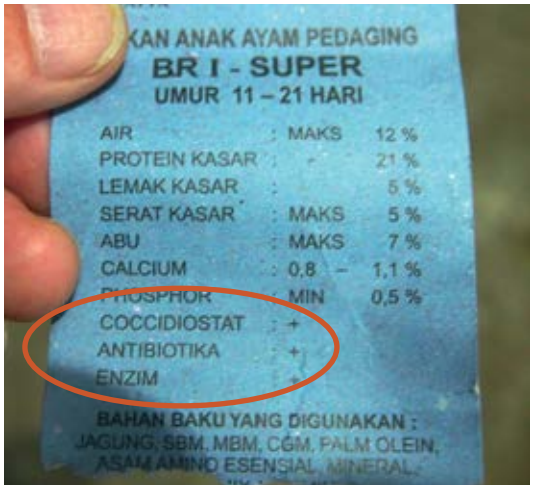
Antibiotic use

There is strong pressure to reduce antibiotic usage in poultry because of the development of resistant bacterial strains that pose a threat to the health of both humans and animals. In many countries use of some antibiotics is only allowed if there is really no alternative and if it appears that the bacteria causing the problem have a high sensitivity to these specific antibiotics. Alternatives to antibiotics include organic and inorganic acids (fighting acid-intolerant bacteria), essential oils (killing bad bacteria and promoting appetite), probiotics (adding good bacteria for good intestinal flora balance), prebiotics (nutrients for beneficial intestinal bacteria) and herbs.

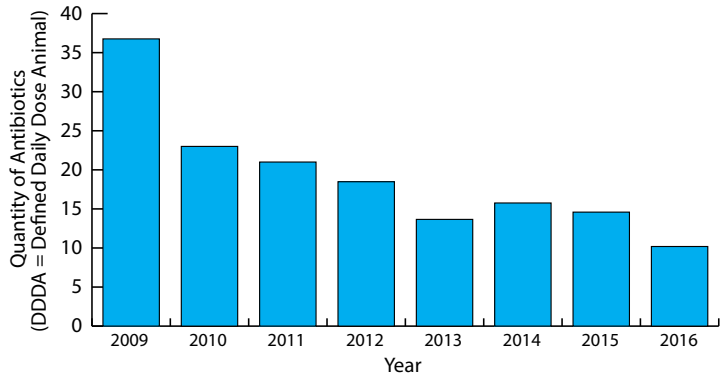
Growth promoters (AGP = Antibiotic Growth Promoter)

For years, certain antibiotics have been mixed into the feed in low concentrations, as a 'growth promoter'. This is no longer permitted within the EU and in many other countries. Growth promoters influence the balance between benign and harmful bacteria in the intestinal tract. They reduce the chance of gastrointestinal disorders, and lead to better feed conversion and higher end weights. Their use is inexpensive and limits the risks of mortalities due to illness. Standard growth promoters are still used in a number of countries outside of the EU.



In Europe, the use of antimicrobial growth promoters in poultry feed has been prohibited since 2006 and since 2015 in the USA. Outside the EU, USA, Canada and Australia, they are still permitted in many countries. The addition of an AGP must be mentioned on the feed label.

Changes in antibiotic use in broiler chickens in the Netherlands



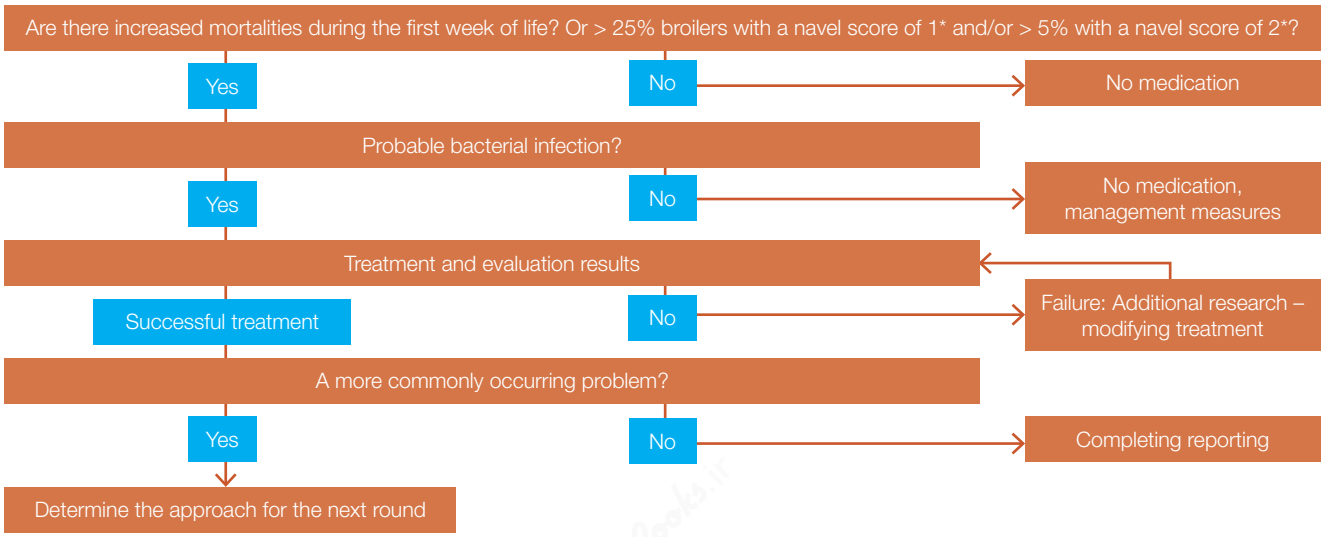
In the Netherlands, antibiotics use on broiler farms fell by 72% during the period from 2009 to 2016. There are higher demands on housing, husbandry, hygiene, vaccinations and feeding to prevent illness.

Very clearly not using hormones and other additives is used here as a positive marketing tool.

Should you use antibiotics and what type?

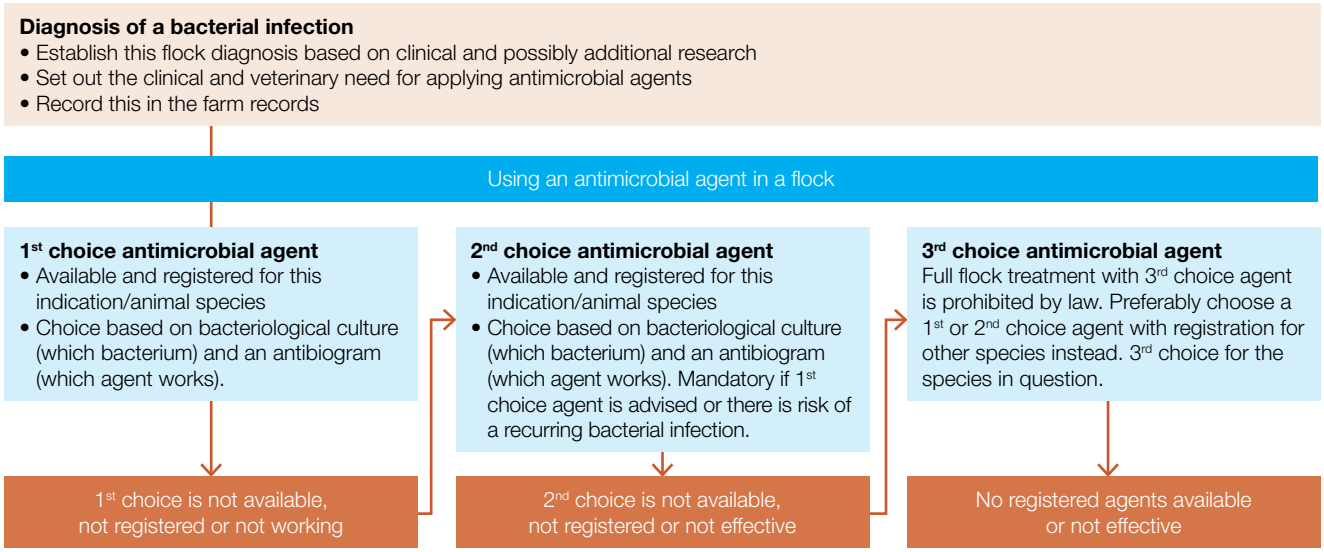
Use of antibiotics is only permitted in the Netherlands for treatment with a vet's prescription, and no longer for prevention. There are withdrawal periods for antibiotics that must be observed, so it is sometimes not possible to treat broiler chickens and have them residue-free in time for slaughter. Target values have been set for antibiotic use (benchmark values). Broiler farmers must draw up a supplementary farm health plan if use on their farm is too high. There are also strict rules for selecting the type of antibiotics (first, second and third choice medications).

Use of antimicrobial agents in the first week of life



Example of a flowchart indicating whether you can use antibiotics in the first week of life (the Netherlands). In view of withdrawal periods, antibiotics are only used after the first week of life in very rare cases. Exclusively when animals are very ill and animal welfare is at risk, antibiotics can be prescribed but with the risk that the birds will have to be slaughtered at a later date.

Choice of antibiotic type



Example of a flowchart showing the agent you can use for a bacterial infection. There is a distinction made between different categories of antibiotics. Using 3rd choice agents should be avoided as much as possible, in view of resistance development.

Food safety

In addition to the good quality of the chicken meat itself, there is also a lot of attention on food safety. Chicken meat must be safe for consumers. Food safety can be divided into three aspects:

- chemical food safety (free of toxins, residues, Fipronil, Nicarbazin)
- microbial food safety (free from Salmonella, Campylobacter, Listeria, E-coli)
- physical food safety (free from bones, metal, glass, etc.)

Chemical food safety

Residues are remnants of chemical substances (in original form, or after conversion). There is a difference between the various types of residues that can occur in chicken meat:

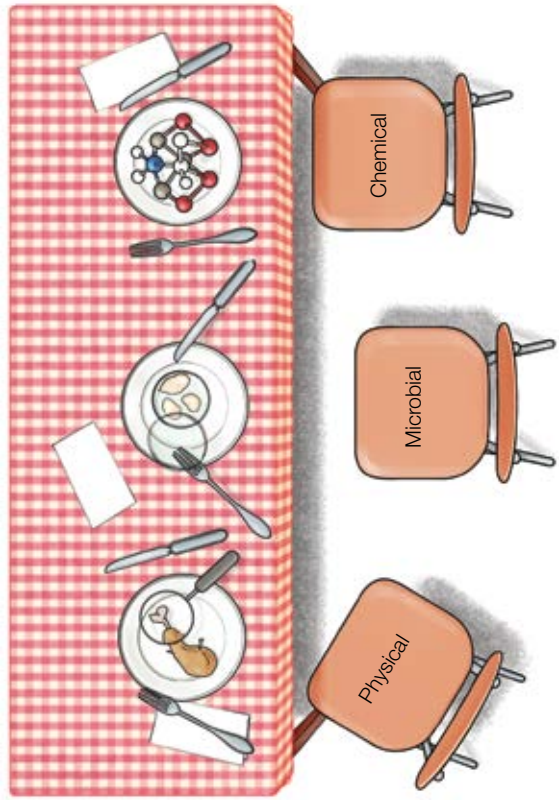
- Medications – medicines that can affect human health.
- Toxins – harmful toxins. Examples include pesticides, fungal toxins in the feed (aflatoxins), heavy metals, poisonous gases (ammonia, carbon monoxide), cleaning and disinfecting agents (e.g. formalin). The responsibility to prevent the presence of these substances in meat lies mainly with the poultry farming sector.
- Contaminants – substances that can get into or among foodstuffs (contamination) unintentionally. They might be substances that remain in the soil or groundwater for years. Examples of those include nitrates, nitrites, PCBs, lindane and DDT. Farmers are not usually liable for contaminants.

Microbial food safety

In addition to sampling in the slaughterhouse, many countries have programmes and legislation to reduce microbial contamination. In addition to that, proper meat storage is essential for restricting growth of harmful bacteria after slaughter.

Physical food safety

In slaughterhouses, in particular, there are many checks to ensure that no foreign objects are included in the meat. There are, for example, metal detectors and x-rays to detect pieces of bone and any foreign materials at various locations in a slaughterhouse.



Importance of HACCP

The industry is working hard on meat quality and consumer confidence. In many countries the broiler sector is strictly regulated through all the links in the production chain to guarantee quality. This is safeguarded through quality systems and risks are identified using HACCP (Hazard Analysis Critical Control Points).

Observe withdrawal periods properly

The maximum permissible concentration of each substance in the meat and edible organs is known as the MRL (maximum residue limit). There are set waiting periods for medicines. A withdrawal period is the amount of time between the last administration of the product and the moment that the residual value can be expected to have fallen below the MRL. Monthly testing for presence of residues in meat is carried out by the regulatory authorities. Positives are very rare.

CHAPTER 3:

The broiler farm

The basis for achieving good meat quality lies with the poultry farmer. The slaughterhouse does everything to preserve this quality, but cannot improve the basic quality of the supplied birds. Today's broilers grow almost three times faster than those of the nineteen-fifties. The weights of the heart and organs have not developed proportionately, which makes a modern broiler's body very vulnerable. It is only possible to produce quality meat with optimal management.

A typical broiler disorder from the past

Some of the previously common disorders in broilers have been bred out of today's varieties. TD (tibial dyschondroplasia) is a good example. This condition occurred in broilers from 3 to 5 weeks and caused stiffness, difficulty walking, thickened and painful knee joints, high feed conversion and increased mortalities. However, TD seems to be arising more often during the last few years.

The quality of chicken meat is strongly influenced by the broiler breeders. That is through genetics but there are many more influencing factors. For example, a chick gets maternal immunity in the egg yolk, so that it is already protected against diseases at a young age. The future broiler receives the right nutrients from the yolk and the albumen.

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Fast-growing varieties

The most commonly used varieties globally are fast growers. These are bred for high proportion of breast meat, good appetite and efficient feed conversion, as well as a high growth rate. Living conditions must be optimal to express their genetic potential.

Image courtesy of Cobb

Cobb 500.
Slaughter age 35-50 days.

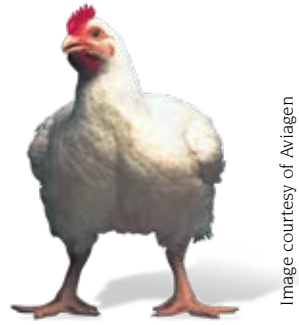


Image courtesy of Aviagen

Ross 308.
Slaughter age 35-50 days.

Slow-growing varieties

A slow-growing variety is more robust – It grows slower and is kept longer (often up to 56 days or longer). This allows the body and organs to handle the growth better. Here are some examples of robust varieties:

Image courtesy of Hubbard

The Hubbard strains are popular for slower growth, free range, and organic farming systems.

Image courtesy of Aviagen

Rowan Ranger –
Minimum slaughter age 63 days.

Image courtesy of Cobb

CobbSasso –
Minimum slaughter age 91 days.

Poulet de Bresse (France) is an age-old protected breed in France – Minimum slaughter age 85 days. Their blue legs are very characteristic.

Image courtesy of Hubbard

The French Label Rouge with a minimum slaughter age between 81 and 110 days.

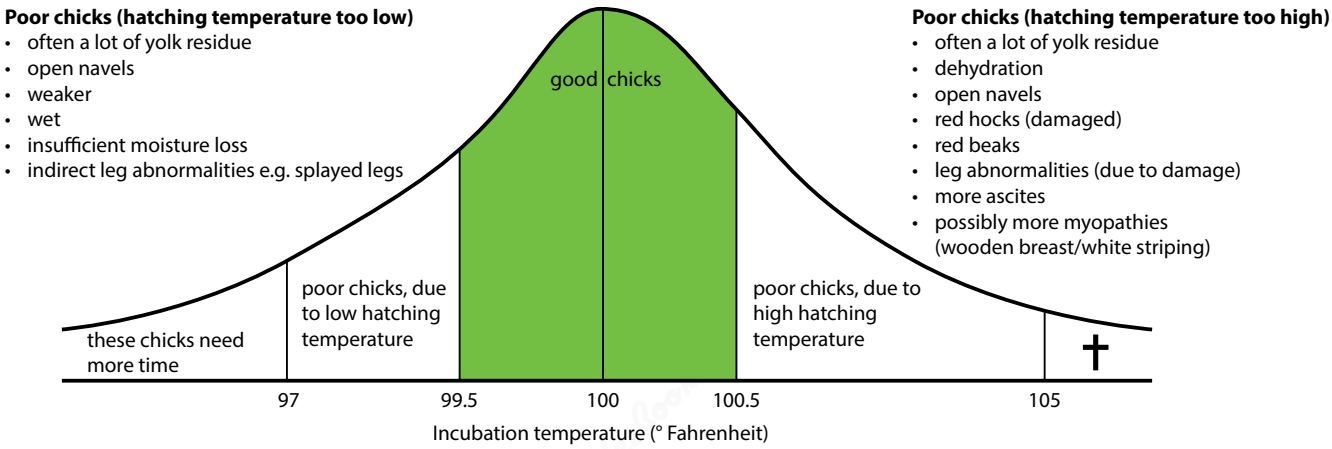
Cockerels from laying breeds

Naturally, laying breed cockerels do not lay eggs. Because the killing of male day-old chicks is not acceptable for many people, there are initiatives to rear them for slaughter at a weight of 1.7 kg. These cockerels reach that weight at an age of 15 to 17 weeks. The body proportions of these animals are completely different, and that requires many modifications in the slaughterhouse. Rearing laying hens requires a relatively large amount of feed (inefficient feed conversion) and is therefore unfavourable for the environment in terms of the water usage and CO_2 footprint.

Hatching requires expertise

Hatchery conditions reflect immediately in chick quality. Where previously the goal was often to attain a high hatchability, chick quality is now increasingly the focus. This has direct importance for meat quality. A lower hatchability will not directly affect meat quality but weak day-old chicks will. An evenly developed, healthy chick is essential for a good start and to ensure the birds' growth progresses well.

Preferably, eggs should not be older than one week for good hatching results. The older the hatching eggs, the lower the chick quality. Air circulation in the incubator is highly important for evenly distributing heat and oxygen and for discharging CO_2. The incubation climate is not easy to manage. For example, there are differences in egg sizes (large and small are mixed). The greater the size difference, the higher the risk that part of the eggs will be too hot or too cold for hatching.



The influence of incubation temperature on chick quality

Incubation temperature	Signal
Too hot	The chicks' hearts are up to 40% smaller. This is a cause of ascites (waterbelly). There is also high embryo mortality, as well as deformities (crooked toes, short legs, and leg position defects), sticky down and smaller chicks.
Too cold	The chicks hatch later. Many embryos will die off and there are many malformations because their organs develop irregularly. Numerous chicks can have navel inflammation
Too dry (low RH)	The chicks are weaker, smaller and paler, with a high mortality rate in the first days of life
Too humid (high RH)	Poor hatching with weakened embryos that have a sticky mass around their beaks. The chicks will be small with swollen, stretched bellies and poorly closed navels

Letting clutches from different days hatch at the same time

Long storage time is detrimental to hatching results and chick quality. Temporarily heating hatching eggs during the storage period reduces the adverse effect of a longer storage time. This imitates the chicken's natural behaviour. The chicken lays an egg every day in the nest, occasionally sitting on the eggs (warming) and other times she stays off them (cooling). Eventually all the eggs hatch at the same time.

Hatching egg, hatching process and the first 10 days

The chicks do not all hatch at the same time. There can be as much as thirty to fifty hours' difference in outcome, so there is variation from the start. Then the chicks have to undergo a whole series of operations after hatching, e.g. being counted, vaccinated and transported. The incubation and hatching period and the first ten days of life are most important for proper body and immune system development. Remember that the hatching period and the first week after hatching combined are half of a broiler's total lifespan! A well-developed chick will be more robust and resilient later in life. It is more likely to recover from infections and will grow faster. Ultimately, that is beneficial for the meat quality.

Chicks that have feed, water and light immediately in the hatchery have better feed conversion and a lower mortality rate. Uniformity is often better and that is important for the eventual meat quality. On top, a system where chicks hatch in the poultry house and, below, one where newly hatched chicks get feed immediately.

Abnormalities that indicate hatching problems

sticky chicks

dehydrated chicks

chicks with open navels

swollen bellies with hard yolk residues

small, pale, underdeveloped chicks

weak chicks

Litter and meat quality

Most broilers are kept in floor systems with litter. Litter can become damp and cause litter spots, hock burn and footpad dermatitis. Poor litter quality means penetration of ammonia, acid and moisture combined with heat. Prevent the broilers from getting digestive disorders as wet droppings increase the risk of poor litter quality. Too little litter means a hard surface which may lead to breast blisters. Peat is the best litter material in this context.

Straw as litter

Straw absorbs little moisture. So the litter stays moist. Coccidiosis and bacterial infections can develop more quickly under these wet conditions. Fermentation in the litter can also lead to litter spots, ammonia burn and footpad dermatitis.

Good litter is loose (> 60 % dry-matter content) and will have less tendency to cause footpad softening and irritation. Poor litter has less than 40 % dry matter. Wet litter becomes mushy. Adding fresh straw has no real use here, a covering of long-stemmed straw will only make a kind of carpet on the mushy litter at best. Clear away spots with wet caked droppings and apply new litter to those areas.

Comparison between types of litter

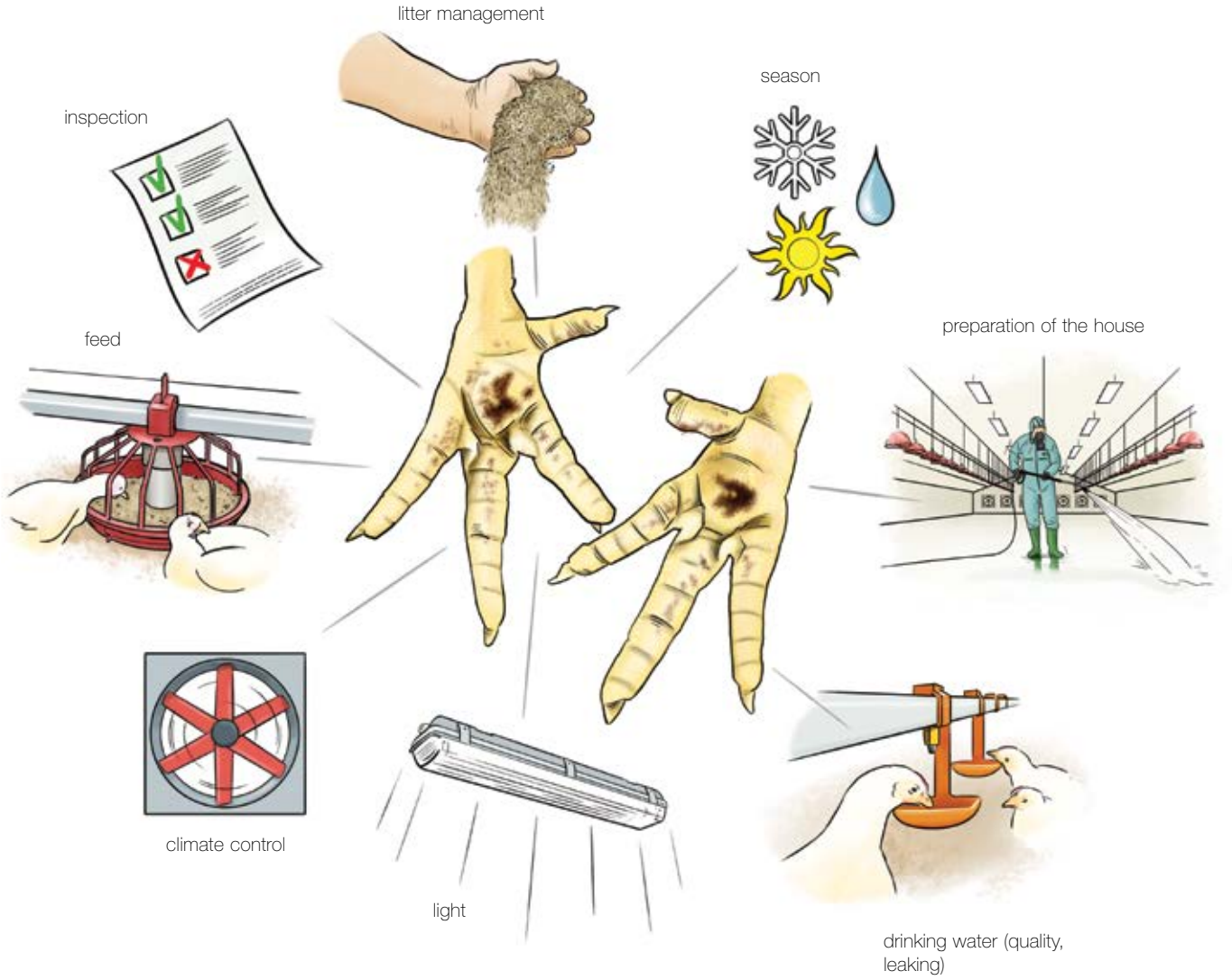
					
Sawdust	Wheat straw	Wood shavings	Chopped flax	Sunflower husks	Peat moss
Moisture absorption capacity: +++	Moisture absorption capacity: ++	Moisture absorption capacity: ++	Moisture absorption capacity: +	Moisture absorption capacity: -	Moisture absorption capacity: +++

Occurrence of footpad dermatitis

Footpad disorders are a clear signal of poor litter quality. If you are seeing numerous cases of footpad dermatitis, pay extra attention to the litter quality (i.e. management and choice of raw materials) during the following rounds.

This broiler is filthy. Check the litter quality and if the quality leaves something to be desired, look into the cause!

Factors influencing footpad dermatitis



There are many factors that play a role in footpad dermatitis prevention.

Footpad dermatitis

The score determines regulatory consequences for the poultry farmer:

$$\frac{\text{(\# broilers score 1 x 0.5) + (\# broilers score 2 x 2)}}{\text{Total \# scored broilers}} \text{ x 100}$$

Over a period of twelve months (calendar year) the average score is determined and assessed with consequences as follows:

Score (NL)	Score (Sweden)	Conclusion
< 80	< 40	OK
80-120	40-80	Warning!
> 120	> 80	urgent preventive action or stocking density reduction

Assessing footpads

A camera can be used as a tool for scoring footpads for tissue damage and haematomas in the slaughterhouse. But the inspection is most often done by skilled employees. The final score may have consequences for the payment but that is far from being the case in all slaughterhouses. This score can also have consequences for the stocking density that the poultry farmer is allowed to maintain on his farm. The average scores of several flocks, often six or seven, over an entire calendar year are taken into account.

Footpad dermatitis scorecard for broilers

Class 0

Smooth, no lesions

Small discoloration

Almost healed lesions (scars)

Class 0 - No lesions – no lesions or very small and superficial ones, slight discoloration on a limited area, mild hyperkeratosis, scars (possibly old).
Only the footpad should be evaluated.

Class 1

Superficial lesions and discoloration

Dark papillae and no ulceration

Substantial discoloration

Class 1 - Mild lesions – Substantial discoloration of the footpad, superficial lesions, dark papillae.
Damage restricted to the epidermis.
Only the footpad should be evaluated.

Class 2

Dark papillae and an infection

Ulcer covered with scab

Abscess/bumble foot and swelling

Class 2 - Severe lesions – Ulcers or scabs of significant size, signs of or actual bleeding, or severely swollen footpads. Damage of deeper skin layers.
Only the footpad should be evaluated.

Source: Livestock Research, Wageningen UR.

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Occurrence of hock burn

In cases of hock burn you see a black-brown discoloration of the epidermis around the hock. This condition occurs after prolonged contact with moisture and ammonia in poor quality litter (ammonia burn). Birds with leg problems will sit on their hocks more often and get increased numbers of problems with hock burn. In addition to the effect on animal welfare, this results in a slight depreciation in the value of legs in the slaughterhouse. In Germany there is a monitoring system for hock burn. In the Netherlands, monitoring is only done on request from the poultry farmer. This is possible both in the slaughterhouse and with the live animals in the house.

You can recognize hock burn by a black-brown discoloration of the epidermis/scales on the back of the hock. This usually means a reduction in the farmer's payment from slaughterhouse.

LOOK-THINK-ACT

Why is this not a good signal?

If broilers sit on their hocks a lot, they have excessive contact with the litter. If the litter quality is poor, they will develop hock burn.

Types of skin damage caused by poor litter

Breast blisters are vesicles of inflammatory exudate on the breast surface, due to hard flooring, metal grids or lameness in heavy breast birds.

Ammonia burns are caused by the action of ammonia in feather follicles. They look like pustules.

Litter spots are the result of wet and sticky litter. Black scabs develop in the epidermis.

Occurrence of skin lesions

Nail scratches (scabby hips) are stripe-shaped lesions of the epidermis and sometimes throughout the skin, with open wounds. Eventually they can also cause an epidermal inflammation (dermatitis), or a subcutaneous inflammation (cellulitis). The scratches are caused by other birds in the flock climbing over each other. Sharp toenails, poor plumage and thinner skin play an important role here. Broilers with skin lesions usually have poor mobility due to leg problems, such as inflamed joints. Risk factors include an unhygienic house that is too wet, excessive stocking density, too few feed pans, excessively long dark periods and rushing around in the house when checking or dispatching birds. Stress is the central factor. Skin lesions always occur in the same place and are therefore easily recognizable. Even if the nail scratch is healed, the skin remains weak locally, which can lead to a new tear during plucking.

Spray vaccination is another cause of unrest and can lead to broilers climbing over each other. You can see clearly that the birds avoid the device.

Nail scratches occur less easily if the broilers have good plumage. Broilers that are less mobile due to inflamed footpads are more likely to suffer skin lesions from birds that climb over them.

This broiler has skin scratches that have already formed a scab. These are three to five days old, so the injury probably occurred during thinning (interim depletion of part of the flock). This broiler's carcass will be rejected.

Sharp nails give the worst skin scratches. You will find the most problems with sharp nails on dry litter.

Wet litter forms clumps more easily around the nails and acts as a protector on the sharp points.

Skin inflammation and subcutaneous inflammations

Inflammation of the epidermis (dermatitis) and subcutaneous inflammations (cellulitis) can occur in broilers. Cases of epidermal inflammation involve inflamed, discoloured and swollen skin. With subcutaneous inflammation, you see necrotic (dead) tissue with bacterial infections. You can recognize this by the white-yellow, caked pus layer. We also call this cellulitis.

Causes of skin inflammations

Subcutaneous inflammations (cellulitis) are often caused by small wounds around week 3, which close again but can continue to proliferate beneath the skin. Injuries that arise during the third week in the house have various causes:

- Injuries occur more often with weak and delicate young skin (it only becomes tougher later in life).
- Sharp toenails cause wounds, especially with dry litter.
- During vaccinations, animals panic and crawl over each other.
- Broilers also crawl over each other after a period without feed (when starting up a feed restriction or withdrawal schedule ready for a vaccination in drinking water).
- Broilers undergo a sharp increase in weight gain at around three weeks of age. The changing house climate (more humid) favours pathogens that can cause skin inflammations.
- At around three weeks the birds appear bald and minimally feathered, because they change their down feathers to the final plumage. So they are more injury sensitive.
- A fairly high house temperature will slow down the plumage changing process. The birds remain bald and unprotected for quite a long time.

Thermostable toxins

Some bacteria that play a role in skin inflammation can also cause food poisoning in humans. At the site of inflammation, the bacteria produce toxins that are heat-resistant (thermostable), i.e. that cannot be made harmless by heating. After consumption, an immune response occurs very quickly in people, producing nausea, vomiting and diarrhoea. This is real food poisoning and not a food-borne infection (as is the case with Salmonella or Campylobacter).

Dermatitis – inflammation of the epidermis. You see a swelling of the skin (dermis) combined with inflammation and yellow discoloration.

Cellulitis – subcutaneous inflammation is a serious, chronic tissue-decaying inflammation under the skin, on the abdominal area in particular. Usually it is extensive and combined with a bacterial infection. It is best to reject the entire carcass including the internal organs.

Assessing skin inflammations

Normal skin is intact, smooth and pale pink, with normal thickness and elasticity. You can minimize skin inflammations through ensuring good hygiene, proper stocking density and good plumage. In North European countries, moisture and heat in the house increase the risk of skin damage. This is also dependent on the time of year.
Local, dark, blackish-brown discoloration on the skin surface is mainly found on the breast skin (litter spot) and on the hock joint (ammonia or hock burn). These dark scabs are not removed during scalding and plucking, because there is tissue damage in the upper layer of the skin (epidermis). Hock burn has less economic importance, because the hock, lower leg and the feet are usually a waste product. This depends on the cut made: hock-off or hock-on. A hock burn score is often a criterion used for animal welfare assessment, in relation to leg strength and stocking density.

Usually you find skin inflammations on the skin of a broiler's back and it may resemble eczema. Sometimes the lesion has a honeycomb texture. In cases of little tissue damage (< 5 cm in diameter), it is trimmed off. But the entire carcass has to be rejected if there is significant skin inflammation.

Mild litter spots.

Serious litter spots.

Mild hock burn.

Serious hock burn

Mesh floor systems

Husbandry systems with mesh floors are permitted in some countries. The mesh can be metal or plastic and the system sometimes comprises multiple levels. Mesh systems and battery cages are banned in the EU. In the context of meat quality, flexible plastic mesh floors are preferable to rigid metal ones. Flexible mesh adapts to the weight, size and shape of the broilers and provides the right support for the breast and legs. This type of floor's good droppings permeability and hygienic conditions prevent footpad dermatitis.

Cage housing is not allowed in the EU. In Russia, for example, they are still used in a layout with four levels above each other and a conveyor belt. If transport is well organized, there are fewer broken legs due to loading. However, in many cases legs/wings frequently get stuck, which actually causes more fractures.

Multi-tier systems are mainly used in China and Russia. There are fewer problems with litter spots, breast blisters and ammonia burn in them.

Differences between multi-tier and grid systems

Multi-tier system characteristics	Mesh floor system characteristics
• Lower construction, land and infrastructure costs per bird through higher stocking density. • Dispatch can be semi-automatic. • Lower energy costs due to less house volume per broiler that requires heating or cooling. • Lower feed conversion.	• Less illness and less medication use because the broilers have no contact with droppings (faeces). • Less litter spots and footpad disorders due to the fact that the birds have no contact with moist, warm litter and droppings. • Optimal ventilation among the animals. • Lower feed conversion.
	
Points of attention	**Points of attention**
• Make sure there is good vertical temperature uniformity. • Provide good lighting on all floors.	• Metal mesh causes more breast blisters on the pressure points. • Plastic mesh provides optimal support. • Beware of dirt accumulation during material transitions. • Mesh size is important!! • Pay attention to heat stress.

Husbandry concepts

In addition to conventional farming systems, there are also concepts with more emphasis on animal welfare, meat quality, nutrition, the environment and social acceptance.

Separate fattening

Male broilers have better feed conversion and growth than females which can be taken advantage of. Fattening hens and cocks separately results in more uniformity within each of these groups. You can rear your male broilers to a heavier final weight, because hens have a tendency to deposit fat. But sexing costs time and money and is therefore only justified if separate fattening really yields a profit. In practice, separate fattening is not very common. The main reason is that flocks are slaughtered so young that weight differences between cockerels and hens are still minimal.

Older slaughter age

In the Label Rouge concept, the slaughter age is between 81 and 110 days. These broilers are often sold as whole chickens, with head and legs intact. To keep the neck intact the broilers are traditionally killed by bleeding from the mouth. These chickens are kept in well-lit houses with natural lighting. The area per house may be up to 400 m^2, with a maximum of 11 chickens per m^2. A poultry farm using this concept may not have more than four houses. The broilers are kept indoors for the first three weeks. As soon as they have their plumage, they have access to an outdoor run with grass and/or shade, and at least two m^2 per animal. There is no antibiotic use.

Covered run

Sufficient movement and fresh air (little dust and ammonia) leads to better health and better welfare. To that end, broiler farms can provide broilers from 21 to 28 days of age access to an enclosed and covered run, also called a 'Winter garden' or 'cold free range area'. The floor of the run must be easy to clean. Covered runs for broilers are mandatory in some countries, such as in Switzerland. The chance of contracting diseases from wild birds is much less than with free-range birds on pasture. And there is reduced risk of parasitic, Salmonella or Campylobacter infections.

Levels

Broilers that are sufficiently active are expected to have a different muscle composition and stronger bones than chickens that only move very little. This is good for their health and welfare, and it improves slaughter quality. A disadvantage is that a lot of movement in litter produces more dust and jumping with a high body weight can lead to bone damage. Applying perches or straw bales at different levels in the house offers one solution for this.

Nutrition and meat quality

The genetic potential of a broiler can only be fully exploited with optimal feed composition. Due to the rapid growth and increasing feed intake per day, the metabolism of the broiler is very sensitive and goes out of balance easily. Contemporary broilers are close to the limits of physiological possibility. The body mass is increasing – more breast muscles and thicker bones, but the area of intestinal surface has remained almost the same. The ratio between muscle bone mass and the surface area of intestinal wall has therefore become wider, leaving nutrient absorption capacity falling behind. Intestinal health is an important limiting factor. A healthy digestive system ensures better feed uptake and provides a barrier against harmful substances.

Structure

Feed particles are finer in pellets than in meal, and they are compressed compactly for better intake. In the crop, the particles separate quickly and form a slurry of fine feed particles, which then go on to the stomach. This fine wet mash leaves the stomach faster than natural feeds, meaning there is more undigested feed in the last part of the intestines. This increases the risk of bacterial overgrowth, a disturbed bacterial balance in the intestines, wetter droppings and more footpad dermatitis due to wet litter. The solutions are adding fibre to the pellets or opting for slower-growing broilers. That will lead to slightly worse feed conversion but the gastrointestinal system will develop better.

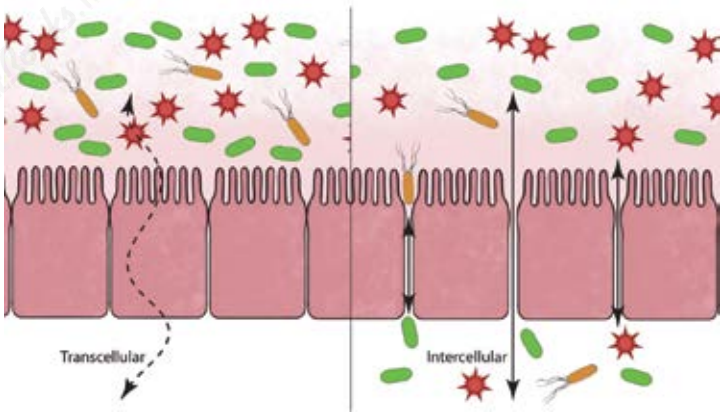
Feed particles are generally coarser in meal than they are in pellets. This prevents the feed from passing through the gastrointestinal tract too quickly.

LOOK-THINK-ACT

What do you see on this feathering?

In the cases of normal plumage in well-growing birds without intestinal problems, you will see good conformation through the plumage after a few weeks (left). If the plumage remains too dense (closed), it often turns out to be a lighter bird (right). This is often associated with intestinal health, that may be compromised due to a wide range of reasons.

Broiler droppings can be greasy and look like diarrhoea. This is due to a high energy content of the feed caused by adding fats and oils. You can often achieve better feed efficiency by adding enzymes. But remember that a broiler also needs crude fibre for good intestinal health.



In cases of leaky gut, bacteria and toxins from the intestinal tract enter the body between the intestinal wall cells. They spread through the body via the bloodstream.

The liver on the left is normal. The one on the right is fatty – it has pale, brittle tissue that crumbles easily.

Poor blood vessels due to oxidative stress can cause spot haematomas.

Leaky gut

If intestinal health is less than optimal, the intestinal wall becomes more permeable. This phenomenon is called 'leaky gut'. It occurs because the cells of the intestinal wall (enterocytes) are no longer packed tightly together and do not form a well-sealed barrier any more. This occurs under different types of stress, including heat stress, free radicals and toxins. Also after death there is a penetration of bacteria through the intestinal mucosa to the blood. Normally, cells in the intestinal wall absorb nutrients, sometimes already processed, after which they are absorbed into the blood and lymph tracts and are transported firstly to the liver. In cases of leaky gut, toxins and intestinal bacteria also enter the body through the intercellular spaces and cause an inflammatory response in that location or further into the body. This will negatively affect the carcass quality.

Oxidative stress

Normal metabolic processes in the body produce short-lived free radicals, which can be harmful. These free radicals are rendered harmless by antioxidants in the body, so that there is no damage to body cells. A ration with a lot of energy and high fat and cholesterol content (HFHC: high fat, high calories) causes a lot of pressure on the metabolism (oxidative stress). The balance between the free radicals and the antioxidants in the body is disrupted. The consequence of chronic or prolonged metabolic stress, can be fatty liver, vascular fragility or even sudden death. In humans, diabetes is a common consequence. This facilitates the formation of haematomas and bruises in legs, wings, and amplifying electrical stunning issues, such as blood splash in the internal side of thighs or breast.
It could be compared with humans only eating junk food and drinking soda.

Prevent contamination

On the poultry farm, there is a risk of meat becoming contaminated with substances that pose a risk to public health. This is mostly easy to avoid preventing rejection of the entire flock or a direct penalty, fines or reputation damage for the sector. In 2017, the Dutch and Belgian laying sector suffered the consequences of using the prohibited anti-lice agent Fipronil with a scandal that lasted for months. Possible contaminants/residues include:

- mycotoxins (fungal toxins) in feed
- medications
- chemical substances

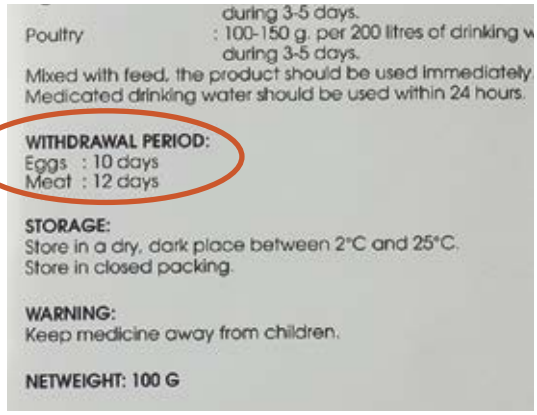
Not all contaminants are equally likely to occur but you must make a risk assessment for each farm to prevent residues in the meat.

Fungal toxins

Moulds in the feed can produce toxins (mycotoxins, such as aflatoxin), both during cultivation of the raw materials and during storage. Broilers that absorb them will grow slower and become weaker due to compromised immunity. Aflatoxin is a known carcinogen, so never give broilers mouldy feed.

Medications

You can prevent medication residues in the meat (e.g. coccidiostats, antibiotics or chemotherapeutic agents) by observing the proper withdrawal period. The withdrawal period is shown clearly on the label. You always have to record medication use to prevent errors; it is a legal requirement in most countries.


during 3-5 days.
Poultry : 100-150 g. per 200 litres of drinking w
during 3-5 days.
Mixed with feed, the product should be used immediately
Medicated drinking water should be used within 24 hours.

WITHDRAWAL PERIOD:
Eggs : 10 days
Meat : 12 days

STORAGE:
Store in a dry, dark place between 2°C and 25°C.
Store in closed packing.

WARNING:
Keep medicine away from children.

NETWEIGHT: 100 G

Always take the withdrawal period into account before administering medicines.

Chemical contamination

Dioxins are formed mainly during burning plastics but they also occur in certain types of clay, e.g. kaolinite. Dioxins are bad for the immune system, brain development and reproduction, and higher doses can lead to cancer. Dioxins break down poorly and they accumulate in body fat, which means that they can also occur in meat.

PCBs have comparable toxic properties. Applications of PCBs include insulation liquids, hydraulic and cooling fluids, lubricants, and as a fire retardant and stabilizer in plastics. PCBs are not used any more but their poor degradability means that there are still a lot in the natural environment (in substrate and silt). Dioxins and PCBs can accumulate in broiler meat through feed and through absorption from soil, so there is a particular risk for animals with outdoor runs on contaminated soil.

Take the following measures to prevent the broilers absorbing any:

- In cases of contamination, remove the soil in the run and replace it with clean sand or soil. Lay paving or a concrete floor.
- Feed the broilers from a feed tray. Do not scatter any feed in the outdoor run.
- Remove any re-used building waste, material from old incinerators or ash from the run.
- PCBs can also originate from old paint, insulation sealants or roof coatings that might leach out with rain. Fit rainwater gutters and remove and replace old paint layers from the house and run.

Do not give mouldy feed to broilers. This is not only bad for the broilers' health; it can also present a risk to public health.

Campylobacter

Campylobacter is a common inhabitant of a chicken's intestine. It can be found in the last part of the small intestine (*Campylobacter jejuni*) or in the large intestine (*Campylobacter coli*). Campylobacter is very rare in the muscles of the living animal. In the EU, these bacteria are the most important causes of human gastrointestinal tract infections. Eating insufficiently heated or unhygienically prepared poultry meat can cause gastrointestinal infections in humans. Campylobacter can be very dangerous, especially for babies, children, and people with immunity disorders, the sick and the elderly. That is why Campylobacter sampling is compulsory in many countries. Campylobacter control programmes focus on avoiding carcass and meat contamination with digestive tract content (from crop or faeces). Campylobacter occurs more frequently in organic and free-range broilers than in conventional broiler husbandry. A vaccine against Campylobacter is under development but currently still not available.

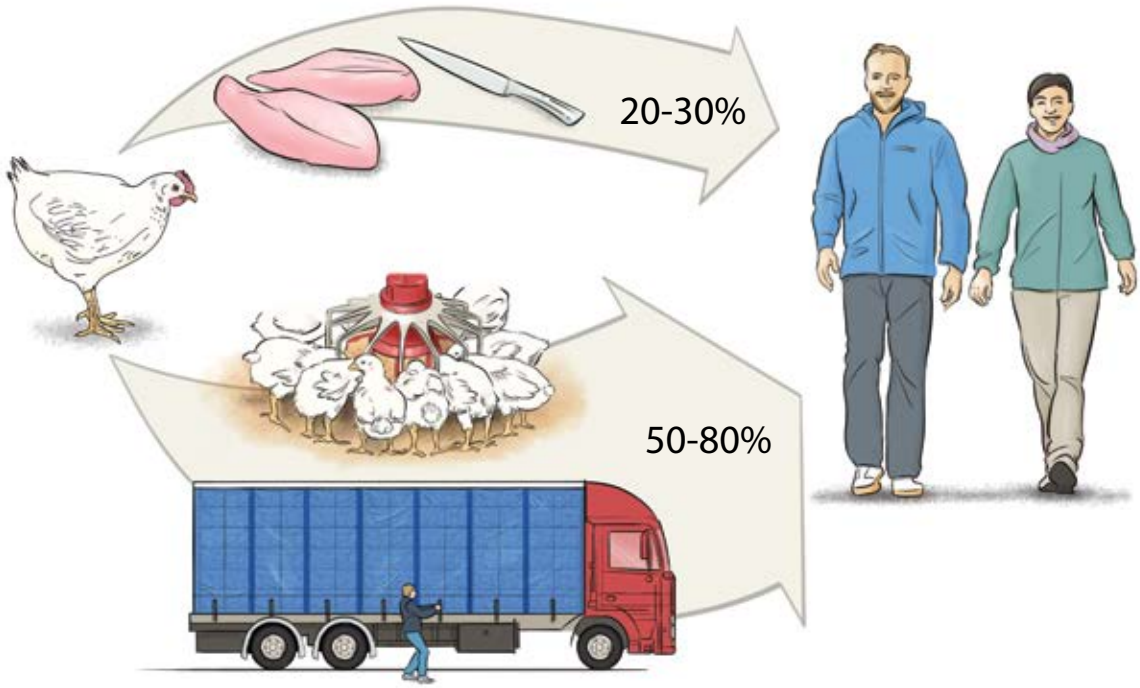
The Campylobacter bacterium is the main cause of food-borne infections in humans from poultry meat (zoonosis). This is because it is difficult to detect:

- Broilers almost never get sick from Campylobacter infections.
- The bacterium is difficult to grow in a laboratory culture. It takes time and often gives false results.
- Campylobacter in birds is difficult to demonstrate at broiler house level.

A complication is that a house can remain Campylobacter-negative for weeks but the percentage of infected broilers rises rapidly from 0 to 100% after infection. Sampling in a slaughterhouse is a routine procedure. In spite of this, it remains difficult to reduce the problem, despite official programmes for preventing and combating Campylobacter.

There are three risk periods for a Campylobacter contamination in the production chain:

- during broiler husbandry
- during transport and prior to slaughter
- during slaughter and processing



The source of Campylobacter infections in 20-30% of cases is through poultry meat processing or consumption, and 50-80% by other routes through the poultry! In 2016 almost half of the broiler flocks in the Netherlands were infected with Campylobacter.

Anti Campylobacter measures

Campylobacter can be controlled in various ways:

- biosecurity
- cleaning and decontamination
- fly screens
- no thinning
- low slaughter age

If a flock is already infected, this flock will be slaughtered logistically in the slaughterhouse (i.e. at the end of the day as the last batch). The production process should be improved to prevent recurrence, but the meat is allowed to be sold fresh (process hygiene criterion).

Biosecurity

Biosecurity is of great importance in all links of the production chain. Proper house cleaning between flocks is an important precaution to reduce the number of bacteria, as is maintaining good personal hygiene. Delivering clean, dry chickens to the slaughterhouse already has a significant effect on the numbers of Campylobacter bacteria on the outside of live chickens. This is directly related to the presence of Campylobacter in the final meat product.

Vermin (flies, rats, mice, beetles)

There are fly larvae on poultry farms, and broilers eat them. As these flies are often carriers of the Campylobacter bacteria, the broilers become infected. This also applies to other carriers (vectors), such as mice and beetles. The bacteria multiply in the intestines and then other broilers pick up the infection through the droppings. It infects all the birds in the house in no time. So fly control is very important on broiler farms. Use fly nets or windbreak mesh to prevent them. And pay special attention to the doors, because they are always a weak point.

The most important measure in combating Campylobacter is proper disinfection to ensure that the bacterium does not enter the farm.

Depopulation

Thinning, e.g. at five weeks, presents a risk. Transport crates or containers and loading crews with materials come onto the farm and into the house. This presents a risk of Campylobacter being introduced and spread within the farm. So hygiene measures are even more important than usual for loading teams and their equipment (clean clothing, clean containers). Make sure you have good protocols and provisions in place, and that you stick to them.

Slaughter age

Flocks of slow-growing broilers and ones with an outdoor run are especially at risk of infection. This is also the reason that there is more frequent incidence of Campylobacter in organic broiler chickens.

Feed withdrawal

A sufficiently long period of feed withdrawal has no part to play in Campylobacter prevention but it has influence on it spreading. If the digestive tract is too full, faeces may end up on the carcass during slaughter and cause contamination. The neck skin offers the best opportunity for detecting Campylobacter because the head is the lowest point on the slaughter line, which makes it very suitable for sample monitoring. If the feed withdrawal is too long, the digestive tract will become weakened and will be more likely to break and contaminate the carcass during processing.

ESBLs

Various bacteria are resistant to certain antibiotics. These bacteria make the enzyme ESBL (Extended Spectrum Beta-Lactamase) that can break antibiotics down and make them ineffective. Bacteria that can produce ESBLs are becoming more common, and they are making infections by those bacteria more difficult to treat in animals and humans. The ability to produce ESBLs is transferable between bacteria. Also from bacteria in animals to bacteria in humans, which means they also pose a threat to public health. The ability of ESBL bacteria to survive antibiotic treatment and multiply faster compared to non-ESBL bacteria makes the problem even worse. Reducing antibiotic use also reduces the ESBL problem, so using the lowest possible amount of antibiotics is very important.

Salmonella

Salmonella bacteria can cause intestinal infections in humans from eating chicken meat. The infection in the chicken usually comes through an oral route (by the beak), i.e. the birds picking up infected material (dust, droppings, feed). The most important sources of infection are humans, vermin (with mice at number 1, but also cats, dogs, darkling/litter beetles or red mites), feed (heating during pelleting is effective here) and dirty material, such as tools, crates or containers. In addition, Salmonella can spread over short distances with dust.
Normally, only a small percentage of birds in a flock are infected (for the long term). Most types of Salmonella only occur in the intestines and therefore in droppings from infected birds. Some types, *Salmonella enteritidis* (SE) and *Salmonella typhimurium* (ST), can penetrate the body through the intestinal wall and then infect internal organs such as the ovary, so that they end up in the eggs. Liver and joint inflammation can also occur. The meat of flocks that are Salmonella-positive should be heated before offering it to consumers (food safety criterion). Salmonella-positive flocks will be slaughtered at the end of the day (logistic slaughtering).

Good biosecurity is a first step towards reducing Salmonella, and it does not have to be complicated at all.

The following requirements apply in the EU:

- Fresh poultry meat must be free from SE and ST
- Poultry minced meat and meat preparations (e.g. pre-seasoned) must be free of any Salmonella species which may cause food-borne infection in humans.
- Poultry meat products and mechanically separated meat (e.g. ready to eat) must be free of all five important pathogenic types of Salmonella.

Types of Salmonella

There are more than 2,700 known Salmonella species. Poultry is sensitive to about 120 Salmonella species. These are the most important pathogenic types for chickens:

- *Salmonella enteritidis*
- *Salmonella typhimurium*
- *Salmonella Hadar*
- *Salmonella Infantis*
- *Salmonella Virchov*

Salmonella enteritidis (SE) and *Salmonella typhimurium* (ST) are the most important. These are not host specific and they can infect people. Both these types can be present already in a hatching egg (vertical transfer). Two Salmonella types that were highly contagious to chickens, *Salmonella pullorum* and *Salmonella gallinarum*, were virtually eliminated decades ago.

Make sure that there is enough farm footwear for visitors or at least a supply of overshoes.

Monitoring Salmonella

There are monitoring programmes drawn up for contagious animal diseases. As Salmonella can be transferred from parent animals to chicks, monitoring is implemented throughout the chain, i.e. in breeding animals, parent animals, the hatchery and the broilers. In addition, the follow-up is monitored during transport to and in the slaughterhouse. In the EU, up to 1% of broilers may be infected with SE or ST annually.

A number of samples are taken on Dutch broiler farms:

- On arrival of day-old chicks, samples are taken from pieces of 40 delivery box inlay sheets from each truck or trailer (input check).
- Maximum of 21 days before slaughter, house samples are taken using overshoes. The laboratory examination results must be made known at least 24 hours before the planned slaughter (output monitoring).
- There is random sampling at 10% of the farms with more than 5,000 broilers (EU-regulation).

In the slaughterhouse, another sample is taken of the cecum in the context of monitoring for Salmonella and Campylobacter.

Sampling in the broiler pens

Salmonella is excreted in the faeces. So special overshoes are used to walk through the house to collect samples for testing.

1. *Make sure that there is no contamination from outside; wash, disinfect and dry your hands thoroughly. Then put on gloves.*

2. *Put on the overshoes. Don't forget to disinfect your boots before you put them on.*

3. *Walk through the house, wearing the overshoes.*

4. *Take them off and put them in a clean and sealable plastic bag that you can send for testing.*

CHAPTER 4:

Loading and transport

Catching and transporting cause stress because the broilers are moved into a new environment and a different climate. They lack water and feed, and could become dehydrated. They are also subject to vibrations, overcrowding and possibly injuries. You need to be aware that the broilers' quality can seriously deteriorate at this point.

The broiler catching procedure actually starts well before loading. Information about the flock must be passed on to the slaughterhouse (between 24 and 72 hours before loading) and feed is withdrawn from the birds. Check the house before the catch team arrives and remove any mortalities in advance. The degree of stress a broiler experiences depends on:

- the housing type
- its condition
- the handling method
- the loading and unloading methods
- the stocking density
- the climate in the truck
- the duration of the transport
- waiting time for stunning
- the stress resistance of the broiler
- the 'life experience' of the broiler

Feed withdrawal

The crop must be empty during slaughter. And preferably, there should be no watery content remaining. If the crop tears during the slaughter process, the crop content (feed, water) can contaminate the meat with feed residue and micro-organisms. The same applies to the intestines – full intestines increase the risk of contamination. Payment for broilers is often based on live weight. It is then tempting for a poultry farmer to make that as heavy as possible with relatively cheap feed in the crop. That is why some payment systems inflict a price penalty for excessive crop fill. The standard presumption is that it takes at least six hours for the crop to empty. This is the required time between the very last feed intake and slaughter (bleeding). The optimal feed withdrawal time is between eight and ten hours. It is best to keep providing water until loading into the crates or containers starts. Water promotes crop emptying and prevents dehydration, so it is beneficial for slaughter hygiene and efficiency, as well as animal welfare.

If animals have not had feed withdrawn for long enough and the digestive system is still full, the risk of carcass contamination with faeces is high, and there will be a lot of defecation in the containers during transport.

A crop with feed residue after two hours of feed withdrawal.

Empty crop after six hours feed withdrawal.

Influence of feed withdrawal on weight

50,000 broilers, 10g of feed in crop = 500 kg feed

Feed price: € 0.37/kg >> cost € 185

Per 10 g feed there is 20 g fluid in the crop as well, so 50,000 x 30 g = 1500 kg body weight.

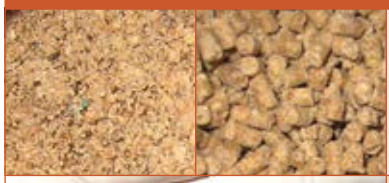
Return on live weight: € 0.87 /kg

Revenues € 1305 Quickly earned cash?!

Feed in the crop is a cheap way to increase body weight. That is why many slaughterhouses give a price penalty in case of too much crop fill.

Withdrawal

The planned slaughter time of a flock is decisive for feed withdrawal. You need to calculate it as follows. If, for example, the full withdrawal time is 9 hours, catching takes 2 hours, transport time is 1 hour and the waiting time in the slaughterhouse is 2 hours, then the feed must be finished 9-2-1-2 = 4 hours before catching. If something happens that disrupts the schedule, you have to lengthen or shorten the duration.

	Feed type	Crop empty after
	Finely ground, in pellet form	6 hours
	Whole grain/corn kernels	8 hours

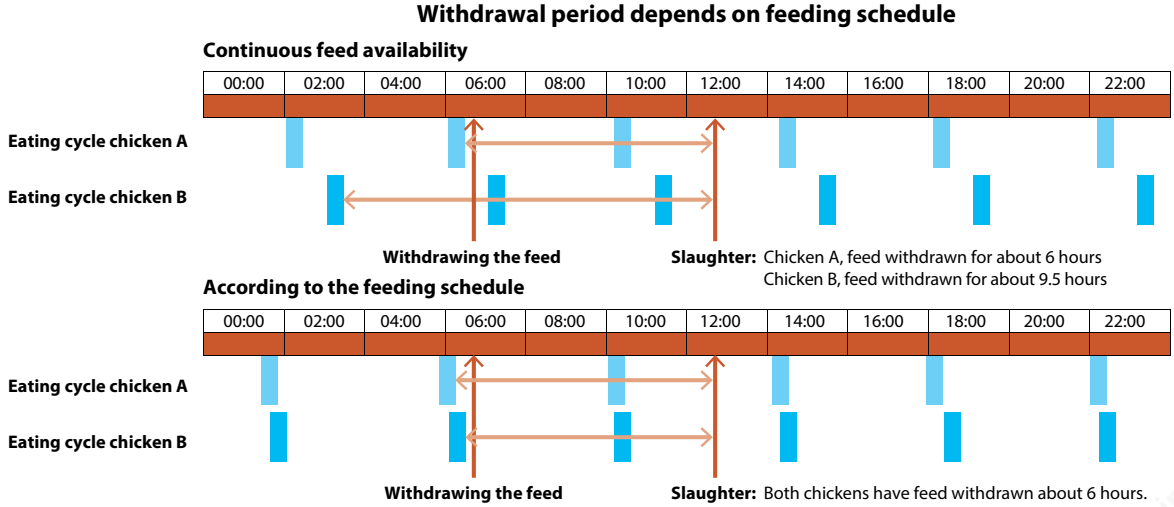
The crop fill after a period of withdrawal depends on the feed type.

Natural eating cycle

A broiler eats roughly every four hours (natural eating cycle). This is not always synchronized in a flock. So it is possible that a particular broiler has not taken any feed for a long period preceding feed withdrawal, while another has just eaten. Within flocks that have continuous feed available (on demand), wide ranging differences in crop fill/emptiness can be evident on the shackles. Birds that are used to a feeding schedule - for example, feeding after four hours of darkness in the house - are better synchronized, and fewer problems occur. On the other hand, birds learn and tend to anticipate periodical feed withdrawal and light programmes by filling their crops (creating a 'feed buffer') and crop contents may still cause contamination during processing. So another view on this is to stop all feeding programmes a few days before slaughter to prevent gorge eating.

Do not leave the feed trough until it is empty

If feeding has to be withdrawn, you must lift up the feed troughs or pans, even if there is still plenty of food in them. Broiler farmers have a tendency to let the birds eat the remaining food. This is not recommended because there are often old, mouldy feed residues in the feeding troughs/pans, which are detrimental to the health of hungry birds eating them and present a higher risk of mycotoxin residues (fungal toxins) in the meat. Of course, you have to empty and clean the feed troughs/pans between flocks.



If the birds have continuous access to feed, they will all have their own individual eating cycle (above). If the feed is withdrawn periodically, birds will eat more synchronized (below), so the content of their intestines at slaughter will be more uniform.

Feed withheld too long

Circumstances (long transport, traffic jams on the way, an unusually long waiting time or a malfunction in the slaughterhouse) can make the period between the last feed intake and slaughter longer than twelve hours. This causes dehydration and weight loss. The intestines become more fragile after an excessive period with no feed, and are thus more prone to breakage in the processing plant. The pH in the crop and the intestine rises so that beneficial microflora disappear and pathogenic bacteria have opportunities to multiply (e.g. Campylobacter), which poses a risk of damage during evisceration. The lack of bile release if there is no content passing through the duodenal loop can result in an over-full gall bladder, which is then subject to increasing tension and might burst. Another danger in the case of excessive time with no feed (more than 12 hours) is that the bird will consume its own energy supplies, especially the glycogen stores in the liver and muscles. A lower amount of glucose and glycogen in the muscles leads to less lactic acid formation after death, and the pH does not reduce as much as usual. This might lead to dry and dark meat (DFD). Make sure that feed withdrawal is not too long. Birds can get so hungry that they begin to eat the litter and droppings. This presents a risk to food safety and animal welfare.

With automatic removal, the risk of an overfilled gall bladder bursting is greater (by damage or pressure from the outside), and the meat can be contaminated with bile fluid. This meat will be rejected.

A dark discoloration of the meat caused by an excessive period without feed. The bird has used its glycogen stock and the water-holding capacity has increased.

Remove the water as late as possible, just before catching. Birds need water to get feed from their crop to the gizzard. If water is withdrawn too soon, the crops may not get empty, creating a risk of contamination.

Schedule from start of feed withdrawal to actual slaughter

Hoist feed trays/troughs, even if there is still plenty of feed in them

Don't let the birds eat the rest, because the residue is often caked and mouldy. Do not start too early – There is a risk that the birds will pick up feed waste, droppings and litter.

Hoist the water lines

Postpone this as long as possible. Hot weather poses a particular risk of dehydration during transport and waiting. This influences meat quality (colour/moisture content) and there is greater weight difference on arrival and more stress for the animals.

Transport to the slaughterhouse

Travel time varies depending on distance, road conditions and driving speed. This is important for calculating feed withdrawal period. Longer than four hours is undesirable.

Unloading containers and stunning (gas/electric)

About 15 minutes.

Catch the animals and load them into the truck

Make sure that catching does not take longer than 45 to 60 minutes. The truck should go directly to the slaughterhouse, as soon as it is full.

Arrival and lairage at the slaughterhouse. The animals settle down.

Do not allow longer than a two-hour wait, ideally in a dark room with good ventilation and (spray) cooling.

Actual death (cutting/bleeding)

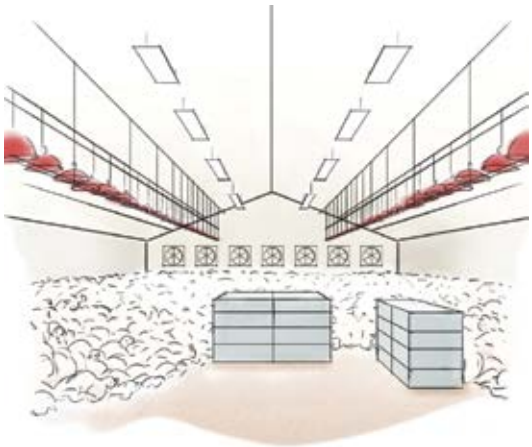
At this moment, the digestive tract comes to a standstill.

Points of interest for loading

Dim the light well over an hour before you start, to keep the broilers calm during catching. Broilers are calmer when there is a long light period before dimming. Hang blackout curtains in front of the entrance during daytime loading.

Load the birds carefully, to prevent legs, wings or heads getting stuck.

The loading process

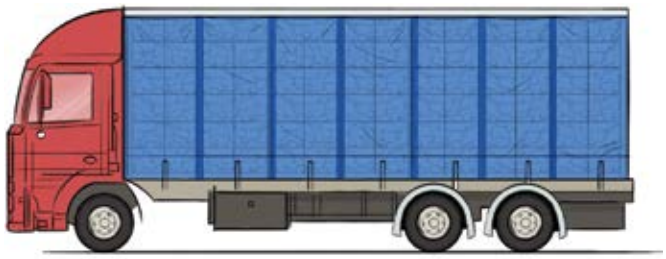


1. The house is ready.

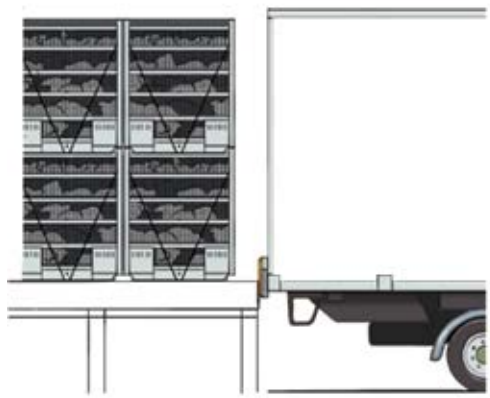
2. Catching the birds (manually or mechanically).

3. Putting them into the crates or containers – Put the containers close to the broilers to ensure short walking distances.

4. Loading the containers onto the truck - Always keep the containers horizontal. Keep in mind that the birds first loaded have to wait the longest. On average, it takes one hour to fill one truck.



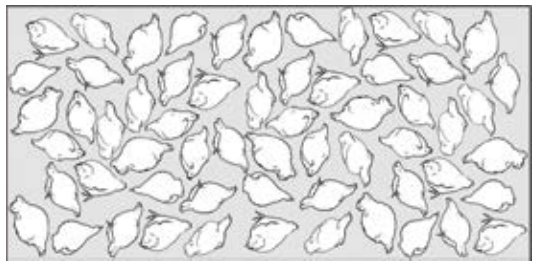
5. Actual transport from the poultry farm to the slaughterhouse – If the transport distance is short, the truck takes no breaks. With longer transport distances, drivers must take a break every 4.5 hours due to driver working-hours legislation in many countries.



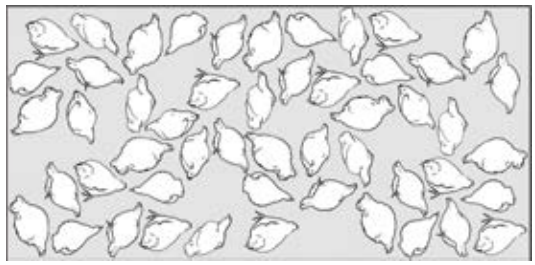
6. Lairage at the slaughterhouse – Containers are removed from trucks on arrival at the slaughterhouse and put in the slaughterhouse lairage area. The climate should be regulated there.

Thinning

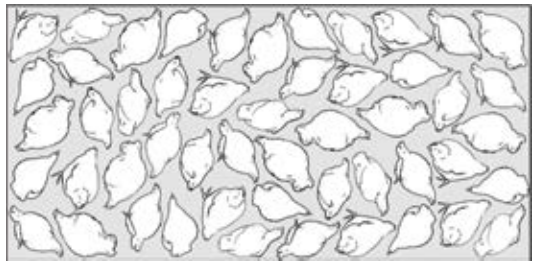
In order to avoid excessive stocking density in the house, while still producing a maximum weight of meat per m^2, you can deplete interim batches of birds. Another reason could be that the slaughterhouse requires both lighter weight broilers and heavier birds for breast meat. In this example 15-25% of the broilers are sent to slaughter at a live weight of 1,700-1,800 grams (32-35 days old). Then the remaining broilers are kept until they reach a higher final weight. If you are keeping hens and cockerels separated from each other in the same house, first load the hens to leave space for the cocks. Cockerels gain more weight per day and deposit less fat than hens and that leads to more favourable feed conversion (0.4 points better than hens at the same weight).



100% animals at 35 days



85% animals left after thinning



85% animals at 45 days

An example of thinning: At an age of 35 days 15-25% is slaughtered. This gives the remaining animals some extra space to grow.

Benefits and disadvantages of interim depletion (Thinning)

Benefits	Disadvantages
More kilograms of meat per square metre of housing, and therefore lower fixed costs per raised broiler	Feed withdrawal, unrest and fluctuations in climate during catching cause stress among the remaining broilers.
More space per broiler after depletion. This promotes the welfare and development of the remaining broilers. The extra space also reduces risk during hot periods	Greater risk of coccidiosis in the remaining broilers due to a prolonged period of coccidiostat-free feed (unless coccidiostats with no withdrawal period are used)
More flexible production to match market demand	Non-farm catch teams/materials are a serious threat to biosecurity, particularly the risk of Campylobacter contamination
	Higher stocking density of chicks placed at start of the crop means more manure production per square metre and increases the risk of poor litter
	Due to flapping during thinning, green muscle disease (Oregon disease) or Deep Pectoral Myopathy can develop in the remaining birds' carcasses.

Catching under blue light

Broilers have good vision and see more detail and colours and have more frequent visual input per second than people do. For example, a broiler sees a normal fluorescent lamp (50 Hz) flickering. Broilers can see ultraviolet and are more sensitive to colours than we are. Lighting with a specific colour influences a broiler's activity. In blue or green light, the broiler moves less than in white or red light, even though research does not show that they see blue light less well. That is why many broiler farms use blue light during catching. This is difficult to achieve in houses with natural light. Blackout curtains are needed for this. Animals in a house with both light and dark periods are better trained for changes in light intensity. Slaughterhouses often use blue light to keep the birds calmer in the waiting area and during shackling.

It makes sense to use blue light when catching. Apply the light at least one hour before catching, so that the animals are at ease when the catch crew enters the barn. Never catch broilers in a fully lit house. This causes stress and unnecessary anxiety.

The headlights you use should also emit blue light.

Catching in the dark or in very dim light can ensure that the broilers remain calm.

Catching in daylight can cause wing damage due to flapping by active broilers.

Expert catch team

Broilers have become increasingly vulnerable over the past fifty years. An expert catch team knows how to keep skin lesions, bleeding, bruising and fractures to the minimum, and thus reduce the number of rejected animals. Catching broilers is heavy work, with continuous repetitive actions. If a catcher catches 1,000 broilers per hour with a weight of 2.5 kg, this means that he handles 20,000 kg of broilers in an eight-hour working day. This requires working under pressure, often during the night and in a dusty environment. It is therefore important that the catch team has both the know-how and motivation to load properly. This is achievable, for example, with a reward system partially based on the percentage of catch damage (bonus-penalty).

Calm catchers

Calmness during loading contributes to tastier, more tender meat and fewer injuries. Calmness is also important for animal welfare. Agitation produces the stress hormone cortisol, resulting in a higher glycogen level and therefore more glycogen breakdown after death. This results in more lactic acid (lower final pH) and more chance of PSE meat (Pale, Soft, and Exudative). Besides light intensity and light colour, the catching team's behaviour is also important. Make sure there is a calm and decisive approach to the birds. Move slowly, quietly and steadily through the flock of broilers. Avoid excessive speed of movement, because it scares the birds.

Training the catch crew and driver

Catchers in a catch crew change often. Good catcher qualities are essential for maintaining high broiler quality. Training and certification can help here. In Europe every professional poultry transporter is obliged to have a 'Poultry Transport Driver' certificate with him or her and he or she must attend 35 hours of re-training every five years.

LOOK-THINK-ACT

Why is it better not to pass birds to others?

There is a high risk of more injuries occurring when broilers are handed between several people. So do not do it! The more steps there are in the process, the higher the risk of catching injuries.

The 'dos and don'ts' when catching

- Do not catch or carry the animals by the neck or wings.
- Make sure that animals do not collide with objects during catching, e.g. the water system.
- Do not swing the broilers and never let them dangle. Do not turn your wrists either. Minimize handing over birds to other people. It is best to put birds directly in a container or crate.
- Grab the animals by one leg. Research has been done on lifting by one or both legs. It revealed that lifting by both legs causes more injuries and takes more time.
- Never throw animals towards containers from a distance. This will lead to fractures and bleeding.

Sick and/or injured broilers are unsuitable for transport. Legislation also forbids loading these birds. They must be killed immediately by a trained person. Set up a protocol on how to deal with sick and injured animals while catching.

LOOK-THINK-ACT

Fine dust during catching?

A catch crew has to handle a lot of fine particulate dust in the air during catching. To prevent inhalation, you should always wear a dust mask during catching, and it is best to cover mouth, nose and eyes.

Hygiene during loading

Loading the broilers puts farm biosecurity under risk. Check that the catch crew and driver use clean work clothing and footwear and ensure they wash and disinfect their hands. Do not forget to check the cleanliness of the transport crates and loader. The same applies when using a catching machine. Some companies have a self-managed catching machine that is not used elsewhere. Otherwise, cross-contamination occurs between the various poultry farms.

Hand-catching methods

Catching by the legs

A catcher picks up broilers by the legs, with three to four birds in each hand at once. Catchers pick up the birds upside down and load them into transport crates or containers. Broilers can be injured during catching, especially when the catch team is overtired or there is a rush to load the birds. It involves heavy weights, i.e. seven 2.5 kg broilers means 17.5 kg total.

Whole body catching

With whole body catching two broilers are caught simultaneously by the trunk, both remain upright and held. You grab one broiler with each hand, supporting them under the breast from the side with the thumb on the back. That allows you to hold the wings in place. This method causes little stress and injuries. It does require skill and involvement from the catch team.

If you carry the birds by the legs, do this correctly. In the right-hand photograph, the animal is held too high which can cause drum bruising.

Creating compartments

Compartments are made to avoid the risk that broilers overrun each other and pile up. Also - when done in a smart way - the birds set aside to be caught later can still drink.

Divide the house into segments, done here with a mesh partition lowered after the feed and drinking lines were winched away.

© Zinpro Corp.

The crates can also be used to make separations.

© Zinpro Corp.

A separation made with plastic, dividing the house into a front and back part.

Crates/containers

Broilers are loaded into:

- loose plastic, wood or metal crates
- fixed metal crates on the truck
- large plastic or metal containers, which are brought into the house. Containers are available with drawers that may or may not be slide-out or with a floor that you can open like a flap. Loading most types starts with the bottom layer and then stepwise until the top is full.

Nowadays, using a container system is most common.

Traditional loose crates

In some countries, people still use traditional, loose crates. Dimensions vary. A small 80 x 60 x 30 crate, for example, can transport 12-15 broilers. Loose crates are easy to handle and you can take them into the house, e.g. on a pallet. In crates with a top opening, the broilers are put in the crate head and wings first. With crates with a side entrance, you push the birds in from the side. The opening must not be too small, because that will easily cause wing injuries. These crates offer flexibility and low cost, but require more labour, and it is more difficult to regulate the climate properly during transport.

Preferably, place the containers inside the poultry house. If the containers do not fit through door opening and have to remain outside, the broilers have to be carried a long way to the containers.

If the catching crate opening is too small, the broilers' wings or legs will get caught easier. In such cases, keep the wings well together.

A crate with a large flap opening.

A crate with two flaps.

Stocking density per crate

The number of broilers in a crate is critical. Overloading has the risk of suffocation or injuries. But under-loading leaves space and the birds can slide around during transport, which increases the risk of bruises, haematomas and fractures. The surfaces should be suitable for the physical condition of the animals, the probable transport time and the weather conditions.

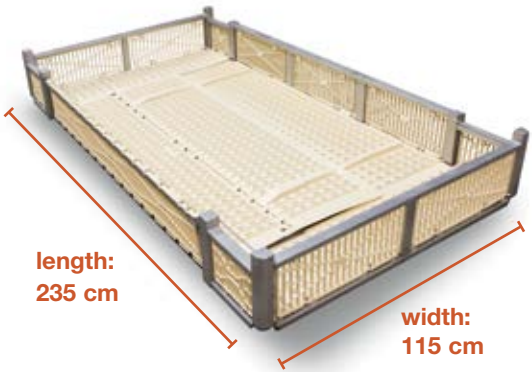
Standards for available area

Category	stocking density
Poultry < 1.6 kg	180-200 cm^2 per kg
Poultry 1.6–3.0 kg	160 cm^2 per kg
Poultry 3.0–3.5 kg	115 cm^2 per kg
Poultry > 5.0 kg	105 cm^2 per kg

The standards for the density for the transport of poultry in containers are described in EU Regulation 1/2005. These numbers may vary, depending not only on the weight and size of the animals, but also on their physical condition, weather conditions and estimated transport period.

Free range broilers respond in a more alert and smart way to threats. This makes them more difficult to catch. This also applies to slow-growing broiler breeds. They are stronger and smarter than conventional broilers. They tend to climb back out of the crates during loading.

LOOK-THINK-ACT



How many 2.25 kg broilers are you allowed to put into this tray?

With 160 cm^2/kg maximum stocking density and a surface area of about 27,000 cm^2 this means: Per layer you are allowed to have 27,000÷160 = 168.75 kg in this container. With an average weight of 2.25 kg, you are permitted to load 168.75÷2.25 = 75 birds per layer.

When there are too many birds per create, you can imagine that injuries occur easily.

Handle the crates with care when there are live animals in them. Don't tilt them, like in this photo.

© Zinpro Corp.

Large capacity containers

Loading broilers is very efficient in large containers that are custom made to fit the truck. There are two types of systems: the release system or the tilting system. With a container without drawers, floors are pushed between the levels of broilers. These containers can take - depending on the body weight - 144 broilers spread over several drawers, and even 280 to 300 in a double version. Containers make loading easy, because they have large openings. A common size for these broiler containers is 1.2 metres wide, 2.4 metres long and 0.3 metres in height per drawer/level. You can also remove drawers from the containers. Choose a type of container that suits your unloading system.

A special step to prevent the catcher from lifting the birds too high and breaking legs. The situation is still not optimal but it is better than it would be without the step.

Containers with a large capacity of 75 birds per layer.

Fill the container upwards. Resist the temptation to throw in the broilers while filling the top drawers. That can lead to injuries and it is bad for animal welfare and therefore for quality.

Ten-layer container system

Here you see an example of a ten-layer container system from Spain. This system is made of stainless steel, with foldable bottoms. You load the containers per layer, from bottom up. The broilers are discharged at the slaughterhouse onto a platform that rises in steps. The disadvantage of this system is that broilers' legs regularly protrude through the bars, causing serious bruising in the drumstick.

In multi-tier housing systems, the manure belt can often serve for catching the birds. The conveyor transports the birds towards the crates and it is easy to remove them.

In this system, the animals are transported to the outside on a conveyor belt, and then put in small crates. The net above the belt prevents birds from jumping off.

Mechanical catching

Broilers get stressed quickly when handled by people and catchers sometimes do it too harshly. With a mechanical catching system you have lower staff costs and often fewer injuries. In Europe, mechanical catching systems are used on about 20% of poultry farms and 5% in North America. The capacity of these systems ranges from 8,000-12,000 broilers per hour.

Biosecurity

A catching machine is profitable for larger scale farms (more than 100,000 broilers) or if poultry farmers buy a machine cooperatively. The technical lifespan is around twenty years. There is always a risk of cross contamination if the machine is used on several farms, because these machines are difficult to clean in practice. But there is also a risk of introducing diseases when working with manual catch teams.

Injuries with mechanical catching

Mechanical catching reduces stress and the number of injuries in broilers. The broilers remain calmer. The percentage of injured broilers is lower than with manual capture, unless the speed of the machine is set too high. On the other hand, the proportion of mortalities is slightly higher with this method, partly because the machine does not distinguish between healthy broilers and small or sick birds (manual catchers will not catch these animals).

Catching systems

There are two main types of automatic catching systems that work with a loader, which moves towards the birds.

1. *The broilers step on the moving conveyor belt themselves and a second belt moves them to the crates (fitted with a scale or a bird counter).*

2. *The broilers are collected with long, rotating fingers and put on a conveyor belt.*

Catching injuries

An independent poultry farmer is responsible for ensuring that the animals do not suffer injuries or fractures during catching and loading. He or she must ensure that the animals are caught in an animal-friendly way, and instruct and correct the catchers handling his or her birds. This also applies to using catching machines. It is difficult to determine in the slaughterhouse whether an injury originates from catching, given the high slaughter line speed and the great number of birds to be assessed at the time. The poultry farmer often pays a penalty if the inspection at the slaughterhouse sees more than 2% of the animals suffering catching injuries. This is different if the birds are owned by a poultry integration. Integrations have their own catch team, often on their or the slaughterhouse's payroll.

With injuries that occurred after death, you recognize the absence of haematomas. The injury on the left occurred after death and the one on the right while the bird was alive.

Uniform assessment on catching injuries

Assessment of catching injuries takes place in the primary processing department, in a well-lit location where the carcasses and wings can be assessed properly. This is separate from the veterinary inspection that takes place earlier (before cooling). The count is made on the breast side of the carcasses. This is done in the form of random checks in periods of two minutes and twice within a flock. The count only includes haematomas larger than 3 cm, with a maximum of one per animal. The counts are converted into percentages, based on the belt speed. Example calculation:

- belt speed of 200 birds per minute
- 2 x 2 minute counts
- the 1st time count was 7 catching injuries, and the 2nd time the count was 9 injuries, so a total of 16 injuries

The calculation is thus: 200 chicks * 2 * 2 = 800 chicks assessed. 16/800 = 2% catching injuries.

Hip haematomas occur mainly when you lift broilers to an awkward height above your strength, e.g. when filling the top container tray. You then have the tendency to twist your wrists and the bird's leg, with the risk that the hip gets dislocated. So lift your arm up high enough, like this.

If you see clear bruises on the back of the carcass, this is probably caused by the broiler being trapped when closing the container slide roughly. Besides avoiding rough handling, you also have to use the correct crates; the depth of the crates varies from 21 to 30 cm. Don't load heavy broilers in crates that are too shallow.

Catching at night and early slaughtering

In warm countries, people often catch and slaughter at night. The temperatures are lower for the broilers and the catchers, and the birds are calmer in the dark. And electricity is often cheaper at night and it is quieter on the roads. An additional advantage is that the meat can be called 'day fresh' for a longer period – in some cases the meat can go to the market the same day.

Causes of injuries

In general, more injuries are found in a slaughterhouse in broilers that:

- have been without feed for a long time
- have all been captured by a hired catch team (compared to the farm's own people)
- were manually carried to the crates (compared to using a cart or forklift that places the containers close to the animals)
- have been driven to a separate house compartment prior to catching (to reduce catch team's walking distance)

Before loading in the truck, check the broilers in the crates for trapped wings, legs, heads, splayed legs or birds lying on their backs. That is a signal that the broilers were caught or loaded roughly. These animals will experience pain and distress during transport, or may even die.

Make sure the crates are intact. The broilers can injure themselves on damaged parts.

LOOK-THINK-ACT

Should you slide drawers closed as fast as possible?

When sliding the top of the drawer, make sure that there are no wings, heads or legs pinched. So close the crates gently. With larger sized broilers (around 3 kg), you see more haematomas and bruises on their backs from sliding drawers open and closed.

Transport

Transport must meet high standards to enhance animal welfare and in view of its direct, positive effect on meat quality. Make sure that broilers can sit comfortably during transport, with their heads up. Chicks produce heat and moisture: that combination can quickly lead to distress. That is why good ventilation is very important. In addition there is a requirement that:

- the broilers are safe and do not undergo unnecessary suffering or injury
- the birds are protected against weather conditions
- the broilers cannot escape or fall out, and the truck's movements are easy for them to handle
- the birds are transported in good air quality with sufficient oxygen
- there is good accessibility and lighting to allow monitoring and caring for the broilers during the journey
- the broilers have grip on the floor
- no manure can leak
- everything is easy to clean and disinfect

In Indonesia and other South Asian countries, poultry from small-scale farms is still transported in crates like these sometimes.

The driver's role

The driver is an important link in the process. He is responsible for the welfare of the animals during loading the truck, transport and unloading. Drivers of live birds have to consider their driving style carefully:

- Pull away gently.
- Avoid sudden braking.
- Take bends carefully, especially on roundabouts.
- Change gear smoothly.
- Take motorways and major roads as much as possible, because poor road conditions increase the vibrations in the truck.

The driver of the truck is also a source of contamination – keep the cab clean. Special farm clothing and overshoes are essential for the driver too.

Drive calmly and carefully. Choose the most optimal route (distance, weather, traffic jams, road quality). Have a back-up plan for emergencies or unforeseen events.

Type of truck

When transporting broiler chickens you can use closed and open trucks.

Open truck	Closed truck
	
+ Cheaper construction + More fresh air + Easier loading and unloading + Clear overview of the cargo and animals	+ No loss of manure, dust, feathers during transport + Less risk of spreading infectious animal diseases + Allows better temperature regulation for the birds + More calm and reduced stress for the birds
- More influences from weather, i.e. precipitation, wind, sun, cold. - Greater climate differences between the outside and inside of the load - Loss of dust and manure on the way -> spread of infectious animal diseases (avian influenza, i.e. bird flu)	- Loading containers/crates is harder - Dependence on an energy supply, i.e. in the event of poor power supply, the climate control system turns off - More expensive to purchase

Mortalities during transport

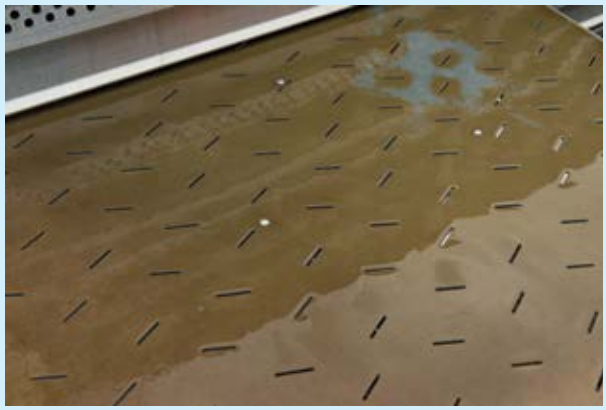
A mortality during transport is described with the term DOA, i.e. dead on arrival. These are mortalities that occur between the time of catching and actual slaughter. DOAs are related to slaughterhouse operations, the journey length, the outdoor temperature, and the birds' plumage, body weight and health. You see more mortality with longer journey times. With every extra fifteen minutes of journey time, the number of DOAs increases by 6%. And for every fifteen minutes waiting time at the slaughterhouse, mortalities increase by 3%. If the normal DOA rate is 0.2%, this would result in an increase to 0.4% with 4 hours extra journey time (4 x 15 minutes x 6% x 4 hours = 96% higher).

The upper limit for a normal percentage of DOAs is around 0.5%. The average is around 0.2%.

Accidents during poultry transport

In case of an accident a truck can tip over and many birds can die. Driving into a bend at a relatively high speed or, conversely, braking too much can cause the broilers to slide to one side. That movement of weight can cause the truck to tip over. The risk of this is increased if you have loaded considerably below the loading density norm of 160 cm^2 per kg of body weight. So it is actually safer to load the animals according to the standard with birds closer together. This also prevents the broilers from getting haematomas in their wings and breasts by sliding and colliding within the containers during the journey.

Grip on the floor



Broilers have to handle movements from bends, bumps and speed changes on the road. In addition to correct loading density, the broilers having sufficient grip on the floor is also essential to prevent them sliding around which can cause stress and injuries. It is important that the broilers are always put upright in the crates and do not lie on their backs. On the left a floor that provides less grip than the container on the right.

Heat stress and meat quality

Ambient temperature is one of the main causes of stress during transport. Broilers generate a lot of heat at slaughter age and they exhale humid air. As both temperature and relative humidity increase, heat stress increases very quickly. Broilers can control their body temperature well within a certain temperature range. When it gets warmer, the birds breathe faster and superficially (gasping) to lose heat. This causes them to dehydrate faster. They also release more CO_2, which increases the blood pH, but - in order to restore the acid alkaline balance - reduces it in the bird's organs and muscles (< 5.8), resulting in loss of meat quality. In cases of severe heat stress, birds die during transport.

Regularly measure the temperature among the broilers. This device measures both the temperature and relative humidity (RH). The combination of temperature and RH determines the degree of heat stress.

Prevent heat stress during transport

The upper temperature limit in the containers is about 25°C/75°F with relative humidity 70%. When the journey is longer than four hours, there must be ventilation that provides airflow between 0.3 and 1.0 metres per second (at ambient temperature 10-15°C/50-60°F). Simple modifications and practices can reduce the risk of heat stress during transport:

- Adjust the curtains and/or raise the roof.
- Allow access to drinking water for as long as possible up to the actual time of loading.
- Respect stocking density norms when loading and ensure equal numbers in each container.
- Ensure optimal temperature and relative humidity (the best is around 70%).
- Provide adequate air circulation throughout the load (especially in the middle!)
- Preferably, transport birds at night.
- Avoid stress prior to catching.
- Prevent stress during transport.
- Avoid traffic congestion.
- If high temperatures are expected, add vitamin C to the drinking water prior to catching.
- Ensure sufficient air movement and cooling on arrival at the slaughterhouse with fans and a sprinklers system.

You can assess how the animals are feeling by their distribution in the crates. At a good temperature the birds distribute evenly in them. If they are too close together, they have been too cold, and if they are all sitting at the sides, it is too hot.

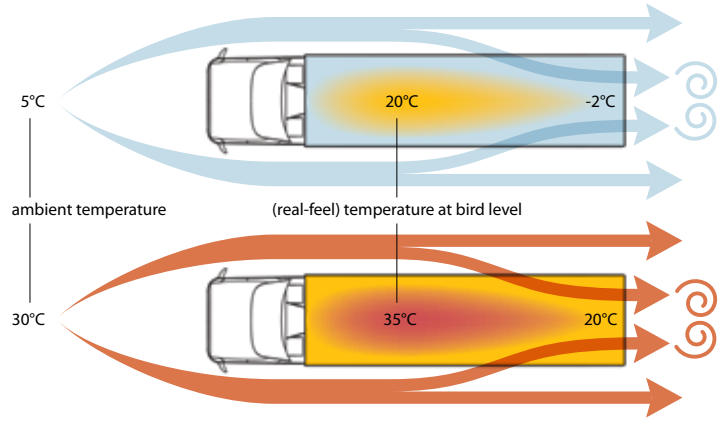
Microclimate in the truck

There must be good ventilation in the truck both when driving and at a standstill! It is evident that climate conditions vary in different locations in the truck, and it is difficult to control uniformly. Thus local microclimates occur in the truck. For example, broilers in low-lying crates on the outside of the load are most likely to suffer cold stress and those in crates in the front are most likely to be heat stressed. Install extra fans for such locations. Heat stress can even occur with a cold ambient temperature, if the truck's curtains are closed while driving.

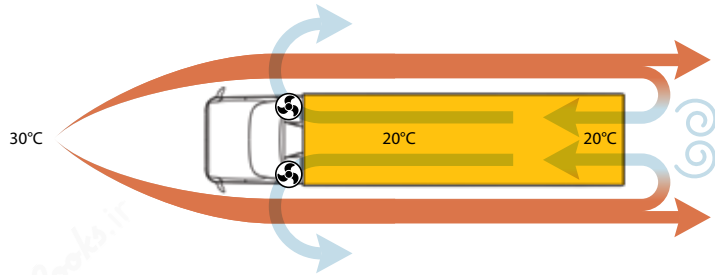
The climate in the truck is a factor that is receiving increasing attention in broiler transport truck design nowadays:

- air space in the centre of the truck
- air movement from the floor upwards
- a roof that can be lifted
- floors with a good ventilation option, without manure falling through from overhead containers

When birds sit down during transport the airflow through the floor will be minimal, so make sure the birds have enough head space (depth of layers).



If the ambient temperature is low, the wind from driving will cause wind chill, which will reduce the real-feel temperature in rear of the truck to below zero. If the ambient temperature is mild, it can become too hot in the truck when there is a lack of cooling by wind chill from driving, and that can lead to heat stress.



An area of low pressure develops between the cabin and the trailer during driving, and there is turbulence behind the truck. You can utilize these effects to achieve an even temperature among the birds by installing inlets at the back of the trailer and ventilators in front.

There are air inlets at the rear but extra ventilators could also be installed. Then, alternately, the airflow can be reversed during cold periods. The air going back and forth distributes the heat evenly within the trailer.

With a closed truck you can use fans to ensure that the temperature and humidity in the whole load space is the same. Here you see a system where the air exhausts at the front.

Extreme conditions

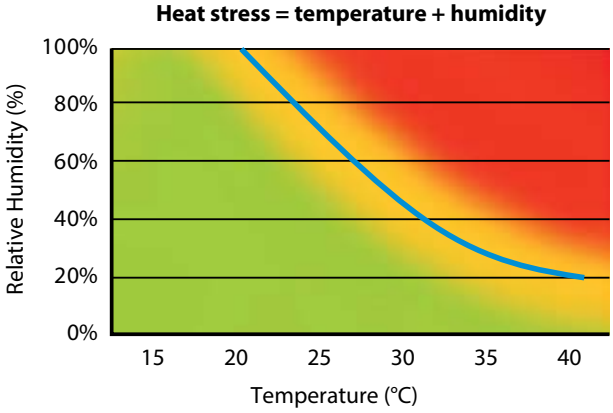
You have to take remedial measures with both high and low temperatures. Sometimes they are even the same solution. When the ambient temperature is 35°C/95°F or more on the farm, you should stop loading as quickly as possible.

Wind break mesh ensures that there is a free gas exchange and cooling, without the wind blowing through the crates and the animals cooling too much locally.

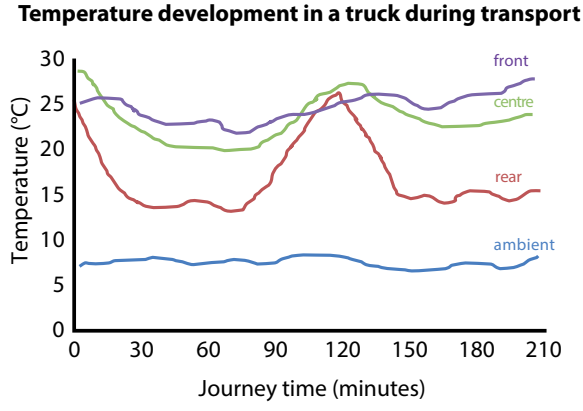
When it's cold, a tarpaulin will keep the birds warm. The gas exchange (oxygen, CO_2) is more limited and moisture cannot disperse well. So check the conditions in the crates, especially at the centre of the load.

Measures at low/high ambient temperatures

< 10°C/50°F	> 27°C/80°F
• **Load and unload under shelter wherever possible and without delay** • **Fill crates/containers inside the house if possible, and then load them as quickly as is feasible onto the truck** • **Use just-in-time delivery and limit waiting times as much as possible** • **The slaughterhouse provides a suitable climate in the waiting area**	
Truck sides must provide shelter from cold. This can be done with 'fixed' sides or curtains, windbreak mesh, etc. (of course, proper ventilation must still be possible)	Modify the stocking density in the crates/containers and pay particular attention to any 'hotspots' on the truck
	Start the journey immediately after loading and avoid unnecessary stops on the way. Avoid traffic jams and keep driving around if you know your arrival will be 'too early' at the slaughterhouse. If you have to wait for the slaughterhouse, park in the shade and use mobile fans and/or 'standstill ventilation' on the truck
	If necessary, cool the asphalt/environment with water. Pay attention to air humidity (cool before the animals are there). Catch and load during the cooler hours of the day.
	Catch and load during the cooler hours of the day. Adjust slaughter times to avoid delivery during the hottest hours. This requires internal and external fine-tuning. In the Netherlands, the NVWA (Netherlands Food and Consumer Product Safety Authority) is informed in time regarding the required supervision capacity



If the combination of temperature and humidity becomes too high, animals will die from heat stress. The blue line indicates the maximum. Above this level, birds suffer severe heat stress.



Temperature and humidity in different parts of the truck. The truck was parked for between 60 and 120 minutes. You see a rapid temperature increase among the broilers.

Journey duration

During short transport, a broiler loses on average 40 grams of weight. This includes manure and fluid, but almost half of the loss is carcass weight. The lairage period at the slaughterhouse is calculated as part of the journey. It is only mandatory to provide water when the journey is longer than twelve hours.
This is not possible with broilers, so the transport time should not exceed 12 hours.

Welfare index for broiler transport

A welfare index based on nine control points has been developed for broiler chickens during transport. Weighing up these points produces a score that is used as a basis for comparing slaughterhouses, catching teams and poultry farmers. An animal welfare quality mark can even be linked to it, so that only meat with a certain minimum score will receive the quality mark. The nine check points are:

1. mortality
2. fractures
3. trapped body parts
4. supine birds (lying on their backs)
5. haematomas/bruises
6. broilers with splayed legs
7. crowding
8. thermal stress
9. rejections

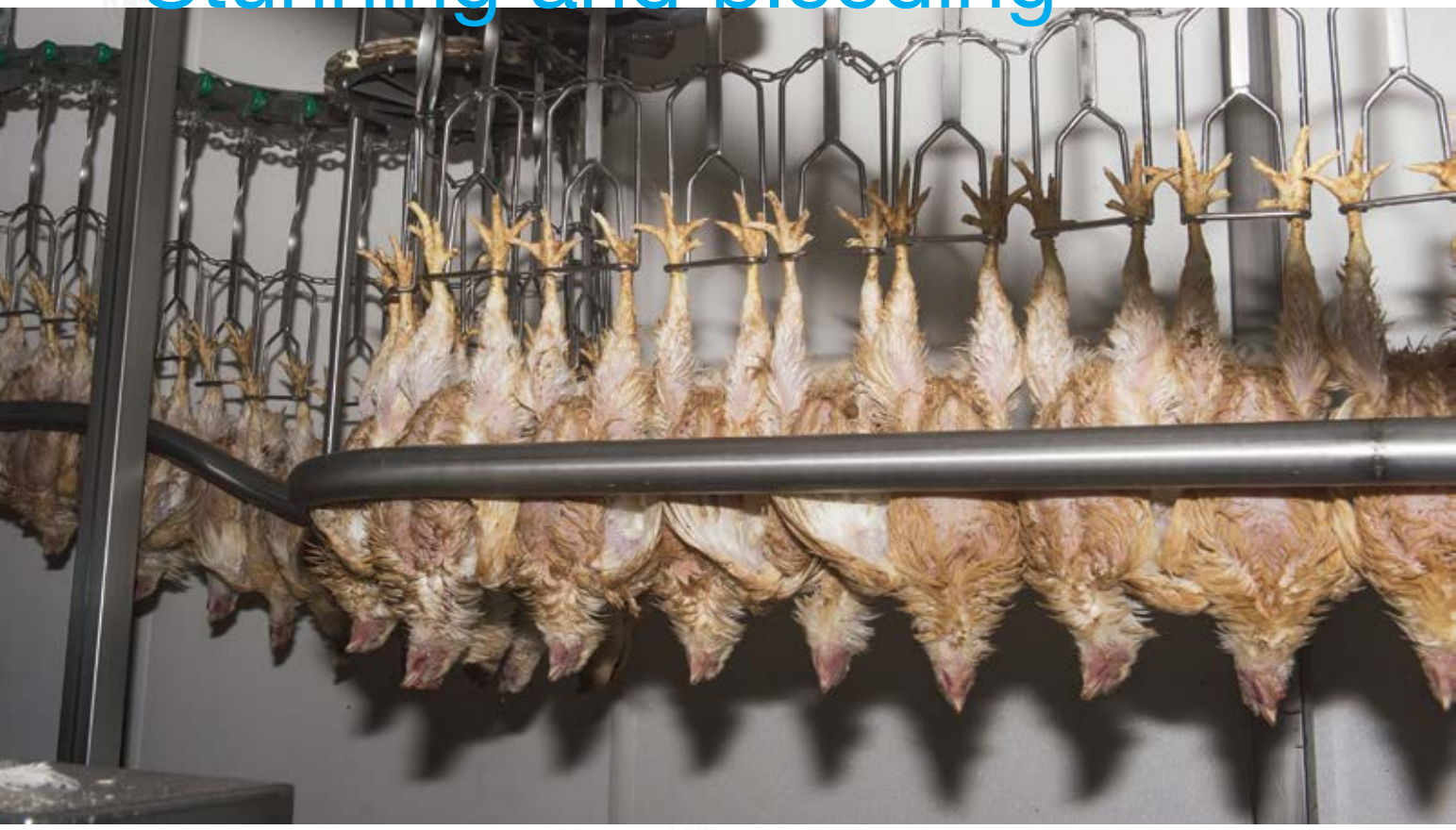
The full truck (including the driver) is weighed on the weighbridge. The broilers are then put in the containers in the waiting area. After unloading, the truck is weighed again on the weighbridge. Correction for the weight of empty containers gives the live weight of the broilers delivered.

On arrival, trucks sometimes have to wait a little longer before slaughter can start. If that happens, make sure they park in a cool place, and perhaps with the support of fans to cool the birds.

It is also important that there are fans in the waiting area for containers with birds, if necessary, combined with mist cooling, to prevent heat stress occurring among the broilers.

CHAPTER 5:

Stunning and bleeding



The poultry processing industry has become more and more sophisticated and large, efficient processing companies have emerged. The quality of the meat must be kept optimal from arrival at the slaughterhouse right through to packaging. The first steps in the process are from unloading the truck to scalding.

Lairage time

After arrival at the slaughterhouse, there is usually a resting period of one to two hours between arrival and shackling the birds. That gives the birds time to settle down. This is especially important if the broilers have been exposed to extremely hot or cold conditions, or a long journey. The broilers will have sufficient time to reduce their stress levels and to regain normal breathing and heart rhythm. This is important for preventing problems further along the slaughter line, and to keep meat quality optimal.

In many countries, the delivery of broilers must be accompanied by basic food chain information (FCI). The poultry farmer sends this information about the flock to the slaughterhouse 24 to 72 hours before the scheduled slaughter moment. The FCI assessment determines whether the flock may be slaughtered without any special conditions (e.g. last batch of the day slaughtering in case of salmonella contamination, or a loading/slaughter delay if a medication withdrawal period has not yet expired).

Checking the birds on arrival

On arrival, the data is checked for correctness and relevance to the flock. Then there is an ante mortem inspection, which includes physical assessment of the broilers. This involves consideration of the following:

- Diseases, abnormalities and injuries. Special attention is paid to infectious diseases such as Avian Influenza (AI) or NewCastle Disease (ND).
- Animal welfare. This concerns the stocking density in the load, weather influences, the internal climate and the journey duration.
- Percentage of mortalities on arrival (DOAs = Dead On Arrival). The average here is around 0.2%. The maximum permissible percentage is 0.5%.
- Catching injury monitoring. This is a count of broken bones and severe haematomas (not more than 2%).

It is impossible to check all the birds individually on the truck or during stunning, so this is a global assessment. The official veterinary inspector is ultimately responsible for this inspection. There is also an animal welfare officer at slaughterhouses, who warns and reports. This is EU-legislation, but also a demand of customers.

The slaughter line is set up separately for each flock of broilers, depending on flock quality, breed, weight distribution and the feed withdrawal duration. Employees with experience and skill are required to perform plucker adjustments, in particular. Faulty adjustment can lead to unnecessary costs.

A veterinary inspector checks the temperature in the container.

The first reason for rejection is dead bird on arrival. These animals may not be processed.

A hygiene and safety kit of the slaughterhouse for truck drivers, so he is able to clean his vehicle in the correct way.

After unloading, the vehicles and containers are cleaned and disinfected; ready for the next load.

The slaughter process

Modern meat processors with automatic evisceration systems and cutting sections can process 13,500 to 15,000 broilers per hour on a slaughter line. Fifty years ago this was only 2,000 birds per hour. Broiler qualification and screening can even be computer-controlled (video monitoring). The cut-up lines have a slower speed, with a maximum of 7,000 birds per hour. So multiple cut-up lines are needed to keep up with one cooling line.

Steps in the process:

1. unloading

2. stunning (electric, gas)

3. bleeding

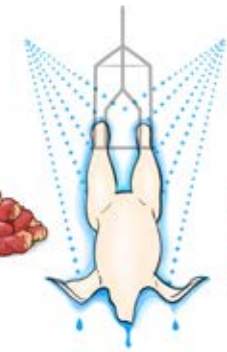
4. beheading

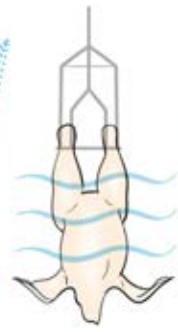
5. scalding (water, steam)

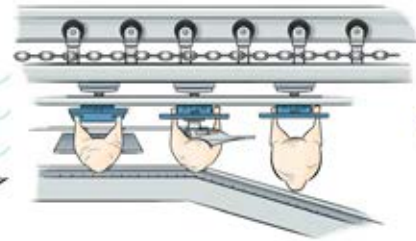
6. plucking

7. rehanging from slaughter line to evisceration line

8. evisceration







9. veterinary inspection

10. harvesting the organs

11. removal of any left-overs (crop and lungs)

12. washing and rinsing (inside and outside)

13. cooling (air, water)

14. weighing and grading

15. cut up and packaging

Unloading

Discharging a high pile of crates with an adjustable conveyor belt. This is good for humans and animals. On the right, a method that is a lot less pleasant for both humans and animals. The stress in the birds has a negative effect on meat quality.

Stunning

The broiler is rendered unconscious before slaughter – this is legally required in the EU. It can be done electrically or with gas.. Originally, stunning was applied to ensure that the animal would not move any more so that it was more easy and safe to handle, as well as to prevent violent convulsions after the cutting. Nowadays, stunning is mainly used to improve animal welfare. It minimizes pain and suffering. There are strict government regulations for stunning.

Blue light also helps to keep the birds calm during the final phase before they are stunned.

Electric water bath

+ Inexpensive
+ Little floor space required
+ Relatively easy, technically
- Animal unfriendly (live shackling)
- Haematomas in breast fillet (also due to EU requirements on electrical current for stunning)
- Ergonomics – shackling live birds is difficult
- Risk of damage (e.g. from wing flapping)

CAS (Controlled Atmosphere Stunning)

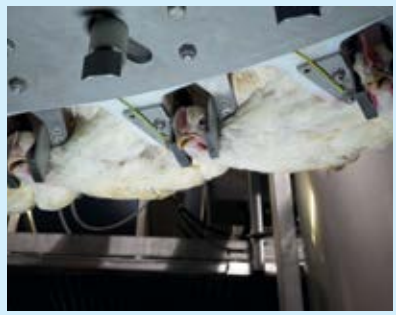
+ Lower incidence of vascular lesions
+ More animal-friendly
+ Broilers are stunned before shackling
+ Broilers stunned before unloading from container (depending on system)
- Cost of gas
- Cost of installation
- Required floor space
- Technically more complex
- longer time to plucking: lower plucking result

Head-only stunning

A less commonly applied method is head-only stunning. Electrical head-only stunning stuns birds individually. The broiler is positioned after being shackled and then stunned. Every current is measured to determine whether it has been adequately administered and recorded (according to EC1099). If it turns out that stunning is inadequate, the animal is automatically separated to an integrated back-up electrical water bath and is still stunned. Because the process is individual and reversible, it is acceptable for many forms of religious slaughter.

Supporting the body during shackling.

Positioning the head.



Actual head-stunning process.

Dust

Flapping causes a lot of dust while shackling live chickens. So employees should wear a dust mask to protect the lungs and prevent zoonoses. After gas stunning, the broilers are clammy and motionless. The operator doing the shackling can work without dust masks and in a well-lit environment.

Shackling prior to stunning

With electric water bath stunning, broilers are hung directly from the crates or dropped from containers onto a conveyor belt and hung upside down from that belt. At smaller slaughterhouses or when there is respect of a religious tradition (Halal, Kosher), non-stunned shackling is still common. You need to prevent live hung broilers from getting stressed. If they do, they will flap their wings trying to move upright. This causes a lot of wing damage.

After shackling, the animals are moved on to the electric water bath. This should take at least 30 seconds (to allow the birds to relax) with a legal maximum of one minute, and should have minimal disturbances (bends, ups and downs), because it is stressful for the broilers and can cause a lot of damage (meat quality, fractures, etc.).

Ensure that crates are intact and closed properly. Otherwise, birds can escape. This means extra work and the poultry farmer might not receive payment for those birds.

The risk of escaping birds is an inherent risk with non-stunned shackling. They have to be caught again, which is all extra work and animal stress. Prevent this by avoiding an overfull container of live birds and taking the most active ones out first.

Shackling the birds non-stunned remains a system in which broilers are restless and a lot of damage can occur. And for the operators it is physically heavy work.

A lift allows shackling operatives to work at the same height continuously. And the animals are always picked up in the same way. This is better for humans and animals.

On the way to the electric water bath

This bird is not correctly shackled and missed the guiding rail. The dirty back has probably slid along a partition. The bird on the right also misses the rail (see arrow).

Broilers can suffer stress if the line suddenly goes upwards or downwards (ups and downs). So pay attention to the slaughter line layout.

A bend in the slaughter line will cause non-stunned birds to flap. This causes a lot of wing damage, so it should be avoided.

Birds flapping their wings while on a bend in the line can smash against a wall and damage their wings.

Slow-growing broilers or ones that had outdoor runs are highly alert and have stronger muscles. They sometimes try to escape from the shackle.

If the animals have to travel too long, there is a chance that they will work loose. These animals are clearly stressed and one has been able to work loose.

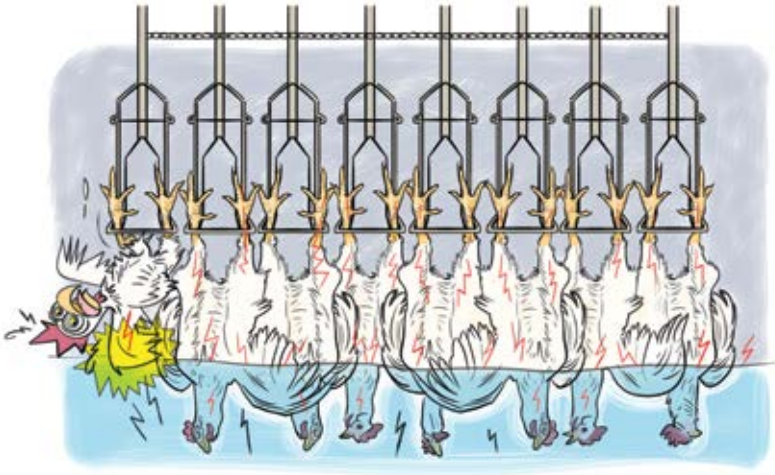
Hanging with their breasts against a flexible flap helps to keep them quieter than they would be if hanging loose.

Guiding the broilers through a tunnel with plastic flaps prevents stress and damage to the birds.

The slaughter shackles touch guide bars at the top on both sides to ensure that the stunning current is never interrupted.

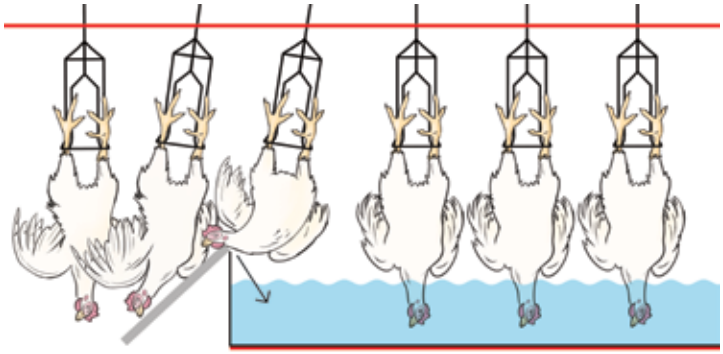
In the electric water bath

The birds' heads are submerged in the water bath that has an electric charge (water reaches shoulder level), while the shackles complete the electrical circuit by contacting earth. The aggres-sive method produces deep stunning. But the current pulse makes muscles contract very strongly and there is a greater risk of internal haematomas and fractures, which is often a significant damage item. A milder setting (high frequency e.g. 600Hz) reduces the damage, but also the depth of stunning. So there is a dilemma between animal welfare and product quality.



It is very undesirable for a broiler to first touch the water with its wing (e.g. if it is hanging crooked). The bird is shocked, pulls itself upwards and misses part of stun process. The head touches the water too late and stunning is insuf-ficient. A special infeed plate will prevent this.

Stunned birds leaving the water bath hang straight, don't move, only tremble and have their eyes open.



A special infeed plate prevents pre-stunning shock. The wings cannot touch the water. At the end of the plate the head falls into the water bath immediately.

More than average

The effectiveness of the stunning depends on frequency (Hz), contact duration, signal form and individual current (mA). Because the individual electrical resistance varies between broilers, the electrical potential difference (voltage) has to be slightly higher than for the average broiler, so that birds with the greatest resistance are also properly stunned (Ohm's law).

Frequency	Individual current
< 200 Hz	100 mA
200-400 Hz	150 mA
400-1500 Hz	200 mA

EU-standards for electric stunning of broilers (EC Regulation 1099/2009). The birds should be stunned for at least 4 seconds.

Insufficient current?

If the amperage is lower than expected (based on the number of broilers, voltage and Ohm's law), check the following:

1. The contact between the power supply and water – Does the electrode cover the full length of the water bath (mandatory in EU)?
2. Contact between water and head – Do all the heads contact the water simultaneously (within 30 cm)? This is clearly visible. Stunned broilers are stiff and stretched.
3. Contact between feet and shackle – Spraying the shackle with water before shackling a bird ensures good contact (mandatory in EU).
4. Contact between the shackle and the earthed guide bar - during stunning, the shackle must stay in contact with the guide bars to maintain the circuit. This can be secured by applying a double guide bar.

The effectiveness relies mainly on voltage, frequency and contact time. Increasing the voltage leads to a higher current, leading to a deeper stun. Increasing the frequency leads to a less deep stun. It is useful to post a guideline in the switch cabinet as a reminder.

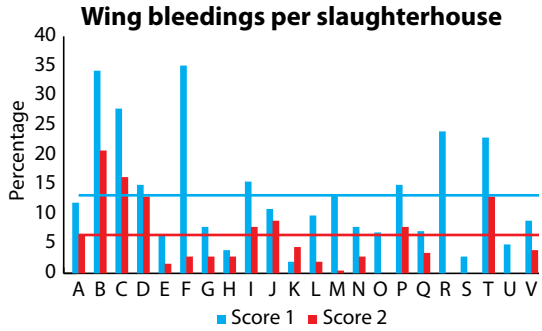
Make sure that the equipment is easy to read. You will only get the right results with the proper settings. And they should be easy to check. The condensation here makes that difficult.

Why is the Amperage in the electric water bath set at 2,6 Ampere? Because of the use of low frequency (below 200 Hertz), every broiler should receive a current of 100 mille-Ampere minimum. In this case there should be a maximum of 26 broilers in the electric water bath at the same time.

You see a darkening of the muscles in the groin area on some carcasses on the slaughter line. This has been caused by the fact that this bird has repeatedly pulled itself up on the shackle.

Bleeding and electric stunning

With electric water bath stunning the shackling of live animals and the consecutive strong electric current going through the whole body can cause bleedings in the carcass. Bleedings could originate from catching and loading, but the difference in colour and coagulation tells you when the bleeding occurred. Bleedings due to stunning are a signal of the quality of your process.



There is a lot of variation in the number and severeness of wing bleedings between different slaughterhouses. Of these 22 slaughterhouses, the ones scoring above average should monitor their bird handling and stunning method.

LOOK-THINK-ACT

What is the signal indicating the location of the wing hematoma?

Wing haematomas can be seen on the inside or on the outside of the wing. You can derive the cause from this. Bruises on the inside are usually caused by putting the broiler into the crate. Do this carefully and with awareness. Bruises on the outside of the wing are usually caused by striking the wings against walls and in bends on the slaughter line. Prevent flapping by applying dim or blue light and avoid stress caused by ups and downs, bends, sudden noise, draughts, light or bumping into objects. A plastic plate along the breast on route from shackling to stunning makes the birds calm (mandatory in EU).

Dead animals in the water bath, a very rare situation, but if it happens it can have a negative effect on the operation. Remove these birds immediately and look for the cause. Of course, you should only do so with the power off!

Assessing the effect of water bath stunning

Stunning should always be checked well on the slaughter line. Insufficiently stunned broilers will be physically paralysed but they might still experience pain and stress. After the water bath stunning, a number of sample birds are checked for stun level. This involves checks on how long it takes for the broilers to react. The bird should not be able to regain posture (stand up) within one minute after stunning.

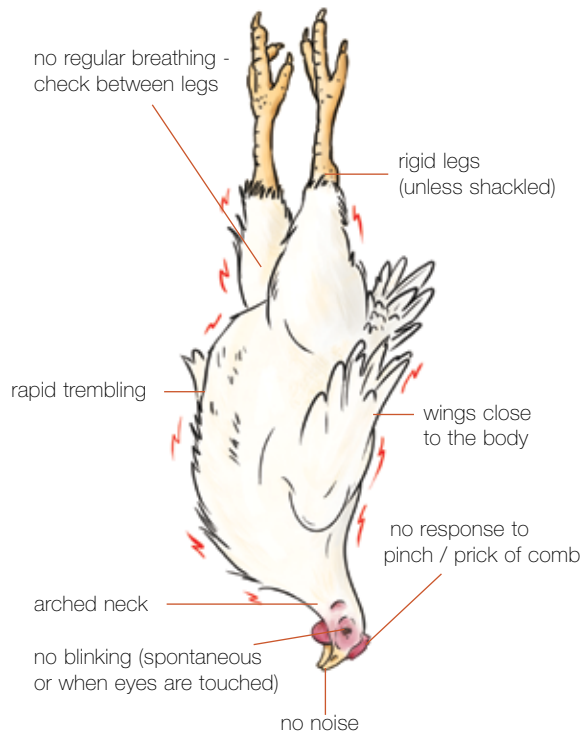
If the broiler is not stunned, it will try to flee, have no muscle cramps, breathe regularly and have an eye that focuses and notices the environment.

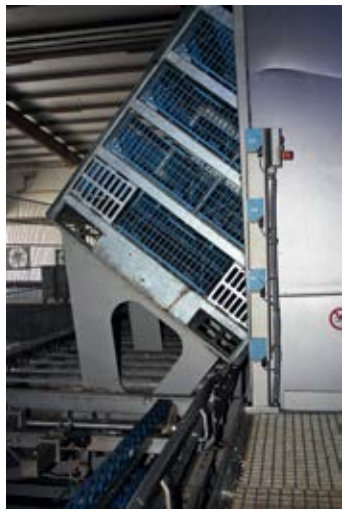
LOOK-THINK-ACT

What signals show blood build-up in the extremities?

After bleeding too much blood can remain in some parts of the bird, especially in extremities like wing tips and the tail. If birds have flapped their wings in the live stage and during stunning and bleeding, blood is forced to the tip. It can also happen after harsh stunning, when birds immediately let their wings hang down during bleeding. Hanging wings do not drain by gravity. Furthermore, if the heart stops pumping, initial bleeding will also be slower. During plucking the remaining blood is forced further into the extremities where it cannot escape: the blood pressure increases until the blood vessels 'burst'. This leads to red wing tips and similarly to a red tail (Parson's nose). And there is always some divergence, so it is difficult to give each animal the right level of shock. It also depends on how wet a bird is and how easily electric current is conducted.

Check for consciousness





When tilting the containers with non-stunned broilers special facilities are necessary, like slides or an impact-absorbing conveyor belt. This prevents bruising of shoulder joints and breast on landing.

Controlled Atmosphere Stunning (CAS)

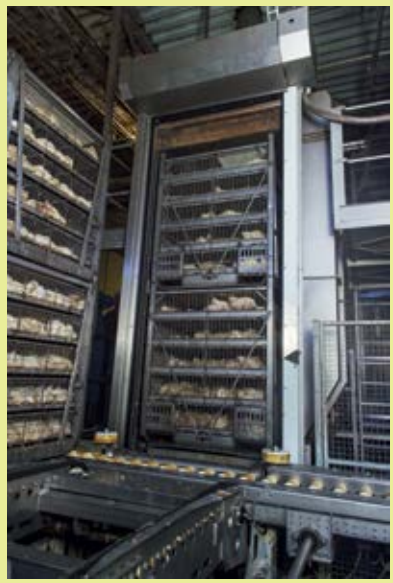
There are two commonly used CAS systems:

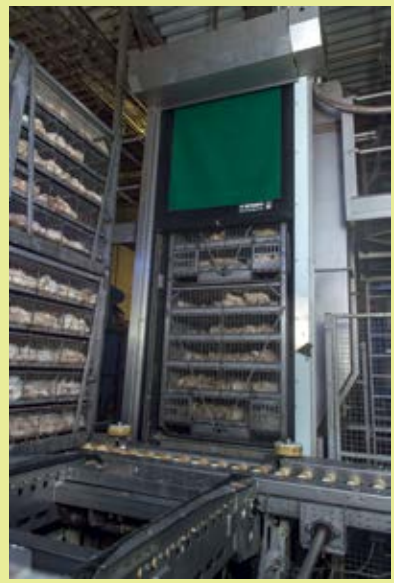
1. The broilers are unloaded on a conveyor belt (by tilting the crate/container), and then transported through the gas stunner.
2. The broilers are stunned in the container/drawer and then unloaded, e.g. by tilting.

CO_2, argon or mixed gases are used in both systems. After gas stunning, the broilers are hung manually. Unconscious animals are easier to handle, which reduces lesions and stress among the birds. Make sure that the temperature of the gas is correct. When the temperature of the gas deviates too much from the body temperature, the animals can panic. It is important to keep them calm during the whole process.

LAPS

In the new LAPS method (Low Atmosphere Pressure Stunning) the air is removed from the space containing the birds. The animal is stunned due to the oxygen deficiency caused by negative pressure (semi-vacuum). It is considered to be a 'low-pain' method.





Stunning broilers in a batch system, where the entire container goes into the gas stunner.

Stunning gases

There are various forms of CAS. The birds are irreversibly stunned in this CAS system. Many slaughterhouses have both CAS and electrical stunning systems available. If there is a fault in the CAS system, they can directly switch over to electric stunning. Another reason to have an operational electric stunning system at hand is to be ready when customers require halal products. For some religious methods, a mild electric stunning is allowed, but gas stunning not. Gas stunning is animal-friendly because live handling, live shackling and in sometimes live tilting is avoided. A quality advantage of CAS is that the fierce contractions of the breast muscles (during electrical stunning) are avoided. Besides, it is much easier for employees to shackle the animals in gas systems.

Stunning with CO_2

CO_2 is heavier than air and therefore easier to control. In a tunnel and pit system the output line often runs upwards, so most of the CO_2 remains in the stunner.

Stunning with inert gases

Inert gases (gases that are chemically non-reactive) can also be used, e.g. argon (Ar) and nitrogen (N_2). Stunning with such gases causes muscle cramps and wing flapping, causing haematomas and fractures. This flapping causes more dust and odours and accelerates the rigor process. N_2 is hard to keep separated from air, and Argon is relatively expensive.

Stunning with nitrous oxide

Stunning with nitrous oxide (N_2O, laughing gas) is also a form of CAS. Laughing gas (nitrous oxide) is especially suitable for killing smaller numbers of animals and for killing birds in houses that have to be cleared (e.g. due to diseases like AI or ND).

CO_2-gradient

Currently common CO_2 systems work in two steps:

1. The broilers lose consciousness at a low concentration of CO_2, which is not painful.
2. The unconscious broilers are then irreversibly stunned with a high CO_2 concentration.

During both the first and second steps, you can also increase the concentration step-by-step. In the example shown here you see a tunnel system with 5 CO_2 concentration gradients.

A stunning tunnel where the animals are unloaded and transported through the gas stunner, in which different gradients of CO_2 are used. The windows allow operatives to check whether the throughput and stunning are running okay.

Shackling stunned birds

The broilers are hung with their backs towards the shackling operative, so that they enter the slaughter line facing the right way. One operative can shackle about 1,500 birds an hour. A carousel is an easy system; the stunned animals lie on a belt that rotates in a circle. After the shackling, the broilers are counted electronically.

After the gas stunning, containers can be tilted and the animals dispatched on a belt (left). Or they stay in the drawer/crate and are hung directly from there (right). There will be less transport damage if they remain in the drawer/crate.

LOOK-THINK-ACT

What caused this haematoma?

This broiler has a haematoma on its shoulder joint. This is caused by a fractured wishbone (collarbone) or shoulder joint dislocation. This could have occurred at different times, e.g. when the bird flapped violently during catching in the house or while being hung on the line. It could also have occurred if the container was tilted roughly and the bird fell on its shoulder. If there are many of these haematomas on shoulder joints, these points in the process need careful checking and evaluation.

This broiler is not properly shackled and that will cause problems later in the process, e.g. during killing. The feet seem too thick for the shackles. Make sure the shackles are not distorted and that they are the correct size.

Shackling stunned birds is much less labour intensive and a less dusty job than non-stunned birds.

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Stragglers

Birds may get stuck by a toe nail sticking in a hole. After tipping, such birds may still be in the container (stragglers). A second tilting may help but it increases the cycle time. However, unloading containers, tilting stunning is a synchronized process with little spare time for extra steps, especially if heavy birds are processed. Heavy birds mean less birds in a container, so more container-loads needed per hour to keep the line filled, so less time available per cycle.

By default, containers are tilted twice. If there is a call for higher processing speed, sometimes they are tilted a bit faster or only once. That results in more stragglers in the containers. Stragglers hang by their nails inside the container. So you should tilt twice, to increase the chance of proper unloading. This occurs often with older animals (or slow-growers) that have longer and crooked nails.

Remove stragglers immediately, as the cycle time is often critical. They can often still go for regular slaughter.

After the removal of stragglers, the containers are washed and checked. A disinfection follows after washing, as shown here.

After emptying the containers, these are automatically cleaned immediately. If necessary, they are manually cleaned as well. Inspect especially the bottom of crates/containers after cleaning. There shouldn't be any crumbled dropping patches larger than 1.5 cm. Disinfection can only take place after cleaning has been carried out correctly.

Mortalities are handled as category 2 waste. Employees on the slaughter line are trained to select these animals before shackling.

If the bird is dark blue, it probably died during transport. If a bird is greenish, it has been dead for some time. It may have died immediately after loading or it might have been dead when loaded...

An experienced employee will identify whether the bird was DOA and rigor mortis has already set in by feeling the slackness of the body. The bird on the left is a DOA, the bird on the right properly stunned.

DOA or stunned?

When using gas stunning, there will also be animals in the containers that have been delivered dead (DOAs). The person shackling the birds must be able to assess this properly. A broiler that was already dead on arrival should not be going to the slaughter line, and it will not bleed properly anyway. A bird that does not bleed will be detected and removed by the inspector after cutting. There is often a pre-check that serves as a first selection immediately after plucking. That is to say, before the veterinary inspection. This inspector also has a role in recognizing DOAs. With the introduction of gas stunning, many DOAs were only selected after scalding. Employee experience led to shifting this selection to increasingly earlier stages, so that most of them are already removed during shackling nowadays. The colour and stage of rigor mortis are particular DOA indicators. Their body temperature will have dropped too, so the birds feel cool. If a bird was dead on delivery, some rigor mortis will have already occurred. This also has an effect on the muscles around feathers; this rigor reduces the pluckability. These animals will then not be plucked properly.

Neck cutting

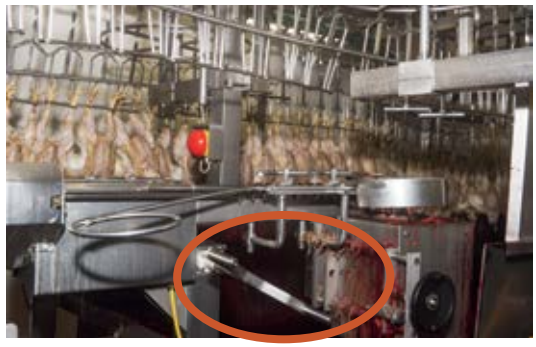
After electrical stun, the bird should be killed by a neck cut a.s.a.p. A maximum of thirty seconds is allowed between electric stunning and killing. Most of the time this is only a few seconds. Bleeding is done by cutting the neck blood vessels. There are several ways to do this: a single cut through a carotid artery and a jugular vein, a single or double cut through both carotid arteries and jugular veins, or through one or both of the vertebral arteries. The EU requires cutting both carotid arteries and both jugular veins, or the vessels they derive from. Outside the EU the most commonly used method involves cutting the jugular vein just under the jaw. This method is easy to perform manually or automatically and results in good bleeding, with the head, trachea and oesophagus remaining intact. This is very important for proper mechanical removal of the trachea later. Automatic high-speed systems work with a system that puts the bird's neck in a position where the veins can be cut with great precision.

Poorly killed birds give us an important signal about the stunning too. If broilers are not properly stunned, killing can also go wrong. A non-stunned bird will always retract its head and miss the guide rail for the neck cut.

After the water bath the animals go to the killer. They are brought into the correct position by a guide rail.

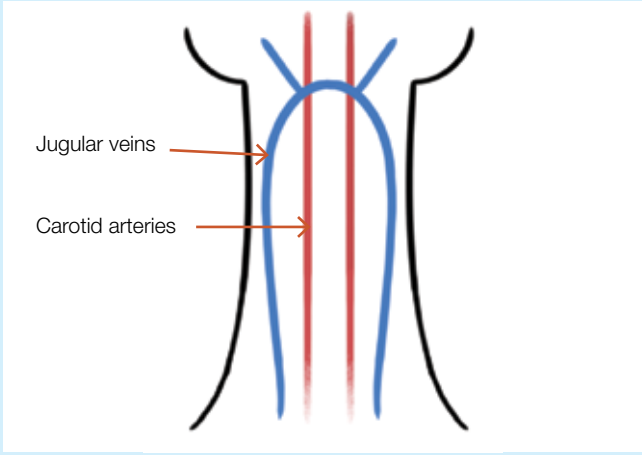
Attaching an extra plate prevents birds missing the guiding rail.

When there is a lot of variation in the uniformity of a flock, like here, the knife will not be at the correct height for every bird. If the flock's uniformity is low (weight variations up to 1 kg per bird occurring), an additional person will be required for cutting during the post-slaughter inspection.



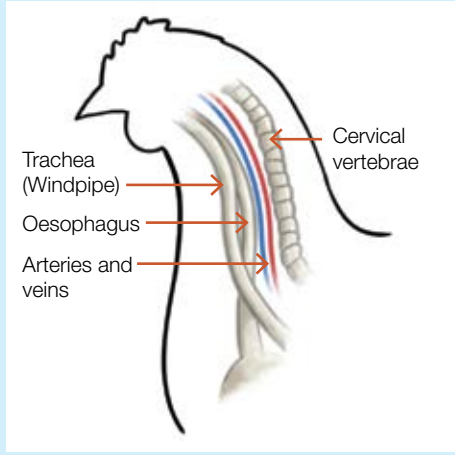
You can adjust the position of the knives accurately per flock. If too many birds are missed and require manual cutting, the blade needs adjusting.

Preserving the oesophagus



If the arteries do not have to be cut, a roller-guide moves the broilers along a rotating knife. The cut is made into the side of the neck, which cuts the veins. This prevents cutting the trachea and oesophagus. In this way the oesophagus remains connected at both ends, i.e. to the head and to the proventriculus. During head pulling the oesophagus will break at the weakest point, i.e. near the crop. The disadvantage here is the risk of crop content contaminating the neck. The advantage is that evisceration requires less force.

Cutting the oesophagus



The carotid arteries lie just behind the oesophagus. If both carotid arteries have to be cut, also cutting through the oesophagus is almost unavoidable. Once cut through, the oesophagus is detached from the head, so it is not removed from the neck during head pulling. A disadvantage is that the eviscerator still has to pull the full length of the oesophagus out of the neck, but with a bigger chance that the oesophagus is removed completely, without risk of tearing the crop.

Less common methods of killing are decapitation or cutting the veins through the beak. Here you can see the killing through the beak, a practice used in some countries (Spain, France). This method leaves the neck intact and the animal can be presented as a whole.

Killing without stunning

Stunning is not always permitted. In Saudi Arabia, for example, broilers are cut without stunning. In countries where stunning is permitted, the current must be mild enough not to kill the bird by stunning.

Halal slaughter

'Halal' means that which is lawful, i.e. everything a Muslim can do to please God. The following requirements apply to halal slaughter:

- The neck cut must slice through the four blood vessels in the neck. Sometimes it may be mechanical or a manual method may be required.
- A specially trained slaughterman of Muslim faith has to perform the slaughter, and cut through the blood vessels in the neck, the trachea and the oesophagus in one operation. The slaughterer must pronounce the blessing 'tasmiya' ('bismillaah allahu akbar') with each broiler.
- If machine killing is allowed, the machine must achieve the cut as described above. Machine killing is only possible after stunning. A non-stunned broiler behaves too unpredictably for machine cutting.
- In the case of machine killing, the tasmiya is usually pronounced once by the machine operator (a Muslim). The blessing then applies to all the broilers that are subsequently killed in that continuous session. The tasmiya must be pronounced again each time the machine restarts. The slaughterer is often given a picture with an Islamic prayer.

Halal certification is awarded by an Islamic institution. There are many types of halal certification. The rules differ for each Islamic movement and by regions. Often, the certification body is mentioned on the label, so Muslims can know which rules have been applied.

بسم الله الرحمن الرحيم

The tasmiya that is pronounced.

In some cases, the slaughtered animal must be facing towards Mecca during cutting, in other cases the person who kills manually must face towards Mecca.

If a chicken is halal slaughtered, it is always stated on the label, in Arabic, and usually the form of Halal slaughter too.

This halal slaughterer has a knife with electrical power on it. The animal is therefore cut without stunning but electrocuted during the cutting, so that the animal does not struggle during bleeding or undergo violent muscle contractions. For the same reason, the broilers sometimes go through an electric water bath after cutting.

Kosher slaughter

'Kosher' also means that which is lawful. Kosher slaughter is called Shechita. Like with Halal, Shechita doesn't allow stunning, as stunning is considered to be injuring, and Shechita forbids to slaughter injured animals. The slaughterer, 'Shochet', is accredited by a religious authority and is under supervision of a rabbi. The purpose of this way of slaughtering is that the animal loses blood as quickly as possible and therefore also its consciousness. The animal must be properly immobilized for slaughter. The slaughter knife ('Chalaf') must be razor sharp, to ensure killing the animal immediately. The knife is checked for sharpness after every slaughter.

After the slaughter the meat is inspected according to Jewish tradition . This includes examination of the lungs. The butcher then removes all fat parts and fatty tissue, including the fat from the veins in which coagulated blood of the slaughtered animal is still present. This task is called 'Porging'. Then frequent salting is used to remove any remaining blood in the slaughtered animal after the neck cut, because consumption of blood is strictly forbidden.

Scalding is not permitted in kosher slaughter. Because no hot water is used to loosen the feathers, a more aggressive method of plucking must be applied. This increases the risk of skin damage and bone fractures (see arrow).

All internal organs, including the lungs, are removed and checked for defects. A cut in the hock tendon (Achilles tendon) also serves as a quality check, particularly to ensure that bleeding was adequate.

When slaughtering (healthy and stress-free) broilers, the carotid arteries, the trachea and the oesophagus must be cut with a 'Chalaf' in an uninterrupted movement. The blood is collected in a funnel and may not be processed further.

Before the meat may be eaten, it must be put in salt for at least one hour and then washed in a water tank, to remove any remaining blood insofar as possible.

Bleeding

Changes in a broiler's body begin at the moment of onset of death. Cutting the neck veins causes the heart to pump the blood out of the body. The blood flow from the body starts immediately and takes 2-5 minutes, depending on the size and type of broiler. Factors that influence the amount of blood loss include pre-slaughter stress, the stunning method and the time between stunning and bleeding.

Due to the capillary veins and the rapid blood vessel constriction, 50-65% of the carcass's blood volume remains. Especially in the vital organs and in the capillaries. This is approximately 3.5% of the body weight (i.e. approx. 70 ml in a 2 kg broiler). This also gives the meat the pink colour. If a broiler does not bleed enough, the flesh may become too dark and you will see blood stains and swollen wing veins. If the broiler loses too much blood, the breast fillet may become too pale. Broilers bleed best when stunned electrically with a high frequency.

The head puller

At the end of the blood gutter or the slaughter line, the broiler's head is inserted between two guide rods and pulled downwards. This breaks the neck vertebrae at the weakest spot in the neck, between the atlas and the axis. Depending on the cut performed at bleeding, the oesophagus and trachea are removed at the same time (up to the point of attachment to the lungs). This is heavy work if you have to perform it manually. After passing through a crusher, these parts are dispatched to the slaughterhouse's waste storage.

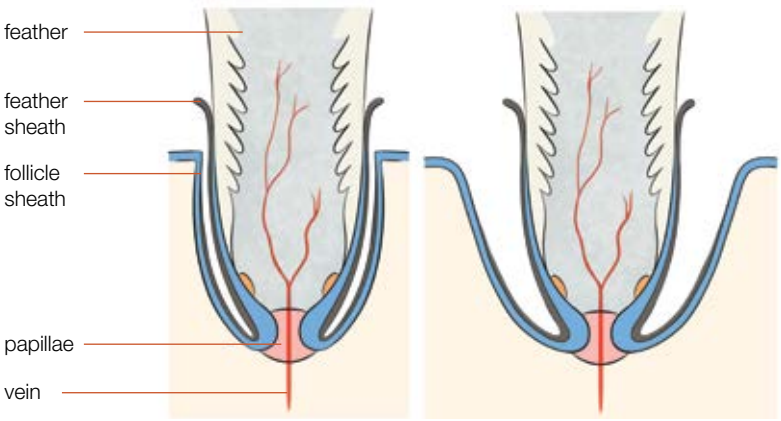
Between cutting and bleeding, an inspector checks whether the animal has been properly cut. There is a visual inspection during bleeding, and the post-inspector can still cut any birds that have been missed or where cutting was poor. The white plate behind the carcasses makes it easy to see if the animals bleed.

The blood is collected in a blood gutter. It must be long enough to allow a broiler to bleed for 2.5 minutes.

The head puller works under a lot of power. Its height is adjustable for the size of broilers in the flock.

Scalding, plucking, evisceration

The killed and bled broiler is now called a carcass. After scalding, plucking and evisceration the meat is clearly visible. The veterinary inspection is done after these steps.



Scalding softens the tissue around the feathers. They are now less embedded, so that they can be removed during plucking (right picture).

Scalding loosens the feathers by softening the feather follicles. The process can be performed by immersing the broilers in a long, hot water bath. It is usually a series of several baths in succession. When applying hot water scalding in a tank, there must be good water movement and a uniform water temperature to ensure that the heat penetrates well everywhere.

Low or high-temperature scalding

There are two distinct scalding methods, high and low temperature.

- Low-to-medium scalding at a temperature of about 52°C/125°F, for 2 to 4 minutes – The epidermis will remain intact with this method, which prevents bacteria and water penetrating through the skin.

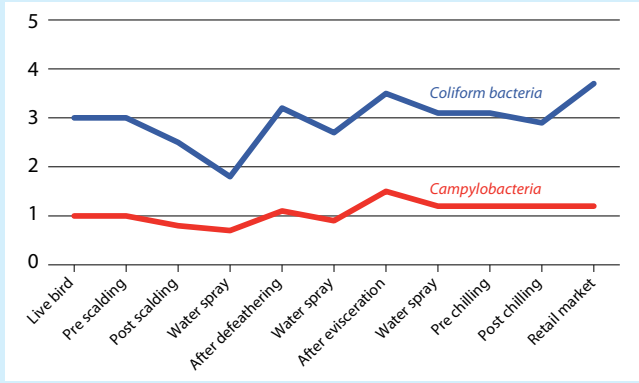
- High-temperature scalding at approx. 58°C/135°F for 1.5 minutes – This method loosens the epidermis and the plucker removes it. Skin without epidermis is easier for bacteria to penetrate. This scalding method is mainly used for meat and carcasses that will be frozen. Once the epidermis is removed, the surface needs to remain moist to avoid discoloration.

In Europe, low-to-medium heat is usually used for young broilers, because it prevents skin damage, while still allowing relatively easy plucking. In the USA, the epidermis is almost completely removed as standard practice.

Hygiene during scalding

You would expect the scalding water to be a source of infection during immersion and jet stream or jacuzzi scalding. But it seems that many more bacteria are washed off the bird into the water than get onto it. The scalding tank is in fact more comparable to a washing machine, and multi-stage scalding increases the rinsing effect.

Bacterial contamination during the process



The number of bacteria (E-coli, Salmonella, and Campylobacter) decreases during immersion scalding. So the benefit of washing (due to the turbulent water flow) and killing bacteria (with the scalding temperature) therefore far outweighs the disadvantage of cross-contamination. Contamination increases considerably again during plucking but part of that is flushed off again. Here it also increases a little during evisceration but the internal and external washers bring it down again. The biggest increase is seen during the post-slaughter journey to the consumer.

Air bubbles from the bottom (jacuzzi) or jet streams ensure that the feathers stand well apart. This allows the hot water to reach the feather follicles well. A still water bath would cause the feathers to flatten, creating a barrier that would prevent the water and heat from reaching the skin. Besides that, the carcasses would start to float.

Keep in mind that a lot of contamination washes off the broilers in the submersion scalder. That makes the scalding water look dirty but the temperature still kills many bacteria. The water temperature must be constant.

LOOK-THINK-ACT

What do you see here?

Make sure that broilers do not hang in hot water for too long, e.g. in the event of a break-down. That produces cooking effects in the meat (pale, dry and fibrous). It is a superficial phenomenon. The dark coloured part is locally less cooked, because the skin there is thicker, and it protects the meat from the heat.

Hygiene measures

- Use potable water to fill the scalding container.
- Keep the scalding water at a fixed, constant temperature.
- Empty, clean and disinfect the scalding tank every day.

Scalding temperature

The higher the scalding temperature, the easier the feathers release from the follicles. On the other hand, high-temperature scalding has a heavier effect on the skin and the outer layer of the skin (epidermis) loosens and comes off during plucking. Without the epidermis, the meat becomes lighter and the meat loses its yellowish colour. Skin dehydration causes a parchment-like surface. So make sure there is sufficient moisture supply during cooling after high-temperature scalding. In countries with a preference for lighter skin, high-temperature scalding can be used especially to achieve that. High-temperature can also be applied to components such as feet and legs, because the feathers there are more difficult to remove. If the broilers are very young, even medium heat can remove parts of the epidermis, causing the skin to become sticky. A few degrees difference in the scalding temperature has major consequences. So scalders must have precision controls in steps of 0.1 to 0.2°C (2-4°F).

Often there are several tanks in sequence, and the water from a previous tank can drip off the birds in between. So the broilers go into ever-cleaner water, with fewer bacteria each time. Setting the temperature of the last tank a little higher gives a shot of heat that improves the plucking result.

Do not only rely on the indicators on the screen; double check the temperature regularly.

Hot air scalding

Another possibility is to expose the broilers to moisture-saturated hot air. In this method, compressed air is blown onto the carcass (but not directly onto the breast). The air ensures that the feathers do not stick to each other and that the heat can reach the feather follicles. The use of moist air saves water compared to water bath scalding. Another advantage of air scalding is that you can blow very specifically onto certain parts. Scalding is therefore more controllable. Attention! Never air scald at temperatures higher than 62°C /144°F, because the 'sauna effect' will then cause scalded meat (pale, dry, fibrous).

Extra checks

The chance is minimal that a broiler is not properly stunned, *and* missed by the killer *and* missed by the manual back-up killer. But it is a realistic risk with production numbers of up to 200,000 birds per day. Every broiler that goes into the scalder alive is one too many. You can easily recognise those drowned broilers by their purple colour. If you see this signal, you have to check the stunner and the automatic killer, and have a serious word with the inspector (manual back-up killer).

These birds have - for whatever reason - hung in the scalding bath for too long and have been clearly 'over-scalded'.

LOOK-THINK-ACT

What does a purple broiler signal?

This broiler came out of the scalder purple. This is a serious matter. It is a signal that killing did not work properly. The stunner, the killer and the (human) follow-up inspection all missed this broiler! Purple broilers after scalding are definitely not permissible on the slaughter line. If you see one, check the stunner, check the killer and alarm the manual back-up killer.

Plucking is a process in stages, coarse, medium and then fine. In the first stage, 80-90% of the feathers are removed. The last 10-20% is removed in the middle and final plucking cycle.

Plucking

During plucking, rubber fingers rub the feathers off the carcass at high speed. The broilers hang upside down on the slaughter line and move between opposing-rotation discs with plucking fingers. The height and space between the discs can be adjusted to different broiler sizes, the line speed and the assigned task. Plucking fingers come in different lengths, hardness and elasticity. The rubber used is food-grade, so no threat to food safety. The broiler is sprayed during the operation, to remove loose feathers and dirt and to prevent skin ruptures. The massage effect of plucking fingers on the skin also stimulates the meat ageing process. Plucking is always a quest for balance between maximum removal results and maintaining epidermis quality (if it is required intact).

Rubber plucking fingers have ribs around the diameter and are available in various degrees of hardness (45 to 70 shore). You can thus choose the right hardness for plucking different sections of the broiler.

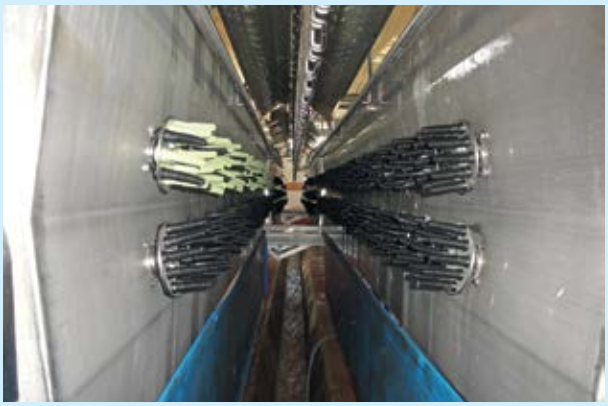
For some final products you want to keep the head on the carcass. If the cervical vertebrae are accidentally cut through during cutting, the head is usually lost in the plucking process.

LOOK-THINK-ACT

Faeces on the carcass. What does this indicate?

You can see faeces on the carcass, between the feathers or on the carcass itself. Plucking discs that exert pressure on the groin with the plucking fingers can inadvertently push out gut parts and faeces from the intestine. This will contaminate the carcass. The birds have not fasted long enough or the pluckers are set too tightly.

Set-up and adjustment of plucking unit



Two parts of the same plucking unit. The 2 x 2 setup for coarse plucking and a 2 x 3 setup for the finer feathers.

New plucking fingers that still have to be placed.

The vertically placed plucking fingers handle the head.

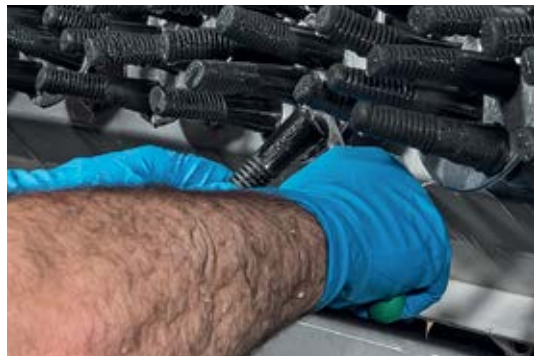
These plucking fingers were worn out and are replaced. The left and right have been broken and the middle has been severely damaged.

Electrical stimulation

You can apply electrostimulation during bleeding or after plucking. This is not a standard procedure. The breast is brought into contact with a stainless steel plate carrying electric current. Through a fast muscle contraction, facilitates the consumption of glycogen in the muscle, reducing fast the pH, and accelerating rigor mortis development and resolution. The meat remains tender, has more consistent quality, is longer lasting and more colour-stable, its pH decreases faster, and there is an improvement in taste. You also need less cooling capacity and have increased turnover speed, because electrostimulation accelerates the ageing (maturation) process, Rigor mortis normally disperses within three to eight hours, and then the meat can go on for processing. Electrostimulation reduces that duration to 1 to 3 hours. That means that the chicken meat can be processed from about 3.5 hours after bleeding. So electrostimulation aims to improve both quality and efficiency.

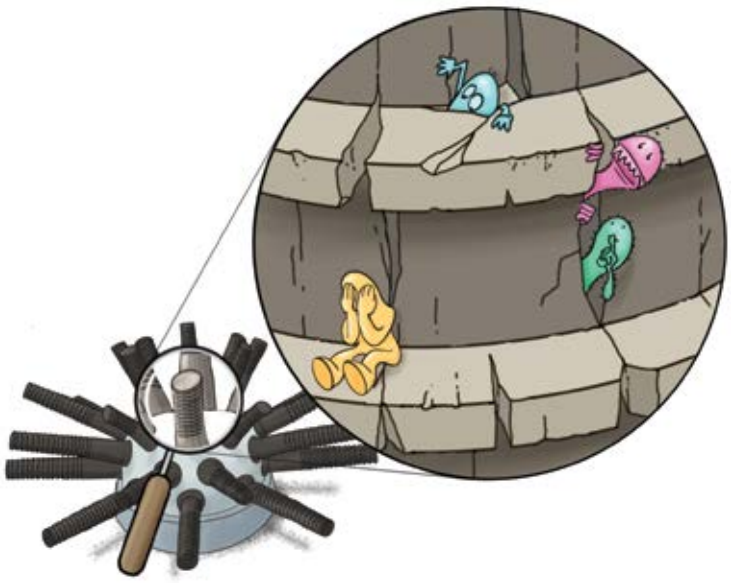
Replacing a plucking finger

The working life of a plucking finger is about twenty days. In a plucking unit with 4,000 fingers, you have to replace 200 fingers every day (this amounts to 200,000 broilers per day/200 = one finger per 1,000 broilers). Check and replace worn plucking fingers every day. Make sure there is good balance between new and old fingers on a disc. Too many new fingers will make plucking too aggressive. Replacement often happens at the end of the day, when employees are tired and want to go home. It is tempting to set the scalder temperature higher if plucking results are under par (compensatory behaviour), but that is only symptom management. So let a team leader or inspector, who does not carry out the replacement work himself, check the plucking fingers in the morning. He or she is more objective and fresh and can point out faults to an operator if necessary. Poor plucking finger replacement is at the expense of quality, i.e. poor plucking results (more feathers remain), and there might be semi-cooked spots due to setting the scalding temperature higher to compensate or more skin damage if you set the plucker plates at a different angle to each other.

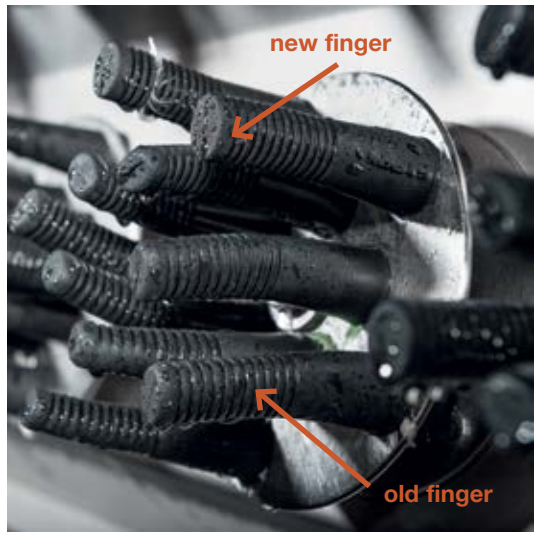


You replace a plucking finger by cutting the old one off the disc and pulling the replacement through the hole again.

With this tool it is easy to fit new fingers.



Porous rubber plucking fingers are breeding grounds for bacteria. The hairline cracks offer a good hiding place and breeding ground for bacteria. And pieces of the fingers can break off over time.



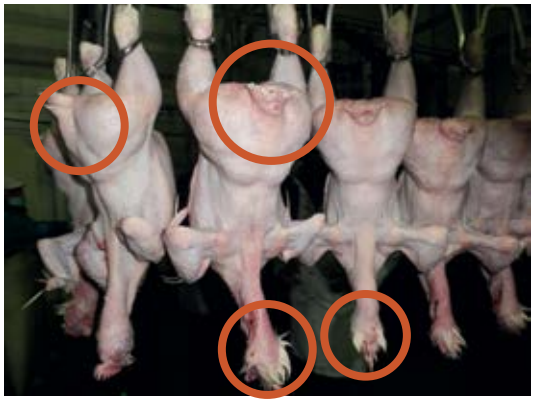
New fingers are more aggressive than old ones. To keep pluckers working at constant performance, you need to replace fingers every day, so that not too many fingers need renewal at once. In that way the average age and extent of wear is constant.

Plucking results

Tricky feathers

Removing the larger and breast feathers is usually problem free but the feathers on the neck, wing tips, tail and especially the hocks are trickier. The feathers on the hocks are a hair-like type, attached firmly and difficult to grip. Removing them requires more force. You can achieve this by placing the discs with the plucking fingers closer to the skin or by fitting more plucking fingers for those particular locations.

This broiler is not plucked sufficiently. You can only pluck a bird well if it is scalded well first. Good plucking finger settings are important as well. This is a relatively small bird in a flock that is insufficiently touched by the plucking fingers.



Feathers usually remain longest around the tail, wing tips and neck.

Plucking and scalding temperature

After low-temp scalding, you use softer plucking fingers than with high-temp. It is important to protect the epidermis after low-temp scalding. With high-temp scalding, the epidermis is removed deliberately. A broiler without epidermis is smoother and therefore easier to pack. Scalding at 50°C/122°F reduces the required force to remove feathers by 30% compared to that needed with a live broiler. A scalding temperature of 53°C/127°F reduces the required pulling force by 50% and 60°C/140°F makes it a full 95% less.

A burner is a good solution for removing the smallest hair feathers properly. The carcass is guided along a moderately hot yellow flame, which burns the feathers off but leaves the skin intact. This also kills microorganisms on the skin and thus prevents spoilage. This is not standard in slaughterhouses.

There is often an inspector after plucking, before the veterinary check. He or she can remove abnormalities, or adjust the scalders and pluckers if necessary.

The feathers have been removed. The feather follicles are now open, and that presents a big risk of bacteria establishing themselves there. This is why the carcasses undergo high-pressure rinsing with spray nozzles, to remove residual dirt.

The feathers have been removed but bits of feather sheath are still in the carcass. However, when the tails are removed this is not a problem.

You might see swollen feather follicles on birds on the slaughter line. These could be tumours caused by an aggressive type of the Marek's disease virus, particularly in tropical countries and among broilers reared over longer periods.

Breed

Slow-growing varieties pluck a lot better and you can scald these varieties with a slightly lower temperature. Although you might expect that they would be more difficult because of their more mature plumage (due to higher slaughter age).

Stunning

The method of stunning also influences the plucking result. Gas stunning is more animal-friendly, but plucking results are inferior because the feathers are fixed harder. The process of rigor mortis starts after stunning, because respiration also stops at that time. The time between stunning and scalding can be up to 10 minutes, or even more. With electric stunning, there are only 2-4 minutes (bleeding time) between stunning and scalding.

Ambient temperature

The ambient temperature has an effect on plucking, because the skin grips the feathers tighter in cold skin (like goose pimples). So make sure that temperatures are never too low during and around transport. When it is cold, removing feathers on the ends of the body is harder. That is to say at the tail and wing tips, where the feathers are harder to remove anyway.

Feed

Plucking results can even be traced back to the feed ration. Sometimes a poultry farmer reduces the ration a little at the end of the production cycle to avoid overweight animals and satisfy advance agreements with slaughterhouses about delivery weights. But those chickens, in effect, 'shrink' and plucking results are clearly worse.

Plucking damage

Tears can develop in the skin (ruptures) during plucking. This often happens in places with scar tissue. If a scratch occurred a long time before slaughter, it is filled up with connective tissue. A lot of stiff collagen is produced in scar tissue, which means it is not elastic. And that means scar tissue will tear more easily, e.g. in the plucking machine. Fresher scar tissue is particularly fragile and will tear open easier under the mechanical influences of the plucking fingers. Skin ruptures allow accesses for contamination with water and micro-organisms during the rest of the process. The value of these carcasses can be between 20 and 50% less if there is extensive rupturing.

This broiler's skin is damaged. The skin of young broilers is more vulnerable than that of older animals. Nutrition plays a role in maintaining good, stretchable skin (good collagen) and the formation of subcutaneous fat. So opt for the appropriate plucking finger hardness for that.

Perforation lines

Some skin ruptures only become visible after plucking but they were not caused by it. Examples include skin lesions from fighting or birds walking over each other. You can recognize older skin lesions by the 'perforated lines' of newly repaired skin, which could tear open again during plucking.

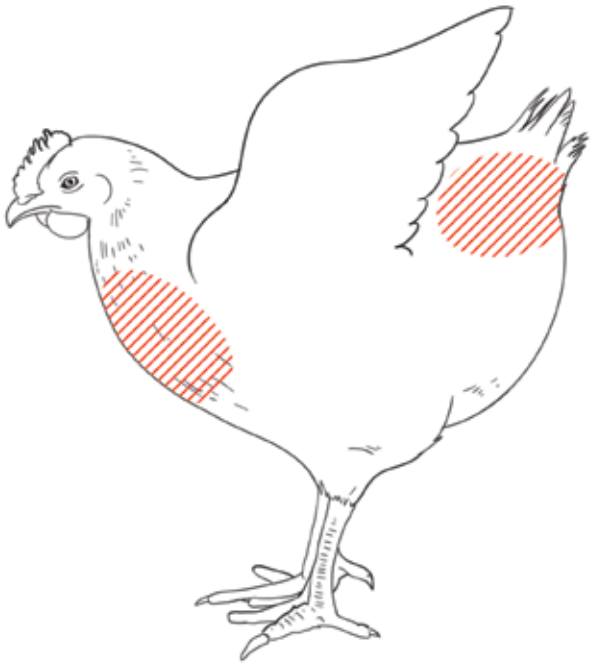
LOOK-THINK-ACT

What do these skin ruptures tell you?

You are seeing multiple carcasses with these skin ruptures after plucking. Besides this being a signal that the animals might have scabby hips, it could be a signal that the plucking discs are set too tight and not properly adjusted to the (larger) size of these broilers. Adjust them correctly!

Assessing skin ruptures

The greatest number of skin ruptures is caused during plucking. They can also occur during dressing whole birds (trussing for presentation). This task puts the skin under tension, which can cause lesions in weaker skin. The whole skin tears in these cases, and without haematomas or inflammation.



Skin ruptures usually occur on both sides of the back near the tail and in the breast skin – Tearing the breast skin is the most problematic/costly from a financial point of view.

A typical case of mechanical damage by the plucker – The skin and flesh under it is damaged and plucking is incomplete.

A severe breast skin rupture. It is clear that not only the skin ruptures, but the meat is affected as well.

Smaller skin ruptures (< 3 cm long) are considered a quality reduction.

Larger ruptures (> 3 cm) are trimmed, especially if they are contaminated.

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Assessing skin scratches

A normal broiler skin is smooth, intact, pale pink and has good plumage cover. Skin scratches on the back and thighs are caused by animals climbing over each other, e.g. during feeding, catching or when people do not take sufficient care when carrying out tasks inside the house. Skin scratches can cause subcutaneous inflammation, from bacteria on the nails that created the wound and from the litter. These infected wounds must be trimmed away because they present a risk of food poisoning in the consumer. Fresh and superficial scratches do not pose a risk to public health, but can lead to reduced value.

Assessing skin colour

You can see and assess the skin for the first time when the bird is plucked. And abnormalities concealed under the plumage become visible.
Skin pigmentation can occur genetically (melanin) or from feed, like yellow maize or feed additives (xanthophyl present in epidermis).

Most of these injuries are fresh (less than eight hours, red, streaky and superficial).

A colour swatch is a quick and simple tool for objectively comparing colours. It is important to do this in a well-lit room.

Older scratches are black-brown and have scabs. In some cases there are infected open wounds with inflammation (red and swollen, and with dead/necrotic tissue).

You can objectively assess the skin and meat colour with an electronic spectrometer.

The hock/feet sections remain in the shackles and are removed elsewhere.

The feet can be processed and are very popular in Asia.

During processing the feet the epidermis is partly peeled off with a scraper. But not more than necessary. The machines are set in such a way that if it feels less resistance, sufficient epidermis has been removed.

Removing the feet

In the first rehanger the birds are rehung from their feet (in the slaughter line) to their ankle joints (in the evisceration line). The metatarsus/foot section is cut off in the rehanger. You have to remove the leg (metatarsus and foot) in a way that does not damage the drumstick. That is why the hock joint is first bent, and then cut with hock/feet cutter. It is important to cut anatomically (through the hock joint), and not through the bone. Cuts through bone will cause dark or red discoloration in the chilled carcass through exuding red bone marrow, and it can become even darker or discoloured to black when cooked. A bad cut can be at the expense of the drumstick, which reduces yield and, besides that, a carcass cannot be shackled from a hock that is cut too short. The cut-off hock/feet sections remain hanging on the line and go to a dedicated dispatch station for those parts. The hock/feet sections can then be prepared for export to Asia or to another market, e.g. pet food. After the rehanger the shackle is empty and can be cleaned. The carcass now goes into a clean department, the primary processing line. Extra hygienic working methods are required here because the carcass is cut open and eviscerated in this department.

Primary processing line

Vent cutter (or venter)

The vent is the point where the cloaca is attached to the skin. The broiler is clamped for vent removal. Then a centring pin is placed in the vent, so that it hangs in the right position for the vent cutter. This instrument is a hollow knife that revolves around the centring pin. The knife diameter must match the size of the broiler. After cutting the vent away, the knife clamps it against the centring pin, so that the machine can pull the vent out of the broiler carcass with the tail-end of the intestine. The vent and the end of the intestine are then hung over the back of the carcass. It is very important that there is no contamination by faeces or intestinal contents. The knife and centring pin are rinsed off after each broiler.

Abdominal cavity opener

To ensure proper removal of organs from the abdominal cavity, the opener makes the hole larger, from cutter-hole to the tip of the sternum (breastbone).

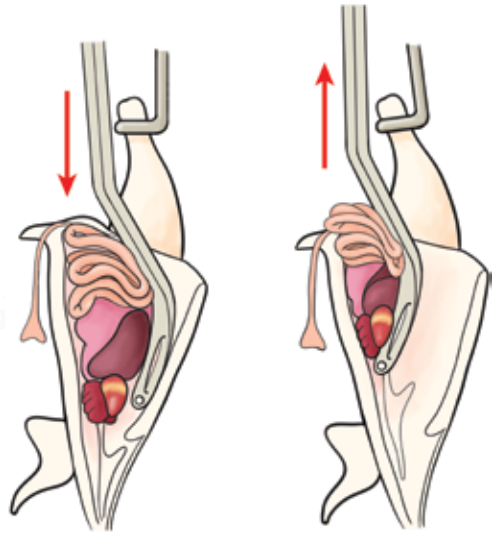
Eviscerator

The eviscerator now pulls all the organs out of the broiler's body cavity in one go. The evisceration paddle slowly moves down as far as possible along the breast side of the broiler and scrapes against the back of the carcass, carefully lifting the entire set of organs upwards and out. Setting the machine to broiler size is very important here, because an incorrectly adjusted machine can damage intestines and carcasses and cause intestinal leaks. The latter involves risk of contaminating the carcass (contamination with intestinal contents, faeces and bile). The evisceration paddle is sprayed clean after each broiler, to prevent cross-contamination.

Influence of crude fibre on evisceration

Some broilers' intestines are easier to remove from the carcass during evisceration. This is often the case with broilers that have been fed a high amount of crude fibre. It leads to better developed and heavier intestines.

The vent cutter – The vent is cut around, lifted upwards and hung over the back.



The eviscerator

The oil gland on the tail

The preen (uropygial) gland, at the tail end of the body, provides preening oil. Touching the preen gland stimulates it to excrete small amounts of oil, which the bird distributes over the feathers with stroking movements of its beak. This gland is often cut away from carcasses going to market as whole birds: its content has a bitter taste.

A veterinary inspector (right) is the final responsible person for the meat inspection, but he is not always present at the inspection platform. Assistants or abattoir employees perform the actual inspection.

Special attention is given to the organs, since diseases can be detected in intestinal abnormalities.

Post mortem inspection

In most countries, broilers and their organs undergo official veterinary inspection and approval for human consumption. In some countries, each individual broiler must undergo inspection on the slaughter line, as is obligatory in the EU. In other countries a flock is assessed by random sampling. The inspector can opt to assess all the carcasses when there is disease outbreak. There are still some countries where there are no inspection requirements at all. This can cause international trade problems, unless the chicken meat only ends up on the local market.

Sets of organs

The internal organs must be identifiable and traceable to the carcass it came from at this stage. This is necessary for proper inspection of the entire bird for veterinary defects. That is why the set of internal organs moves synchronously with the carcass. For example, in cases of severe liver inflammation, you cannot only reject the set of organs, because pathogens and toxins from the liver spread all over the associated carcass through the bloodstream. The organs and the carcass may only be separated after the slaughter inspection. Edible organs (liver, heart, and gizzard) are separated from non-edible parts such as the head, proventriculus and intestines (category 2 offal). There are three possibilities after removing the organs:

The set of organs remains hung outside of the carcass, on the stomach fat on the back of the broiler. This system was generally accepted until the early nineties.

The set of organs is placed on a dish designated for the broiler.

The organs hang on a hook running parallel with the carcass line. The heart and lungs hang above the clamp, and the liver with the rest of the organs below it. The intestines hang at the very bottom, so that they cannot infect the other (edible) organs.

Role of the inspectors

There are several specially trained company inspectors present; they must be able to recognize and evaluate various symptoms of diseases and defects.

They also have to be decisive as e.g. 7,000 broilers per hour pass by each inspection platform, so the inspector has an average of half a second to assess each broiler. The inspector checks the carcass and the corresponding intestinal pack.

The pack: Internal organs such as liver, heart, spleen, lungs and intestines are inspected as they can reveal diseases, infections and other problems. Some defects in the pack lead to the rejection of the carcass as well.

The carcass: Depending on the defect, a carcass is approved, rejected or trimmed. In some cases the corresponding pack is also rejected.

Clearly, inspection is very intensive work. That is why inspectors work in very short shifts of twenty to thirty minutes, and are then relieved. Although the inspectors are on the payroll of the plant, they are under the remit of independent, official, governmental veterinary supervision. It is an important element in maintaining general public health and animal welfare.

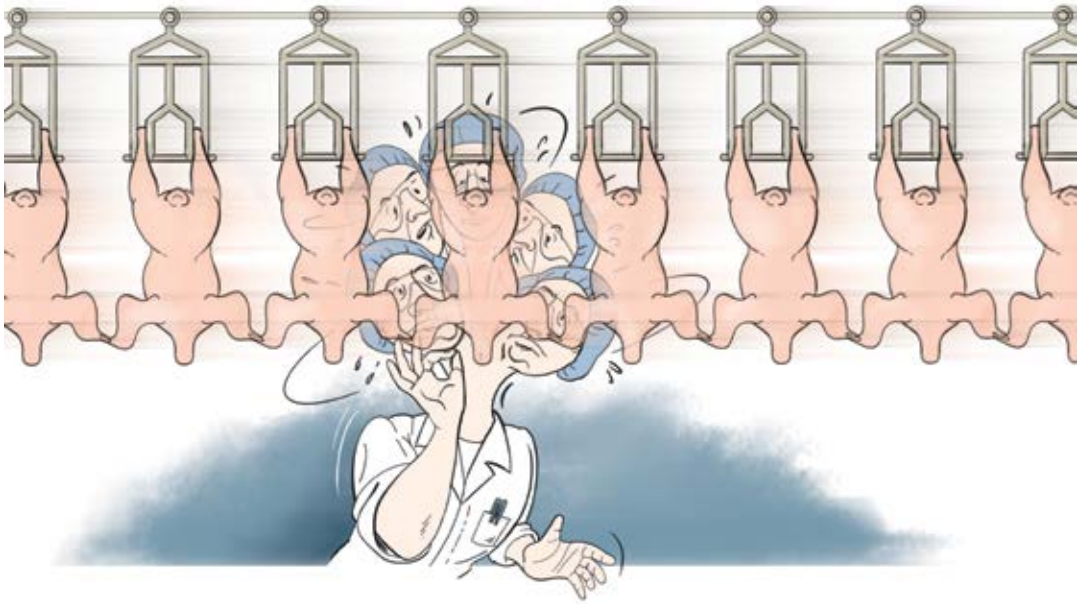
The inspector's inspection points

The inspector watches out for sick animals and carcasses contaminated with faeces or bile. The most common abnormalities the inspector checks for are:

- polyserositis – an inflammation of thin membranes lining the body cavities
- ascites - waterbelly
- hepatitis – liver inflammation
- cachexia – extreme emaciation
- cellulitis – a subcutaneous inflammation
- dermatitis – skin inflammations
- extensive injuries/lesions
- fractures - broken bones
- luxations - joint dislocations
- extensive haematomas
- contamination with faeces or bile
- abnormal colour – reddening caused by generalized infection/fever

Payment varies by country

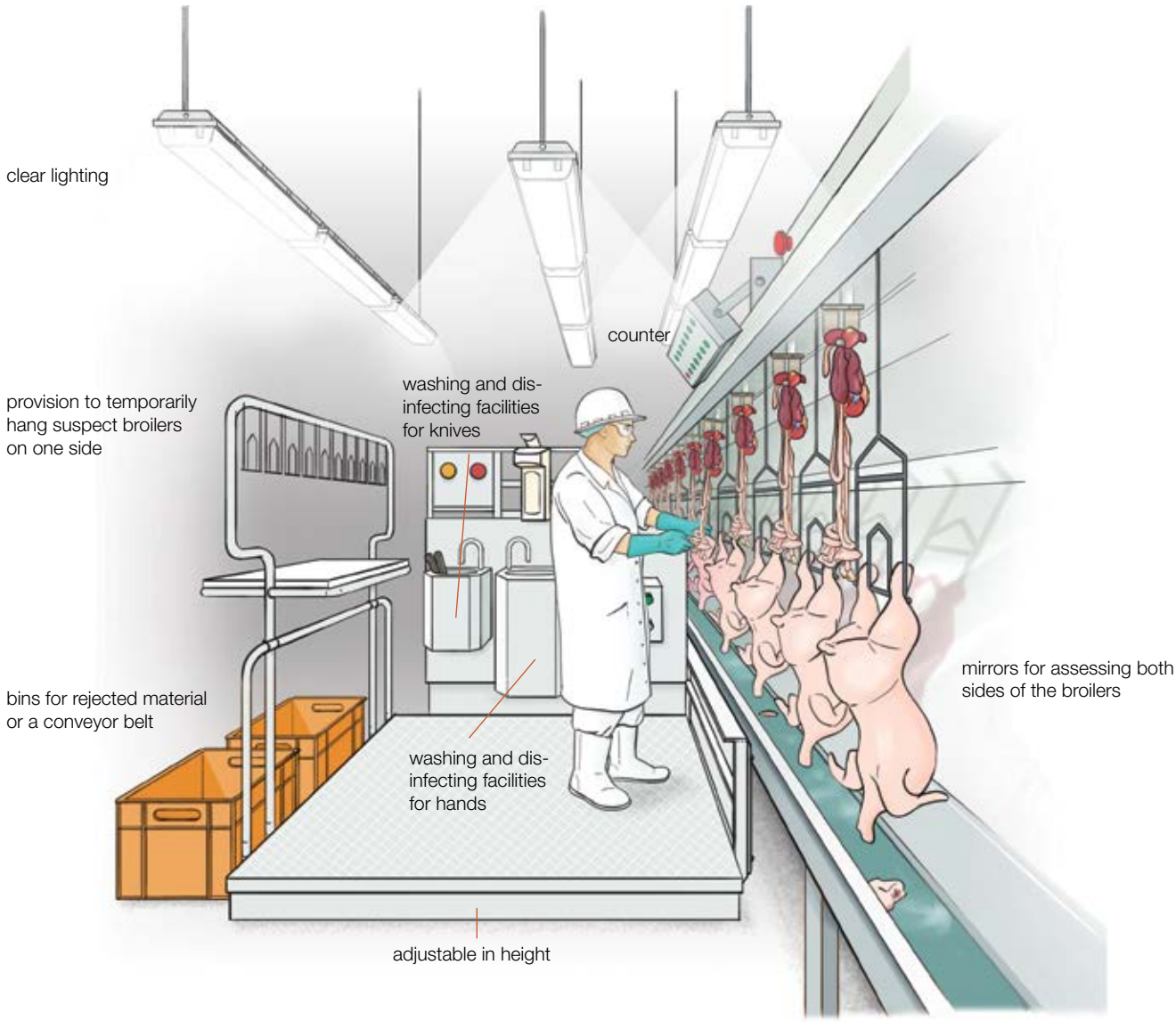
There are different systems of payment to broiler farmers in various countries. In the Netherlands, payment is usually based on live weight. The batch of broilers is weighed on delivery to the slaughterhouse. The poultry farmer will receive a reduction for excessive crop fill, too many rejections, DOAs and catching or transport injuries. In Norway, the slaughterhouse pays the poultry farmer based on the weight that leaves the cooling area at the end of the line. All losses up to that moment are at the poultry farmer's risk.



Inspection work demands supreme concentration and that makes it intensive work. The inspector often alternates between half-hour sessions on duty and half-hour breaks. Inspectors are usually supervised by a veterinarian.

Inspection platforms

The inspection platforms must be brightly lit. The lighting must give a good picture of the true colour of the carcass and may not shed any shadows. The platforms must be adjustable in height, to allow adjustment to the inspector's height. This is a legal requirement in most countries. There must be provisions for hand washing with a minimum temperature of 18°C/64°F, a hot water tank at 82°C/180°F for sterilizing cutting knives after contamination and a rack with hooks to suspend suspect birds separately for further checks. And there must be two easily recognizable, leak-proof waste bins present (one for rejected broilers and another for parts). Most slaughterhouses have a conveyor belt that transports rejected material to a container outside the slaughter unit. This material is then processed by the rendering plant (category 2 material).



Proper assessment

The carcasses must be clearly visible all around. Thus there should be sufficient space between the birds, as the work often involves using mirrors. These mirrors allow the inspector to assess the breast side of the carcass.

To facilitate good assessment, mirrors are often placed on the breast side of the broilers, so that the inspector can check the broiler well without touching it.

This mirror is too dirty for good observation. You need to make sure they are cleaned regularly in the humid environment of a slaughterhouse.

When there is any doubt, the carcass is removed from the line for further inspection.

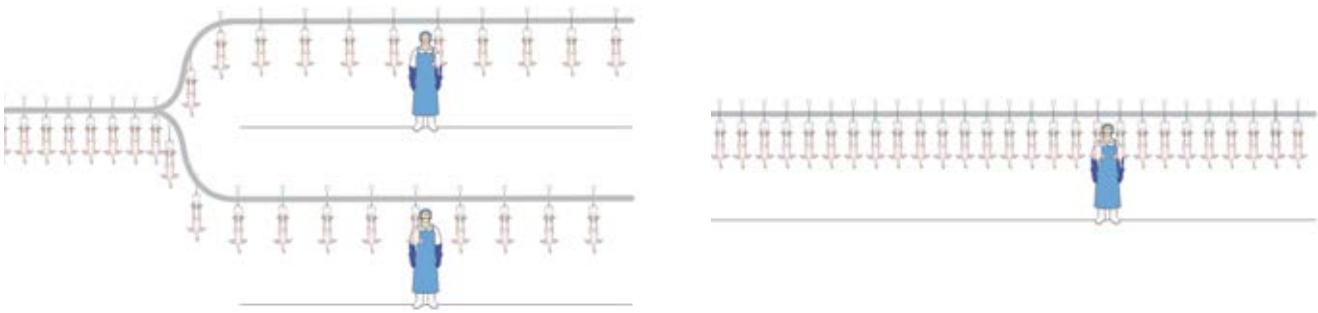
Keeping up to date records of rejections by the inspector can be done in a simple way or with more advanced computer-assisted methods. These are some examples of a manual counter, buttons and touch screen systems.

Line speed

The slaughter line is set at a certain speed, with all its parts tuned to each other. For inspection purposes, the slaughter line can also be split into several intermediate lines so that, for example, one inspector only inspects the even broilers and the other inspects odd ones. Another solution is the use of a single line with marked or coloured shackles with an inspector assigned to check birds on shackles with a specific colour. In the case of a poor flock, an inspector will focus on the most important defects. However, that can lead to some lower quality broilers being let through with these flocks.

Setting the slaughter line slower

In cases of poor flocks, the inspector should have assistance from slaughterhouse staff. Setting the slaughter line slower is not recommended, because it is optimized for a certain speed. Running more slowly can lead to an increase in slaughter faults. Critical times for processes (e.g. bleeding, scalding and plucking) become longer, leading to excessive scalding and plucking damage. Furthermore, broilers will be waiting longer and therefore be without feed too long, which is detrimental to animal welfare, yield and hygiene.



If the line splits, you can use the maximum speed of a slaughter line, while two inspectors can continue to perform their task well. They only have to deal with half the number of carcasses per hour than they would with a single line. Often these split lines merge again into a single line after inspection.

Rejections

There are guidelines on whether a carcass is rejected in whole or part at the veterinary inspection (EU: 71/118/EEC, 91/116/EEC - Chapter IX), so these are legally required inspections. In addition, the slaughterhouse has its own quality system which focuses more on quality aspects that influence the meat sales value. Those can also lead to rejections or trimming.

Top 3 reasons for rejections

The main reasons for rejection during the veterinary inspection are:

1. membrane inflammation in the abdomen and breast cavity (polyserositis)
2. flock-linked disorders such as inflammations in the liver, joints or skin (and under the skin as cellulitis)
3. ascites (waterbelly)

The target for rejections is to keep it below 0.5%. However in practice, this varies per season, per region, per system and per farm. The average in the EU is 1.0%.

LOOK-THINK-ACT

Complete or partial rejection?

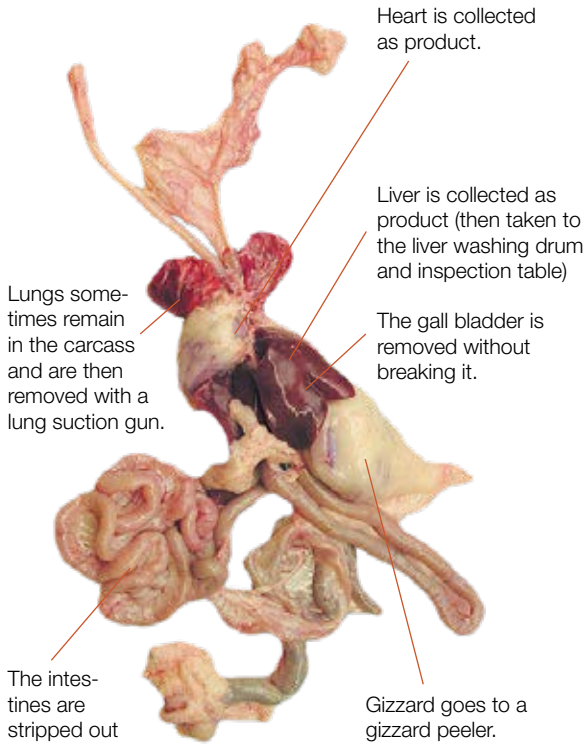
On both photos you see wing haematomas. The haematoma on the wing in the photo on the left is more than six hours old. The bleeding is extensive, coagulated blood is present deep in the muscle tissue. This wing hematoma arose during catching. This carcass is rejected as a whole. In the photo on the right, we see a fresh, local wing hematoma of limited size. The blood has not coagulated and has not invaded the muscle tissue. This one was probably caused by wing flapping during shackling. This abnormality results in partial rejection.

Complete rejection – the damage is extensive and present in several parts, or there are pathogens (sepsis) or poisonous substances (toxins) spread through the body. The number of completely rejected carcasses is noted.

Partial rejection – the damage is local. After trimming the defective part, the rest of the carcass is fit for human consumption.

Organ harvesting

Immediately after evisceration, the carcass and the accompanying package are inspected. After this inspection, the package is processed so that the edible organs can be harvested. The focus here is on gizzards, hearts and livers, fit for food or feed. Inedible organs are regarded as slaughter waste and taken to the storage container. When collecting organs, the risk material is first separated from that with value. Gall bladder removal is particularly important, because bile on the carcass makes the meat worthless.



Processing livers – Livers with abnormalities are removed here.

The gizzard peeler slits it open, rinses it and peels off the strong yellow inner membrane. Then the gizzard is washed and its fat is removed if necessary.

Foreign material

Foreign materials are often found in broilers' gizzards. Sometimes they are metal, e.g. screws. There has even been an incidence of an explosion in a gizzard peeler, and it seems that there was a bullet in a gizzard! These items are usually present inside the gizzard, rarely in the stomach wall itself. To be on the safe side, some plants use metal detectors to check the peeled gizzards. But machines can break if there is any metal in the stomach wall. So most slaughterhouses use metal detectors to detect any swallowed metal and to cover the risk of broken machine parts getting into the meat.

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Edible or inedible by-products

The by-products are subdivided into edible and inedible categories. Edible parts include the heart, liver, spleen, gizzard and blood but that varies in different countries. For example, feet are considered edible in some, while others consider them inedible. This is primarily determined by culture and is not related to public health. Intestines are consumed in some countries and the head is left on carcass in some cases (e.g. Label Rouge). Usually the intestines, head, and bones are processed into animal feed. To prevent pathogenic organisms from passing to these other animal species, the by-products must be pressure cooked at above 100°C/212°F, so that all micro-organisms are killed.

Waste

The veterinary inspector also supervises waste processing. Examples of waste include trimming waste, bones, blood, internal organs, feathers, faeces, mortalities, waste water and fat.

By showing clear visual examples, employees know well which carcasses are not fit for human consumption.

Categories of animal by-products

The waste material is subdivided into three categories, determined according to risk to public and animal health. There are provisions for the processing and destinations for each category (EC1069/2009).

Category 1 material – high risk (e.g. avian influenza (bird flu), Newcastle disease, mortalities, and high-dose dioxins/PCBs). This material is incinerated, buried or burned as biofuel. This material must never be used for animal feed. Category 1 material must be destroyed.

Category 2 material – moderate risk (residues from veterinary medicines, rejected meat). Category 2 materials may not be processed in animal feed, or in cosmetic, pharmaceutical or medical products. But it can be used in technical products, e.g. fats and proteins in organic fertilizers, and for soil improvers or biodiesel.

Category 3 material – low risk, no risk of transmission to humans and animals (feathers, skin, bones, blood, by-products of animal origin and killed day-old chicks). These products are processed into technical products (soil improvers) and biodiesel. This material may also be processed in animal feeds in many countries, but only for animals that are not consumed by humans.

Crop drill

The crop drill (a neck inspection machine) descends into the hanging carcass between the legs. With a pivoting movement, it removes tissues inside the neck skin, like glands and the remains of crop, oesophagus and trachea. The drill is cleaned at the lowest point and then retracts upwards again. During drilling the hole near the wishbone is further opened, allowing rinse water to drain.

The crop drill. A drill goes through the abdominal cavity into the neck. Glands and other tissue are removed. The brush removes any remains from the drill and it withdraws.

Kidneys are not seen as an edible organ and therefore not collected as product. They remain in their original position, against the spinal vertebrae at pelvis level. Sometimes they are removed with equipment such as a vacuum-powered kidney remover.

The neck breaker breaks the neck at a certain point and pulls it off the carcass. This method damages as little neck skin as possible.

Final inspection machine. Usually the abdominal cavity is clean after evisceration. To ensure that it is, a tube with a suction nozzle (lung removal nozzle) is run along the back of the carcass inside the body cavity. It sucks out any lung residue, air sac membranes or water used during slaughter.

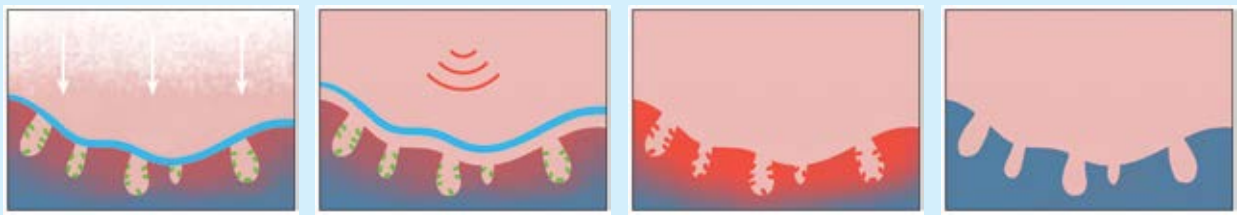
Inside-outside washer

The cleaning effect depends on the degree of the interface, spray time, water volume and water pressure (6 to 8 bar). A higher pressure is not necessarily better. Critical points are handled properly with strategically placed nozzles.

The inside and outside washer in action.

The meat is now clean, as far as we can see. That does not mean that it is not contaminated. Normally there are still a lot of bacteria on the skin of the carcasses. This is monitored continuously by taking samples from carcass surfaces.

Alternative cleaning method



Using a combination of steam and ultrasound ('SonoSteam') is one of the options to reduce Campylobacter counts on carcasses. The ultrasonic vibrations cause very rapid transfer of the heat to the skin surface, making the temperature of the skin surface rise a great deal in a short time. This disrupts the protective air layers around the bacteria, making it possible to reach and kill them. The duration of this process is kept to less than one second, to prevent penetration into the carcass causing heat-damage. Results from this method seem to be quite variable in practice.

CHAPTER 7:

Abnormalities

In the slaughterhouse the chickens are checked for defects. This is important for public health, animal welfare and pricing. To this end there is a mandatory veterinary inspection, and inspection by the slaughterhouse itself. Many abnormalities originate from the farm. It is important to reduce the number of abnormalities and thus the number of rejections and lost income.

Signals from colour of a bruise/haematoma

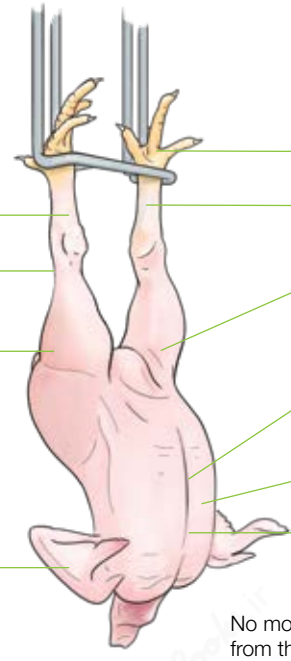
Colour	Age of bruise/haematoma
Red	2 minutes
Dark red and purple	12 hours
Light green and purple	36 hours
Yellow-green and orange	48 hours
Orange-yellow	72 hours
Light yellow	96 hours
Black and blue	120 hours

Haematomas are the most common abnormalities in meat. This is not a public health problem. It is primarily an emotional consideration from the consumer's point of view. Meat with blood results in dark discoloration in cooked products. The inner lining of the blood vessels is composed of endothelial cells. These cells are less developed in fast-growing and young broilers, making them more vulnerable and more likely to be damaged by poisonous substances (toxins) and mechanical action (plucking). Leaking blood vessels manifest as haematomas.

Carcass quality

An unblemished piece of chicken meat is the goal but there are lots of things that can be wrong with it. It is important to be able to recognize a good carcass and identify defects. Here are just a few of the numerous points of interest.

Good carcass



Smooth sole on the feet

Strong bones

Undamaged skin that covers the whole carcass

The growth plate (epiphyseal disk) is a grey, pencil-thin line

A well-keratinized epidermis and a thick and strong dermis

The deep breast muscle is tender and light pink to light red colour

Skin has a pale pink to white colour

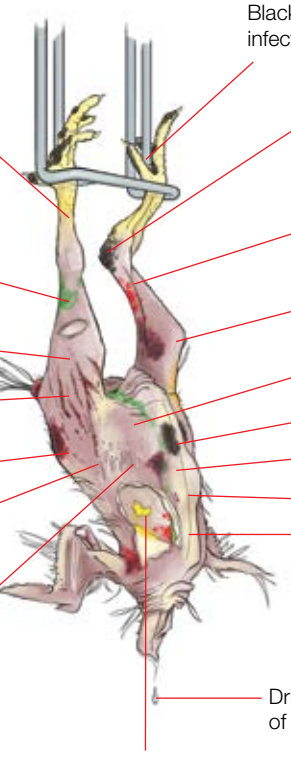
The breast meat has a light pink to light red colour, and it is friable, tender and free of striping between muscle fibres

The pH of breast fillet is 5.8-6.2

The bones are in anatomically correct position (legs, wings, shoulder, hip, etc.)

No moisture exudes from the carcass

Bad carcass



Blackened, infected food pads

Excessively thick growth line and open bone structure

Abnormal bone positions

Haematomas and red discoloration

Damaged or thin skin

Bone fractures and dislocations

Thickened and discoloured skin

Petechial (pinpoint) bleedings

Breast blister

Inflammation

The pH of breast fillet lower than 5.8 or higher than 6.2

Skin scratches (scabby hips)

Swollen deep breast muscle. Red, black or dark green colour. Red line on the edge of muscle

White striping

Haematomas with moist, lemon-yellow gelatinous swellings

Ammonia burn spots

Drip loss more than 1% of total carcass weight

Pale, hard and stringy meat (the surface feels corrugated) Pale meat and it feels soft

Breast haematomas

In normal skin you do not see red spots or red discoloration on the skin or in deeper parts such as the breast fillets. Breast haematomas are often caused by rough loading into transport crates and other impacts. Today's broilers are much more vulnerable than they used to be. Breast haematomas can also occur because veins were not properly drained during bleeding. You see this mainly around the shoulder and the wing. Sometimes you see coagulated blood on the surface that is easy to rinse off. This is coagulated blood from the slaughter process and is not a defect. Haematomas (bleedings) are in the skin, under it or in the breast muscles. A fresh haematoma (< 2 hours) has non-coagulated blood and it is usually confined to one location. Haematomas caused by catching and loading (between 2 to 8 hours of age) have freshly coagulated blood that has penetrated deep into the surrounding tissues. If a haematoma is older (3-5 days) you will see green-yellow discoloration. A smaller haematoma (< 5 cm) can be trimmed off, but a larger one spoils the most important part of the breast fillet and makes it unsaleable. This type of haematoma can lead to higher financial losses, because this is the most valuable part of the carcass.

Fresh and old breast haematomas

The degree of coagulation and the spread tell you whether it is a fresh or an old haematoma.

Fresh haematoma – no coagulation and localized

Old haematoma – coagulation and in deeper tissue layers

Thigh or hip haematomas

Under normal circumstances one does not see red spots on the thigh skin, or haematomas in its muscles or in deeper parts such as the hip joint. However extensive haematomas in the hip joints of certain flocks may be observed, often caused by degradation (degeneration or necrosis) of the femoral head or a dislocation.

Osteochondrosis

A hip haematoma caused by degraded tissue at the head of the femur is called osteochondrosis. In osteochondrosis, the growth cartilage detaches from the surrounding tissues. This abnormality is caused by several factors that reinforce each other:

Genetic – skeletal development cannot keep up with the fast rate of muscle development, especially in fast-growing broilers.

Physiological – only a few blood vessels supply nutrients to the growth line, so it is a vulnerable system.

Movement and behaviour – movement stimulates the blood supply and discharge in the bones, sitting still can pinch blood vessels. Excessive loads can damage the thin connection between articular and growth cartilage and the thin capillaries.

Nutrition – a deficiency or imbalance of calcium and phosphorus, vitamin D3 or A, or trace elements.

Digestive tract health – digestive disorders, diarrhoea and intestinal leaks cause impaired and reduced absorption of important nutrients for bone growth.

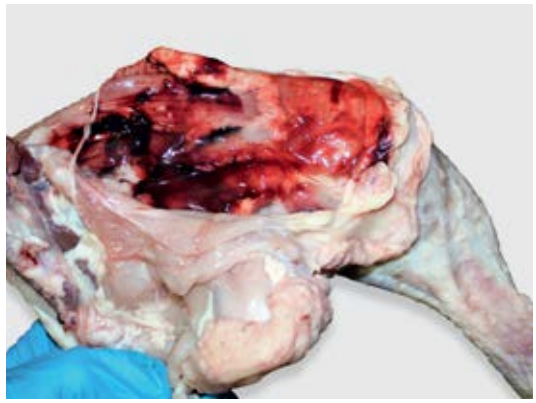
Infections – toxins released by infections (enterococci, staphylococci, E.coli), free radicals, certain medications or fungal toxins cause the inflammation and vascular fragility that sets the stage for the presence of micro-fractures to happen in the growth plate.

Trauma on the farm – e.g. during catching, picking up, wing flapping and being put in the crates. Trauma in the slaughterhouse – affected bones break particularly easily in plucking machines, and thus we see a 'pop-out' profile.

In the event of severe damage, the entire leg is removed, and that leads to considerable financial loss.

Sometimes you see a red spot or bleeding in the skin on the side of the thigh that was caused by a physical injury. Cutting off the affected tissue is sufficient in these cases.

Fresh haematomas (< 2 hours) have non-coagulated blood and are still localized. These can occur during hanging on the shackle.



If haematomas are caused during catching and loading (2-8 hours of age), you see coagulated blood and find it deep in the thigh muscles. Haematomas from 3-7 days old have greenish-yellow discoloration.

Drum haematomas

Most drumstick haematomas are caused by rough handling during catching or shackling.

On a normal drumstick, we see no red spots in the skin or red-blue discoloration in deeper tissues.

Older haematomas (3-7 days old) produce a green-yellow discoloration and lead to drumstick rejections. This is often seen with an infection in the hock tendon sheath (tenosynovitis).

The most common haematomas occur just above the hock joint, and are caused by lifting live animals by the lower part of the drumstick or by hanging them roughly onto the shackle. They are localized, small (< 3 cm), fresh, red haematomas without coagulated blood. Also, reovirus can be behind these drum haematomas.

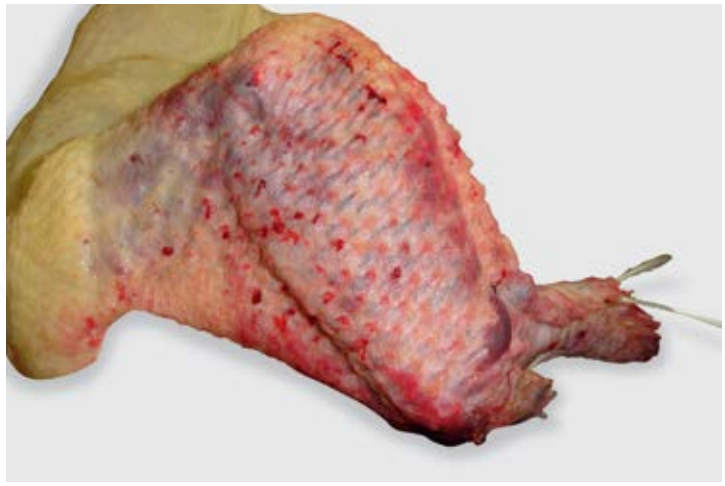
If they occurred during catching and loading (2-8 hours old), you will see more extensive haematomas that have penetrated all the drumstick muscles. These extensive haematomas lead to rejection of the drumsticks, while the smaller ones are considered second category and can be trimmed.

Haematomas in broiler drumsticks are caused by grabbing birds roughly during catching. That is why you should always grab the broiler by its shank rather than the drums.

Wing haematomas

Haematomas at wing tips are not a big problem from a financial perspective, because that part is often not used. But the closer to the body the greater the rejection costs, because more meat must be cut away. Red spots on the skin or under it are more problematic, as is tearing (ruptures), vein leakage and haematomas from other tissue damage such as fractures or dislocations. These might be single or multiple haematomas and they can only be on either the inner side or outside of the wing. Many wing haematomas (> 5%) are a signal of severe wing flapping movements during catching, loading in containers or in the slaughterhouse. They can also occur in the plucking machine. It is important to know where the wing haematomas are caused and whether they can be prevented. It is actually an animal welfare criterion.

A red wing tip is not unusual. Red wing tips are caused by flapping during delivery, hanging and bleeding, but they only become visible during plucking. Even if the broilers do not bash against anything, the flapping itself can force blood into the wing tips.



In cases of an extensive wing haematoma, you remove the entire wing.

Single, small haematomas in the forearm will normally be trimmed away at the elbow joint.

Blood spots on the breast. Extensive and severely smudgy blood spot abnormalities lead to rejection because of poor marketability.

Blood spots on the thigh. You can trim away these local blood spots.

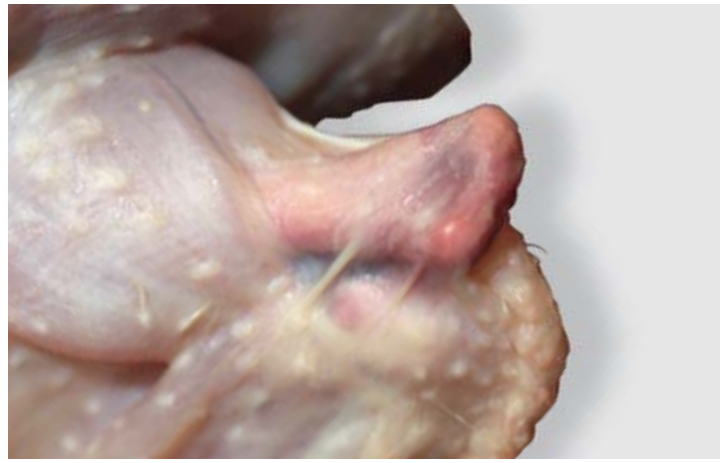
Red spots on the skin are subcutaneous blood spots, often caused by electric stunning. The electrical current seeks the pathway with least resistance and that is through blood vessels.

Blood spots

We do not normally see small red spots in breast fillets or subcutaneous ones on the abdomen and thighs. In certain flocks and slaughterhouses, blood spots (petechial haematomas and blood splash) are common in many locations. There is a clear correlation between blood splash in thighs and breast and high voltage/amperage electric current stunning. Weakened blood vessels (due to toxins or oxidative stress) are another possible cause of blood spots. With this type of problem, small haematomas can occur in the capillaries in particular. Veins and arteries are less likely to suffer damage, because they have thicker walls with muscle and connective tissue. We also find blood spots in the breast fillet of birds suffering muscle diseases. Sometimes you see blood spots on the skin in winter, caused by hypothermia during transport.

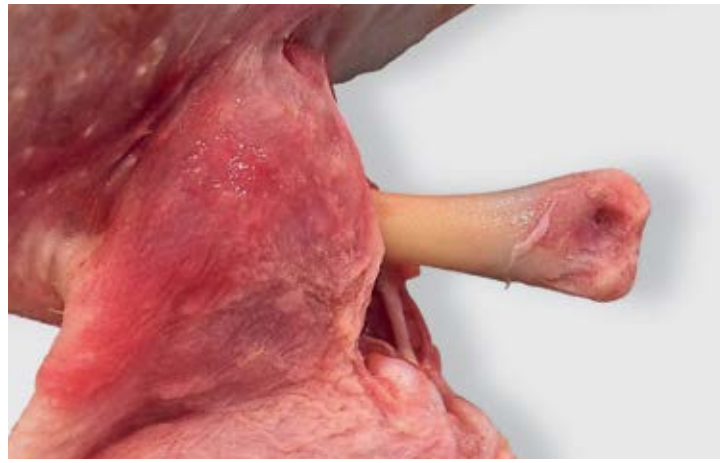
Pop-out

Pop-out is the popular name for an apparent dislocation (epiphysiolysis). In cases of a real dislocation (luxation), there is detachment of two bone parts in a joint itself. You then see white joint cartilage on the two bone parts. In a 'pop-out', the dislocation does not occur in the joint itself but around the growth plate (epiphysary line) and we see grey cartilage on the protruding bone part. This is called a pseudo-luxation (false dislocation). With a 'pop-out' there is a weak bond between growth plate (cartilage) and the newly formed bone below. Dislocations can occur during catching or hanging but most occur in the plucking machine. They occur mainly at the elbow joint, but also in other joints, such as the shoulder, hip and knee. In many cases the dislocated bone part protrudes through the skin, causing contamination in the meat. That is the reason that an 'open pop-out' is cut away (in view of public health risk). Trimming an open 'pop-out' leads to financial loss worth between 10% and 50% of the entire carcass, especially when a wing is cut off and there is no longer an intact carcass available for sale. Pop-outs have many similarities with osteochondrosis (cartilage growth disorders). Here too, there are micro-fractures happening between the articular and growth cartilages.



In a milder form, the skin remains intact and there is no risk for the consumer.

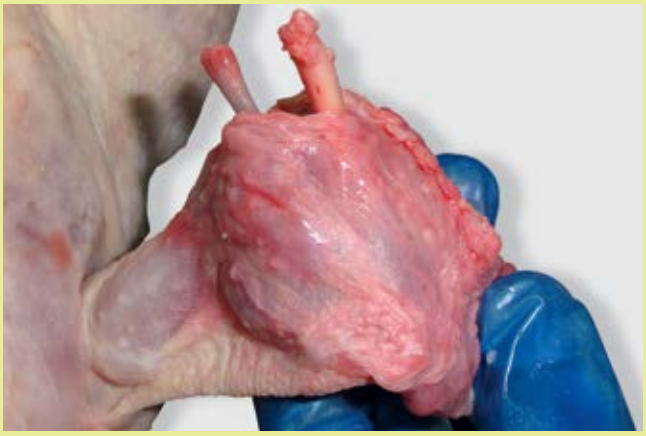
When there is a 'pop-out' in the plucking machine, there is no fresh blood but sometimes some red discoloration due to release of red bone marrow.



If the 'pop-out' occurs when catching or shackling, there is always a visible fresh haematoma.

A carcass with a closed fracture without bleeding may be used whole.

A closed fracture with bleeding must be removed from the carcass. A price deduction of 5 to 20% is applied for this carcass.



Parts with open fractures must always be removed from the carcass, no matter whether there is bleeding or not. The broiler farmer will get a price deduction of 10 to 50% for this.

Fractures

Fractures can pose a danger to public health in several ways. An open break is an open pathway for pathogens, especially if it already occurred during catching. Fractures can cause bone splinters in meat products. That is why many meat processors have X-ray equipment. The cause of abnormalities is not always the responsibility of the broiler farmer. Machines can also cause skin ruptures. The question is whether the skin was broken by a heavy-handed machine or weak skin. Or leg fractures could be caused during manual catching or by the plucking machine.

Straw bales serve well as diversion material for animal welfare but contemporary broilers can get bruises around the growth plate, because it is a weak spot that can easily bruise or break from jumping off them or from a perch.

Occurrence of bone fractures

Bruises can occur easily on bone growth lines, where a great number of cells multiply and there is less blood circulation. Bone fractures on legs and wings mainly occur during catching and handling in the final phase of life. Or they can occur during loading, when birds' wings or legs get trapped onto the edges of the crate or container opening. They can also occur during forceful massaging in the plucking machine.

As a rule, the long bones suffer the breaks, i.e. upper arm (humerus), forearm (radius and ulna), drumstick (tibia and fibula) and the legs. We can recognize a bone fracture by sharp protruding points and bone splinters. They often protrude through the skin, and are thus open, contaminated wounds.

If there are too many fractures, look for the possible cause, including animal welfare factors. Many slaughterhouses use a bonus-penalty reward system for catch teams, mainly to motivate proper broiler catching.

Healthy and fit bones should also maintain the natural posture in a slaughtered bird. On the slaughter line, you can detect a bone fracture by its abnormal position, e.g. an unfolded wing or a leg hanging in a slanting position.

You can determine bone strength by breaking a long bone, e.g. a leg (the metatarsus). A well calcified bone requires significant power to break and you hear a dry cracking sound. A poorly calcified long bone breaks more easily and with a soft cracking sound. There is also test equipment to measure bone strength (Instron tensile tester).

In cases of broken bones after killing we often see red discoloration – that is the red bone marrow leaking from the long bones.

If a bone fracture occurred while the bird was alive, there is a more extensive haematoma.

This heart (from a turkey) contains blood clots. This indicates that the heart has not pumped enough for proper bleeding. It is possible that the heart fibrillated (fluttered) due to excessively strong current during stunning.

This carcass is only moderately bled. You can see this from the red blood build-up in the wing tips, the tail end (Parson's nose), the wing veins and sometimes the feather follicles. The carcass will not be rejected by the veterinary inspection because it does not pose a risk to public health. Although it might be rejected by the slaughterhouse's quality control department, because consumers will not like it.

The carcass in the middle is very poorly bled and is rejected in its entirety. Consumers find this unattractive and the meat is more perishable because blood is a good breeding ground for bacteria.

Not bled, or not well enough

A carcass should be well-bled, so the meat still has a pink colour (not too red, not too pale). You can recognize a poorly bled carcass by the red skin colour, caused by the remaining blood. The head, neck, wings and tail area show redness in particular. In extreme cases, the colour is even blue-purple and the breast meat is too red. These are the causes of poor bleeding:

- heart abnormalities (pericarditis, cardiac insufficiency)
- going into the scalder without being stunned and not cut properly or not at all (i.e. alive and conscious). This affects animal welfare very seriously.

Moderately bled carcasses will not be rejected for that reason. Excessive electrical stunning causes birds to only bleed moderately (because it switches off or fibrillates the heart muscle). If a carcass is very poorly bled, the entire carcass is rejected.

Ascites (waterbelly)

In cases of ascites, you see and feel the birds' bellies are filled with moisture. The breast meat on these broilers is darker or bluer than in unaffected birds. Ascites is one of the main reasons for slaughterhouse rejections. Ascites is not caused by a pathogen. It is a physical disorder. The broiler suffers circulatory problems because the heart and blood vessels are relatively underdeveloped compared to the amount of oxygen needed for the increased meat development. Ascites may start developing in chicks as young as three days old, and sometimes even in the hatchery. The problems only become visible at the end of the fattening period. Some animals can die instantly in a posture with the head down: the abdominal fluid presses against the lungs. You see it mainly on farms where the house climate is not optimal or where other causes of illness play a role too. Low house temperatures, too little oxygen or high CO_2 concentrations during the first weeks of life are a major cause. This disorder is more common when keeping broilers at high altitude. It is highly influenced by genetics and more common in cockerels than hens. During the last twenty years there has been targeted breeding selection to combat ascites.

You can detect ascites by feeling the abdomen with your hands. You feel the fluid moving in the abdomen (undulation). You can also lift the animals by their legs. If the head then turns blue, you have an ascites problem. That is not an animal-friendly method of detection.

Ascites causes a large fluid sac in the lower abdomen.

Fluid in the abdominal cavity

The broiler gets slightly less than enough oxygen in the body for a while, which makes the heart pump continuously harder. More red blood cells are also produced, making the blood thicker, i.e. more viscous. The heart enlarges and its wall weakens. Blood pressure rises and fluid leaks from the blood vessels and liver. This straw-yellow fluid (blood plasma) slowly fills the abdominal cavity and turns the intestines purple, the bird has difficulty breathing and it will die.

Inflamed membranes

Membrane inflammation arises in the following steps:

Membranes thicken and become cloudy. Normally they are completely transparent.

You can see inflammatory material such as pus, caked pus and foam on the membranes.

The membranes fuse with surrounding tissue.

Polyserositis

Polyserositis is a chronic inflammation of multiple serous membranes in the body cavity and organs. A chicken has no diaphragm, and therefore has no subdivision into chest cavity and abdominal cavities. This affects the serous membranes. These are very thin webs that are normally clear-transparent and wet-shiny (you can read a newspaper through them). In a flock of chickens with polyserositis, a mixed inflammation usually occurs in these different membranes.

There are five types of serous membranes in a broiler's body:

1. Membranes that cover the air sacs - balloon-like structures that are connected to the trachea and fill up body cavity space. An inflammation here is called 'airsacculitis'.
2. Membrane that coats abdominal cavity and the intestines (peritoneum). An inflammation in this region is called 'peritonitis'.
3. Membrane covering the chest cavity and lungs (pleura). An inflammation in this is called pleurisy ('pleuritis').
4. Membrane around the heart, the pericardium. An inflammation here is called 'pericarditis'.
5. Peritoneal coating, membrane around the liver (serosa). An inflammation here is called 'perihepatitis'. This is not the same as hepatitis, because the liver itself is inflamed with that disorder.

This also explains the name polyserositis, i.e. several (= poly) serous membranes (serosa) have inflammation (itis).

Causes of polyserositis

Polyserositis is typical of a disease with many causal factors. There is more risk of polyserositis in broilers in climates or seasons where the days are warm and the nights are cold and where there is more than 6°C/43°F temperature difference per day in the houses. The following factors contribute to polyserositis:

- A lot of small dust particles (fine dust) that are deeply inhaled into the air sacs and damage the thin membranes there.
- Gases such as ammonia, H_2S and CO_2 aggravate the situation.
- Excessively high temperature – the broilers breathe quickly and a lot to cool down (broilers cannot sweat).
- Excessively low temperature – the cilia move less in cold and resistance in the airways reduces.
- Excessively dry air (low RH) leads to more particulate matter.
- Excessively humid air (high RH) offers an ideal environment for pathogens.
- Primary pathogens – the presence of specific pathogens that colonize membrane cells.
- Secondary pathogens such as E.coli.

E.coli

In any environment with broilers, there are always normal intestinal E*scherichia coli* (E.coli) bacteria in the droppings and litter. E-coli are a secondary cause of polyserositis. The broilers breathe in the bacteria and that means they get E-coli bacteria in the air sacs. If the membranes of these air sacs are already damaged by the aforementioned factors, these E-coli bacteria will cause clinical polyserositis. In such cases, antibiotics can prevent the E-coli bacteria multiplication, and mortality and growth retardation occurring among the broilers.

Vaccination reactions

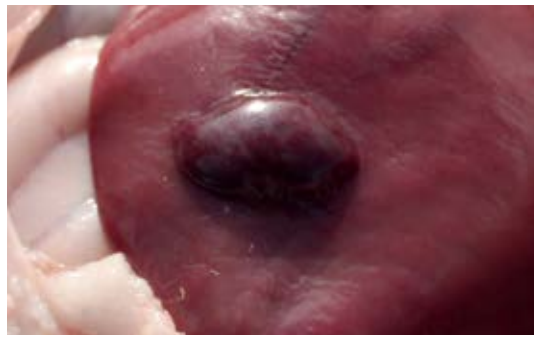
Sometimes polyserositis arises as a reaction to spray vaccination, which involves the birds deeply inhaling live attenuated virus vaccine (especially Newcastle disease). The viral vaccine penetrates the air sacs, where the virus multiplies and can produce disease symptoms. That is why spray vaccinations are always carried out by a competent person in accordance with the vaccination regulations.

ORT in broilers

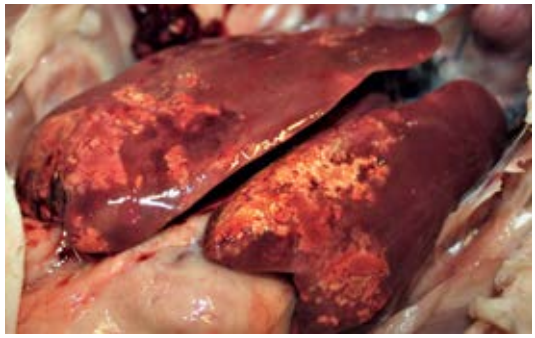
If broilers are making an abnormal sound, taking less feed and there are more mortalities than usual, there might be an ORT infection. ORT *(Ornithobacterium rhinotracheale)* is an inflammation of the air sacs and the lungs. An opaque liquid is formed in the air sacs, which dries into a cheese-like substance. The broiler can break down this cheese-like substance itself and thus clean the air sacs. If these birds are slaughtered when the air pockets are still inflamed, they are rejected on the grounds of having polyserositis.

Liver abnormalities

A liver is usually red-brown. Abnormal coloration can be caused by fungal toxins, necrosis/abscesses after a bacterial infection (such as Clostridium, Salmonella, and E.coli) or a virus infection.
In all these cases, the entire animal has to be rejected for human consumption, especially because the underlying cause (an infection, toxic substance or medicine) will be spread around the body through the bloodstream, and is therefore in the meat.

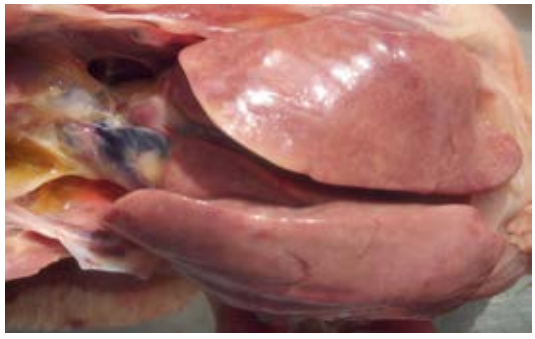


Blood vessels in the liver can get damaged by toxins and leak blood, creating a blood blister, often below the liver membrane.



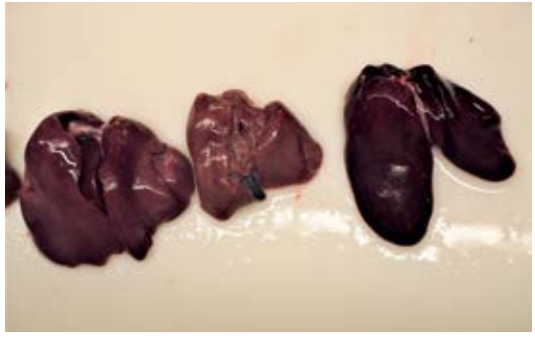
A liver inflammation (hepatitis, jaundice) can be recognized by a swelling of the liver with very small white abscesses of dead tissue from bacterial breeding sites. You do not see much on the broiler itself, but they have to be rejected as whole birds.

The green discoloration usually indicates the presence of toxic substances from infections such as Salmonella or viral hepatitis. Certain medicines/coccidiostats may also cause a green discoloration.

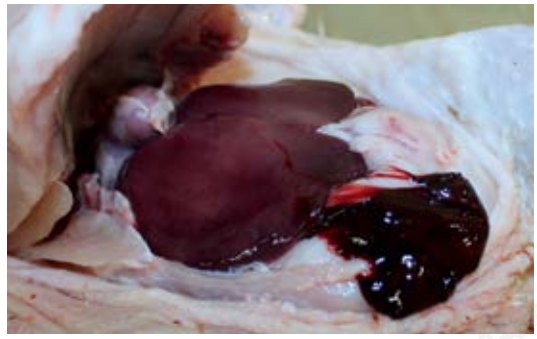


A pale, friable liver often has excessive fat content (fatty liver). This can be caused by poisons/toxins but also by metabolic disorders.

Fatty liver manifests in tissue degeneration.



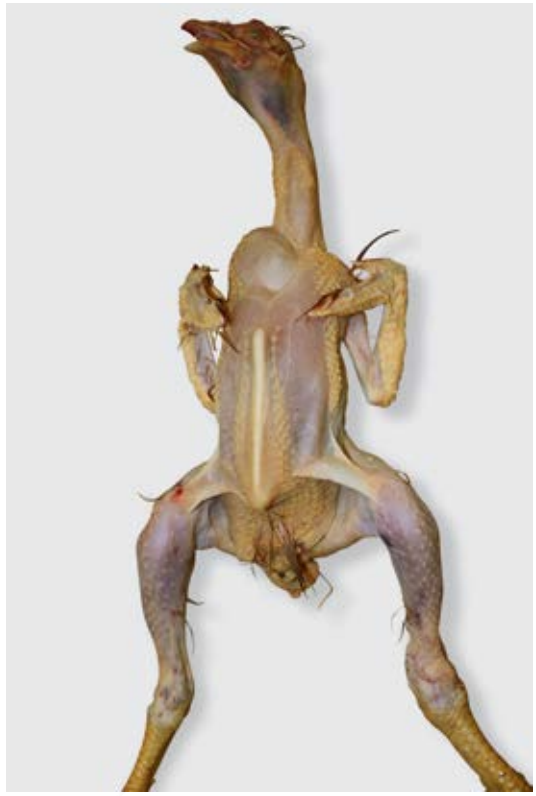
Liver colour also becomes abnormal when broilers do not eat (feed withdrawal). The longer without feed, the darker the colour. From left to right: normal, light, dark liver.



A ruptured liver with a large bloodclot in the abdomen can be the result of rough treatment during slaughter.

Cachexia

Broilers with cachexia are extremely emaciated and malnourished due to a chronic disorder, which causes the bird to consume its own tissues. The original cause can be a serious illness, such as high fever, diarrhoea, joint/leg problems, beak abnormalities or a muscle disease (myopathy), which makes the broiler draw on its reserves. Blood sugar and glycogen reserves are taken first, then the bird's stored fat and ultimately muscle proteins. This causes the broiler to lose weight severely. The sick broiler will also eat and drink less. The result is a bird with thickened blood, low blood sugar (glucose) and less moisture in the muscles (the meat), which makes the meat look dark, firm and dry (DFD). Lack of glucose in blood and glycogen in the liver and muscles means that the body can form very little lactic acid (lactate). As a result, the acidity (pH) only drops slightly during rigor mortis and that shortens the meat's shelf life. The fact that the meat is less durable and probably comes from a sick animal means that it is rejected.



Serious case of cachexia. A clearly protruding breastbone and dark meat. The crop is well filled (i.e. no case of starvation). The cause with this broiler is an infected hock (on the photograph right).

Cachexia and uniformity

Cachexia (left) is an entirely different thing than a runt (right). A runt is small in size, while its meat has a normal colour and composition. A lack of flock uniformity due to poor doers is not a problem for meat quality (although it does pose problems for processing, since machines are set on an average carcass size).

Muscle disorders (myopathies)

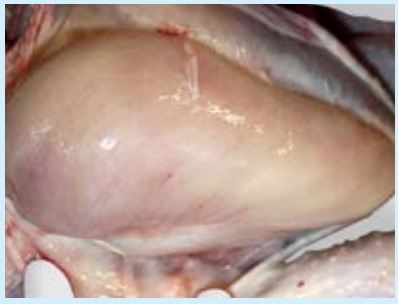
Muscle abnormalities can occur in fast-growing breeds with high percentages of breast meat yield. You can notice the abnormalities from 21 days of age (also in welfare-friendly housing). These are relatively new abnormalities in meat (since 2008), and they have major consequences for meat more fat and connective tissue than normal. The muscles contain less protein and more fat and connective tissue than normal. Muscle disorders arise through factors such as the demand for nutrients and oxygen in the muscle being greater than the possible supply, or because more metabolic waste products and moisture have to be removed than the blood vessels can handle. These waste products are produced mainly during muscle activity, e.g. wing flapping or running. It causes faster muscle acidification and they swell up to 20% increased volume.

Preventing defects

You can give the broilers more light at the beginning of the production cycle, so that the birds are more active and blood circulation develops well in the muscles. Then you give them a little less light during the last weeks of the crop. Make sure you change lighting gradually so that the birds do not suddenly become very active when the light comes on. Avoid excessive daily growth during the last week and do not deliver overweight broilers. Make sure that the broilers are not in a negative energy balance, especially if they are fasting just before dispatch. You can prevent this by adding dextrose and vitamins C and E to the drinking water. As ever, do not withdraw feed for too long.

Types of muscle disorders that sometimes occur simultaneously

A normal breast muscle



'Wooden breast' – a disease of the superficial part of the breast muscle, especially in male animals (colour change and breast muscle hardening).

'White stripes' or 'White muscle disease' – broadened connective tissue strips between the muscle fibres, recognizable as white stripes.

'Spaghetti meat' – muscles with a soft, fibrous structure.

Abnormality of the 'tenderloin' or 'inner fillet' in the breast muscle (colour change).

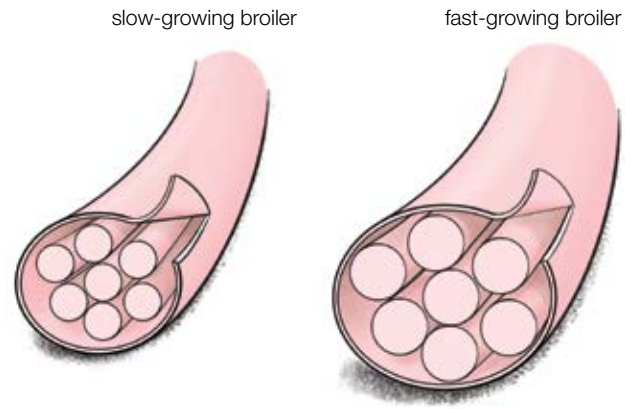
'Green muscle disease' (GMD), deep pectoral myopathy (DPM) or Oregon disease – an abnormality affecting the deep breast muscle.

Muscle abnormalities are already determined during incubation

Muscle cells and blood vessels develop particularly during the embryonic period in the egg and in the first week of life. That is why it is especially important to have optimal nutrition and environmental factors at that time. A well-developed heart in the embryonic phase is essential. The current fast-growing varieties have larger muscle cells (muscle fibres) with a wider diameter. Broilers with lots of breast meat do not have more muscle cells, only thicker muscle cells. They are a bit like body-builders. The result is that substances must travel a longer pathway to and from the blood vessels during the exchange of nutrients (including oxygen) and waste products from metabolism in the muscle cell. But optimal supply and discharge is essential for the muscle growth in these young animals. Some breeds probably have a genetic predisposition for these muscular defects. There is on-going research to find indicators of that and breeding companies are actively selecting against this condition in their breeding programmes.

Muscle abnormalities and consumption

Meat with a muscle abnormality is viewed differently within the EU – roughly, you can see that the Northern EU countries reject the more serious forms. Meat with a severe muscle abnormality must go to the rendering plant. Various South European countries such as Spain and Italy allow this meat for consumption, with advice to incorporate it into processed products and to improve its tenderness. There is no reason to assume that meat with these abnormalities constitutes any risk to public health.



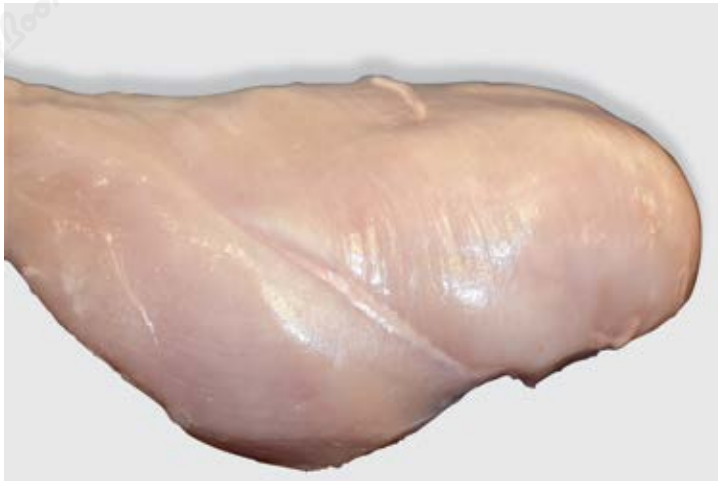
A slow-growing broiler has thinner muscle fibres. This increases the water-holding capacity and reduces the risk of muscle defects. A fast-growing broiler often has shorter cells in the muscle fibres with a larger diameter. This results in lower water-holding capacity and a longer route for oxygen, nutrients and metabolites to pass in and out of muscle cells.

A normal broiler (left) and a broiler with an abnormality: wooden breast (right).

Properties of meat with muscle abnormalities compared to that with healthy tissue:

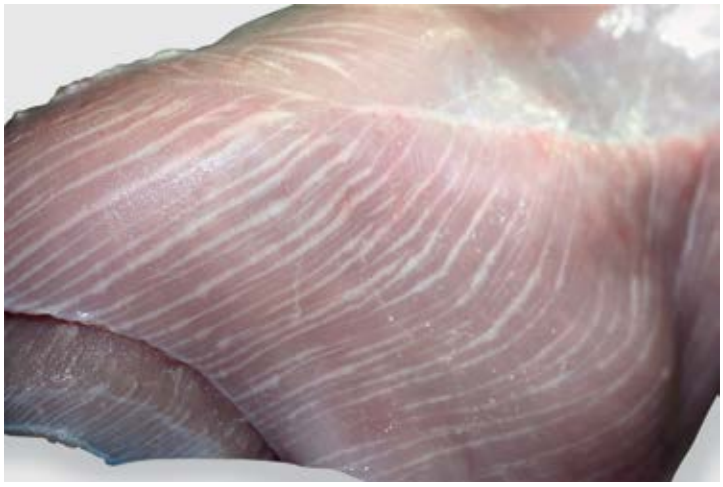
	Normal	White stripes – average	White stripes – serious	Wooden breast - serious	White stripes and wooden breast
Final pH	5.83	5.85	5.92	5.94	6.05
Drip loss (during cooling)	1.01	1.08	0.90	1.15	1.05
Cooking loss	21.50	23.20	26.90	30.90	31.80
Brining					
• brine uptake	14.70	11.00	8.80	7.00	6.80
• cooking loss %	14.80	14.80	15.60	18.30	20.30
• estimated process efficiency	97.40	94.60	91.80	87.40	85.10

Source: Prof. M. Petracci



Normal breast meat has a pale, pink to light red colour. Its structure is soft, tender, pliable and easy to compress. Normally there is no visible striping between the muscle fibres.

With white striping, you see clear parallel white stripes between the muscle fibres, often starting from the shoulder joint. This gives the breast meat and leg muscles a marbled appearance.



A serious form of white striping.

White stripes (White striping, WS)

White stripes are characterized by stripes parallel to the muscle fibres. Especially in breast fillets, but also in thighs. These fillets are difficult to cut and marinate. This has arisen in recent years and it is associated with broilers of a higher body weight (> 2.5 kg). The stripes are clearly visible, even in moderate cases. It often starts at the front of the bird near the wing attachment point. As the abnormality worsens, the stripes are visible through the whole fillet (the entire length of the muscle fibres) and they can become wider. In the striped areas there is an increase in fat and connective tissue (collagen and hyaline), combined with decrease of muscle fibre. It seems to occur more often in cockerels than hens, most likely due to the higher body weight, faster weight gain and thicker muscle cells (hypertrophy). In general, this does not affect meat quality, and it has normal water-holding capacity, colour, texture and tenderness. This meat does not pose a risk to public health and is therefore approved for consumption. Consumers tend not to buy seriously striped meat because of the 'greasy' or 'marbled' appearance. These fillets are used in products that are less subject to visual assessment by the consumer. The abnormality is partly determined by genetics, but the other causes of the disorder remain unknown. In a number of cases white striping can go hand in hand with the appearance of woody meat or spaghetti meat.

Wooden breast, woody meat (WB, WM)

Wooden breast (WB) is a muscle disorder that involves hardened muscle fibres and an inflammatory process is present. You see an obviously firm and swollen breast fillet. It can also occur in other muscles, e.g. in the legs. When touched it feels like hard rubber and the upper surface is corrugated. The colour is paler than normal. The surface is moist with very small purple-coloured blood streaks or a viscous gelatinous fluid. This muscle problem does not have a negative effect on public health. However, the greater the number of white stripes and the more woody the structure in the breast meat is, the less the consumer wants to buy it. The condition already becomes clearly visible in the meat at an age of 18 days. In some flocks it occurs in more than 10% of the broilers and therefore represents a significant financial impact.

You can notice the difference when you pick up a piece of meat – a normal piece of fillet hangs limp in the hand (lower hand). With wooden breast, it is a lot stiffer (upper hand).

Causes and measures

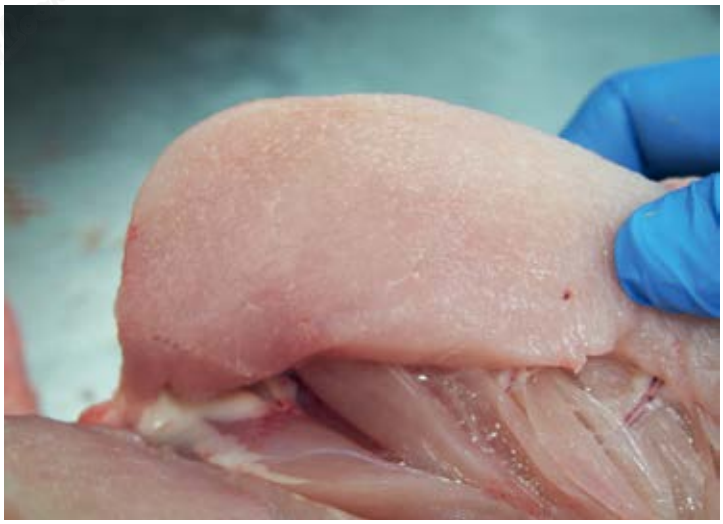
Wooden breast is especially common in fast-growing and highly productive varieties, with enlarged muscle fibres and a higher weight (> 2.5 kg). The disorder is more common in cockerels than in hens. This muscle abnormality is partly genetic, but there is still a lot that we do not know about the causes. High energy and amino acid levels in the feed are factors that influence development of wooden breast. Incubation temperature and growth in the first week after hatching have an important influence on muscle cell development and blood circulation in the muscles. The combination of rapid muscle growth and enlarged muscle cells reduces the blood supply to the muscles. Replacement of dead muscle cells with connective tissue hardens the meat. Early muscle abnormalities have been found in chicks as young as one week.

Good growth in the first week supports the formation of satellite cells which aid in muscle growth and repair. Management to reduce the growth rate between 13 and 21 days can help prevent wooden breast but it can lead to less return because of a lower slaughter weight. Another option is not to rear the birds too heavy, i.e. to slaughter them at a lighter weight. By preference, farmers and the industry are seeking solutions in different feed compositions, to maintain the yield. Current thinking is that more antioxidants, super-dosing phytase, stimulation of blood circulation and prevention of inflammatory reactions can help to combat this disorder. This could be influenced through the ration. Feed suppliers are already responding to this.

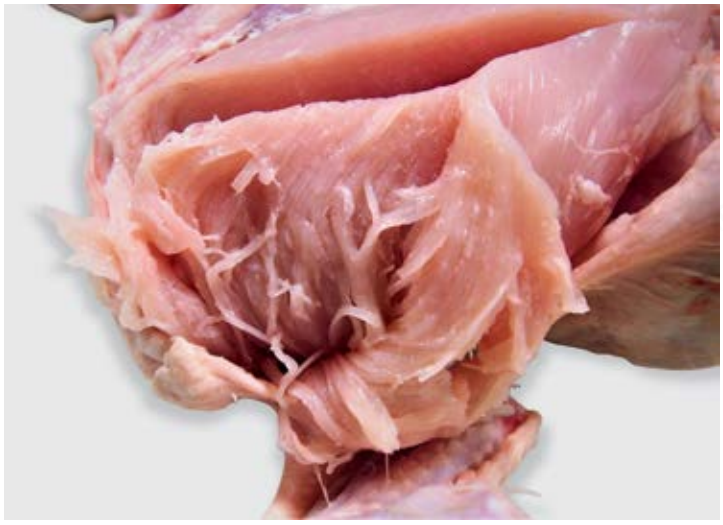
Normal breast meat.

A mild form of wooden breast

A serious form of wooden breast.



Normal meat structure.



A mild form of spaghetti meat.

A serious form of spaghetti meat.

Spaghetti meat

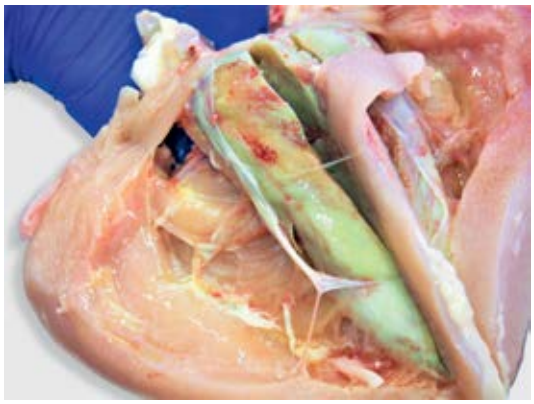
Stringy/mushy breast meat in heavy broilers (often called 'spaghetti meat'). Affected animals (more often hens) may show no other injuries or growth/health problems. You can feel extremely soft and crumbly breast muscle when you touch the slaughtered birds. At the cellular level you see similar abnormalities as with other muscle disorders (white striping, wooden breast), i.e. extensive degradation and recovery of muscle fibres, transparent tissue, poor muscle fibre uniformity, increased fat and connective tissue deposition. You only see this after plucking, where breast tissue appears torn and damaged in affected birds. The breast muscle tears easily during deboning. It clings to the bone and feels mushy. Spaghetti meat is associated with a reduction in protein content combined with an increase of moisture in the meat. The fat content is only affected if there is a case of wooden breast at the same time. Meat samples show poor fibre uniformity, lower protein solubility, higher final pH and a reduction in the meat's water-holding capacity. Yields are lower because some remains on the bone and there is excessive moisture loss (poor water-holding capacity). The problem is probably poorly developed collagen or degradation. Collagen is the most important component of connective tissue, acting as a structural framework in the muscle. Young birds (broilers) only have 0.2-0.4% collagen in the breast muscle, with low strength (cross-links) and stability.

Green muscle disease (GMD)

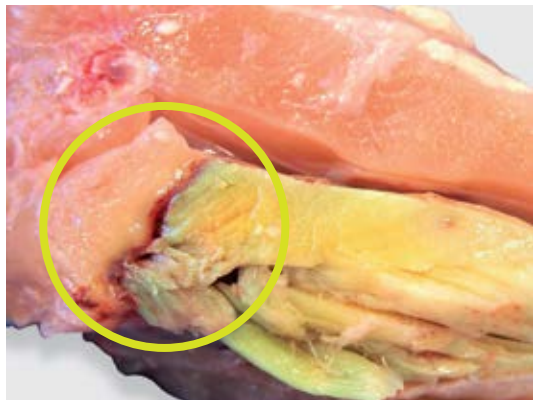
Green muscle disease (Deep Pectoral Myopathy – DPM) is also called 'Oregon disease'. The disease is characterized by the necrosis of the inner breast muscle (the tenderloin), goujon or Pectoralis minor. This is due to poor blood supply and discharge in the muscle cells. Initially, the dying muscle tissue is swollen or brittle, with its colour varying from pale to pink-red. The yellow-greenish discoloration occurs after three to seven days and has almost disappeared after 7 to10 days. The abnormality is usually restricted to the central part of the deep breast muscle and is not perceptible from the outside. This requires incision into the large breast muscle. GMD is caused by excessive activity in the two breast muscle groups but it only affects the smaller muscle. It is more common in heavier broilers. Contraction makes the muscle thicker, with increased blood flow to meet the demand for oxygen and nutrients. The smaller muscle is located between the large breast muscle (Pectoralis major) and the sternum (breastbone) and is somewhat crushed. That makes the muscle restrict itself, which in turn causes blood vessel clamping. GMD is more common in genetic lines with more breast meat and with an inherited tendency for enlarged muscle cells. It is more common after excessive movement, e.g. when thinning and loading in the house and during slaughter. GMD is not a risk to public health; it is primarily a question of sales quality. Only the affected, soft, inner, breast fillets are rejected. In general, finding this muscle abnormality is actually quite rare in slaughterhouses.

A normal deep breast muscle (the pectoral) is pale pink, soft and tender, with little connective tissue. To assess this muscle properly, make a cut through the large breast muscle on both sides and parallel to the sternum.

In the acute form you see an oxygen deficiency with pink-red discoloration and swelling in the deep breast muscle. Sometimes there is a more severe bleeding that is red-black. This type of tissue damage will turn greenish after three days due to the conversion of haemoglobin into bile pigments.



A very serious form. The affected muscle tissue dies off and changes into connective tissue after seven to ten days. In some cases, a bacterial infection can occur, resulting in extensive festering (suppurative) inflammation. This whole carcass is rejected for human consumption.



You see a red demarcation line between the areas of dying and healthy muscle tissue.

The normal appearance of the back.

A carcass with symptoms of DMP.

With an incision, the back muscles (ALD and PLD) appear swollen and bloody red. In older cases of the abnormality, there is yellow-green discoloration with dead muscle tissue.

Muscle abnormality in the large back muscles (Dorsal Myopathy, DMP)

You see DMP on the back, near the shoulder blades. There is a yellow-green discoloration of the skin in that area, often with a local swelling. In some cases, there may be a bacterial infection too. In older tissue damage, muscle tissue might be replaced by connective tissue. Rejections resulting from this abnormality is usually partial, only involving removal of affected muscles and the surrounding tissue, the skin on the back (from neck to cloaca) and parts of the wings and breast. Rejection of the entire carcass is not necessary, unless there is a bacterial infection. DMP occurs in healthy broilers in good condition, with rapid growth and heavy body weight. It is difficult to detect in the processing line but visual evaluation of the skin will show yellow discoloration at the wing base, sometimes with a moderate subcutaneous swelling.

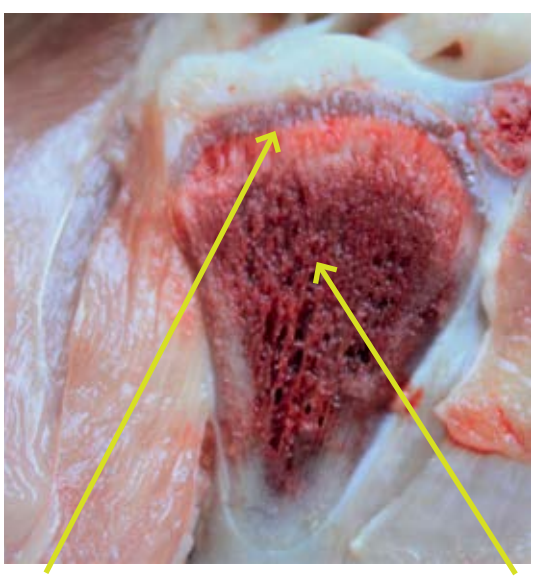
Causes of DMP

The main cause is excessive physical exercise such as wing flapping, along with high body weight, genetic predisposition, vitamin E and selenium deficiencies and toxicity within the cell. High-yielding broilers have larger breast muscles, which has changed their centre of gravity. The main function of the most frontward large back muscle (Trapezoid muscle) (ALD) is lifting the wings to compensate for the increased proportion of body weight taken by the breast muscles. This causes prolonged contraction of the ALD muscles, which can lead to muscle damage. It is more common in a tropical climate, probably due to the effect of wing spreading to disperse heat.

BCO (Bacterial Chondronecrosis with Osteomyelitis)

Bacterial infections (BCO) in the bone tissue can weaken the bones, with results such as the breaking of the femoral head, thinner bone shafts and dislocations around the growth plates. These infections are the main cause of walking problems in broiler chickens and involve a bacterial infection by enterococci, staphylococci, streptococci, E.coli or Salmonella. In many cases, it involves a mix of bacterial species that occur in all animals in the intestinal tract, on the skin and in the airways. The birds have difficulty moving in the house, sit a lot, become paralysed and grow poorly. The flock has poor uniformity, higher feed conversion and mortality (sometimes > 15%), more rejections at the slaughterhouse and poorer product quality. Affected flocks, show about 5% abnormalities, while probably more than 50% have internal defects in the bones (so you only see the tip of the iceberg). It can occur at every age. A case in day-old chicks indicates indicates vertical transmission from the breeders. Nutrition, housing, hereditary factors and rapid growth play roles in flocks with problems. There are various forms of BCO.

- femur head necrosis
- tibial head necrosis
- kinky back (flexible thoracic vertebra necrosis)



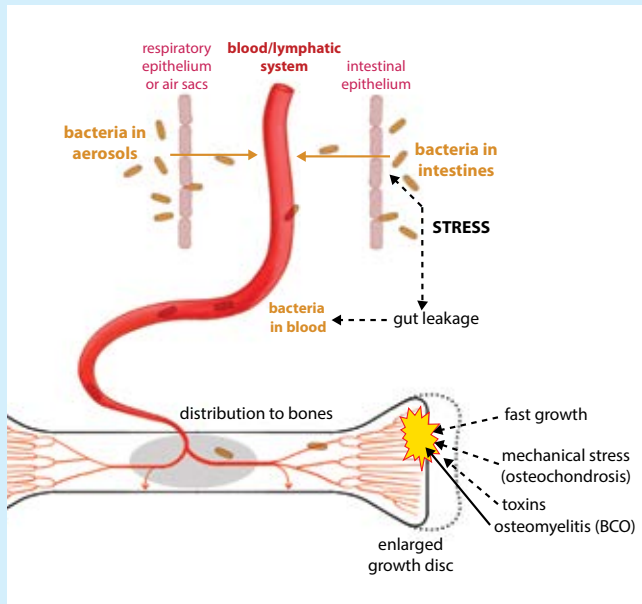
A normal, healthy growth plate is grey and the thickness of a pencil line.

Hard calcified bone bars (trabeculae) with red bone marrow in between.

Recognizing BCO

A normal, healthy growth plate is grey and the thickness of a pencil. This cartilage can be wider or even form a plug if there is no replacement of the cartilage by bone tissue (calcified bone bars with red bone marrow in between). New bone tissue feels hard and you cannot press it inwards. In cases of BCO, the bone bars are soft and easy to press. In some cases the cartilage on the growth plate is loose on the young bone tissue or it is easy to press off ('pop-out' effect). With cases of BCO you find infection abscesses (dead tissue, pus, abscesses), with bacterial content. The bone shaft of the marrow bone parts can be too thin and will break more easily. Red bone marrow can leak more easily through this thin, brittle bone and cause a brown discoloration of the bones (Black Bone Syndrome).

Occurrence of BCO



Damage in the mucous membranes and skin, caused mostly by stress will allow bacteria to penetrate into the body and they can travel through the bloodstream to reach locations such as the growth lines in bones. If there is damage there, young cartilage and bone cells are dead (chondronecrosis) and the thin capillaries are damaged, which offers a good breeding ground for the bacteria. They will cause a local festering inflammation (osteomyelitis). This often happens in locations where there is a lot of pressure and movement on young bone, e.g. the head of the femur, in the upper part of tibia and in the flexible thoracic vertebra.

Femoral head necrosis

Femoral head necrosis is a festering (suppurative) inflammation around the growth plate in the upper part of the femur, just below the head of the femur, at the hip. As a result, there is no longer a tight connection between the joint cartilage (a white colour) and the newly formed bone. These parts can easily become separated (epiphysiolysis), just as with wing 'pop-outs', during life, in the slaughter process and during a section. In some cases, the head of the femur can break off.

Normal femoral head.

Femoral head with mild damage.

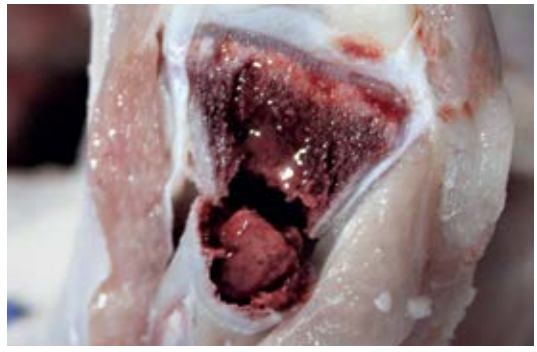
A severe form of femoral head necrosis – the growth plate is broken and you can see directly into the bone marrow.

Tibial head necrosis

Tibial head necrosis is a bacterial infection that we also find around the growth plate of the drum (tibia) just below the knee joint. Again, there is often no more firm bond between the knee joint cartilage and the bone, so the joint is easy to dislocate during a section.

Normal tibia.

Tibia with mild damage.

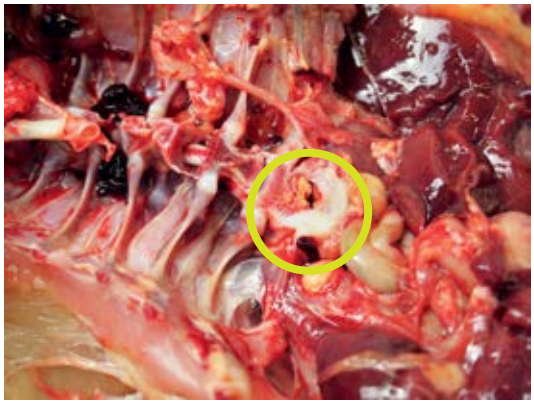


A serious form of Tibial head necrosis – White necrotic sites (abscesses) are visible around the growth plate. Too few bone bars have developed, which makes the new bone feel spongy and mushy. Cavities with dead bone tissue develop in the bone.

Kinky back disease (vertebral osteomyelitis – VO)

In cases of BCO, a bacterial inflammation can arise in the flexible thoracic vertebra – there is often abscess development and local swelling too. This vertebra carries the largest mechanical load of them all. Moving the wings a lot to maintain balance is very harmful, in particular. The name kinky back was also used in the past for the kink in the spine caused by a vertebral fracture or congenital spinal column curvature.

This broiler is paralysed and sits on its rear end with legs facing forwards. Ninety per cent of cases affect the heaviest cockerels of fast-growing breeds. It is best to end these birds' suffering in good time.



Abscess formation is visible in the vertebrae bone material.

BBS (Black bone syndrome)

If the shaft is very thin, black brown bone discoloration can occur due to the red bone marrow leaking through the shaft wall. The following are causes:

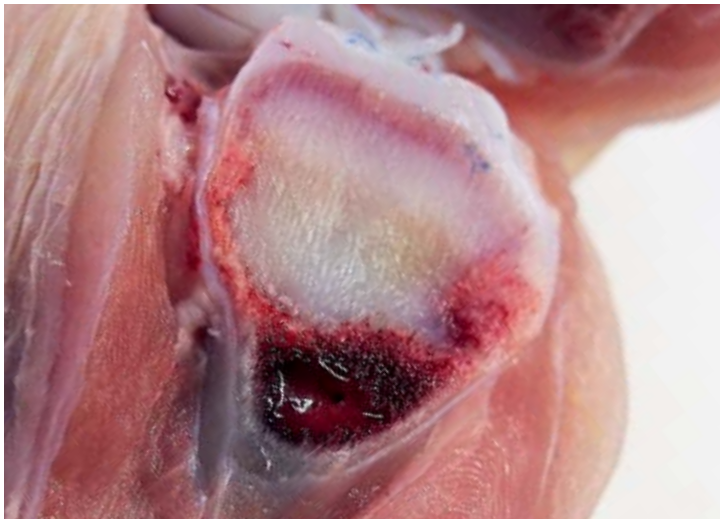
- The shafts of the long bones are too porous due to insufficient calcification during growth. Nutritional deficiencies, e.g. vitamin D3 (normally formed in the skin by sunlight), and minerals such as calcium, phosphorus, iron, copper and zinc play a role in this.
- The shaft of long bones is too thin due to the wrong type of bone growth from the growth line. There are too few young bone cells formed, which are necessary for longitudinal growth.
- If there is a bacterial infection (BCO), there is also abnormal bone development in the shafts, leading to thinner bones and more risk of red bone marrow cells leaking through.

Freezing meat and bones aggravates the discoloration, because ice crystals develop in the blood cells and they expand. This leads to the red bone marrow cells and red blood cells breaking down quickly and the red blood pigment (haemoglobin) leaks out of the cells (haemolysis). The brown-black bone coloration comes from the oxygen released at the same time (oxidation). So you see this more often with frozen carcasses than with fresh meat products. Deep-frozen meat is widely exported by Brazil and the USA. That is why those countries are looking for ways to reduce this problem. Cooking and roasting chicken meat or chicken legs also aggravates the browning.

The bone gets a black-brown discoloration, because the red bone marrow leaks through the shaft wall.

A normal appearance of a sectioned bone.

A mild form of TD. The growth cartilage is thicker than normal.



A serious form of TD. The growth cartilage fills the entire bone.

TD (Tibial dyschondroplasia)

The metabolic disease tibial dyschondroplasia sometimes occurs in young birds with fast growth rates, and it affects the bone and cartilage growth. This was a common problem in the past but it has been largely bred out of contemporary broilers. Yet, it seems to be arising more often again in recent years. The cartilage in the tibia does not mature sufficiently to turn into bone, because the growth plate does not have sufficient blood circulation or because of inadequate P and Ca absorption. And that makes it more susceptible to fractures, infections and deformed bone development. You see very little behaviour and movement abnormality in birds that only have a cartilage plug. At most they fall down when they want to sit, because they experience structural weakness. The birds become lame in cases with infections, crooked growth or dislocation of the growth plate. The vitamin D-metabolism plays a role in this – there is a bad blood vessel development at the growth plate.

Miscellaneous leg abnormalities

Besides BCO and TD, a few other leg abnormalities occur. The causes are pathogens, nutritional or management problems (preventive measures include working safely, good hygiene and preventive vaccinations, e.g. against Reo-virus).

Synovitis

Development and consequences
The joints and tendon sheaths are full of joint lubricant (synovia). The main cause is trauma (sprain) or overload of joints and tendons, causing more joint lubrication (synovial fluid) in the capsule. The bird finds it harder to walk and is more inclined to lie down on its breast than normal. This leads to a higher risk of litter spots and breast blisters on the breast skin. The animal will also take less food and water, because of the pain.

What does it look like in section?
The joint is swollen and filled with more joint fluid (synovia) than normal. This is still a straw yellow colour and pulls into strings. Usually it is one-sided.

Additional remarks
The affected part is rejected for human consumption. This means cutting away to the joint above the problem.

Tenosynovitis

Development and effects
There is inflammation of the Achilles tendon and tendon sheath, which runs over the hock joint and leg (metatarsus). Often it occurs on both sides, because the causative agent spreads through the bloodstream. Reo-virus infection is the main cause. And then bacteria can make the inflammation worse (hence the other name, viral arthritis). The tendon is swollen, warm and painful. This makes it more difficult for the bird to walk and it sits much more than usual. Bruises and skin discoloration can occur around the sternum. Skin irritation and hock burn develop around the hock joint. Feed and water intake decrease and growth slows down, sometimes even with weight loss. Uniformity and slaughter weights will be lower.

What does it look like in section?
You see a greater amount of mucus-like fluid that is yellow to orange in the tendon sheath and the Achilles tendon. With an older inflammation, you see a green discoloration around the hock joint. In a slaughterhouse you will notice hock tendon ruptures, which are caused when the birds use lots of force trying to run away and escape from the catchers. You often see extensive haematomas associated with such hock tendon lesions.

Additional notes
In a case of tenosynovitis on both sides, the entire carcass and the organs must be rejected (blood poisoning).

Peri-arthritis

Development and consequences
There is inflammation around (peri) a joint. This type of inflammation is usually caused by an infection through a local skin wound. The inflammation is subcutaneous, around and in the joint. The birds have difficulty walking and hence visit the feeders less. In some cases, it can spread through the body via the bloodstream and inflammation occurs in the liver, kidneys, lungs and elsewhere.

What does it look like in section?
There is irregular swelling around a joint. In the acute stage, bloody fluid and inflammatory material may be present. With an older inflammation you will find dead tissue, i.e. various stages of pus. It looks white-grey.

Additional notes
In the case of a single peri-arthritis, the affected part is removed up to the joint above. If the infection is spread through the body, the entire carcass and organs are rejected for human consumption.

Arthritis

Development and consequences
There is a festering inflammation in a joint. This almost always involves a bacterial infection, Staphylococci, E-coli or Salmonella. These bacteria come either through a local skin wound or from elsewhere in the body through the bloodstream.

What does it look like in section?
The joint is full of inflammatory material, various stages of pus and caked pus. With an acute inflammation, you see a red discoloration from the blood. With an older inflammation there is dead tissue that is white-grey.

Additional notes
Usually a one-sided inflammation. In that case only the affected part is removed, up to the joint above it.

Twisted leg

Perosis (left) is a typical deficiency disease, caused by a shortage of vitamin B and manganese. There is a delayed growth of the long bones and a dilation of the joint between the tibia and foot. This causes the hock tendon to slip off the bone. You see a swollen hock and a tendon lying in the wrong position. The broiler cannot walk normally. The leg is twisted. Perosis and pseudo-perosis are similar but there is rotation of the tibia in cases of pseudo-perosis (right).

Pseudoperosis

Development and consequences
This resembles perosis. One or both legs are in an outwardly turned position. There is a rotation in the long bones such as the femur, tibia or metatarsus (leg bones). The hatching process might be the cause, i.e. it is already present at hatching. It can also occur later during growth, especially due to young chicks not moving enough. With broilers in cages these abnormalities were seen often. The deviation has been selected out. The birds have difficulty moving and do not get enough to eat. They often die through malnutrition. A good poultry farmer will cull these types of broilers early.

What does it look like in section?
There is no inflammation. There is a rotation in the long bones of the leg, i.e. thigh, tibia and metatarsus.

Additional remarks
Rotation in the bone is no reason to reject the leg or the whole carcass, unless an inflammation is caused by a wound on the lower leg from dragging the leg over a hard surface.

Perosis

Development and consequences
The hock tendon has slipped off (slipped tendon). The Achilles tendon is located next to the back of the hock joint. This causes the lower foot to rotate outwards (twisted leg). The main causes are nutritional deficiencies: manganese, zinc, choline, other B vitamins such as pyridoxine, biotin, folic acid, niacin. The birds have difficulty walking, so they get less to eat and fall behind in growth, thus causing poor uniformity. It can also cause problems when hanging birds on the shackles, because these broilers hang crookedly for the cutter and eviscerator.

What does it look like in section?
The Achilles (hock) tendon does not run over the back of the hock joint. There is no inflammatory reaction; the tendon itself looks just as it does in a normal bird.

Additional remarks
There is no reason for rejection, unless an infection has arisen too.

LOOK-THINK-ACT

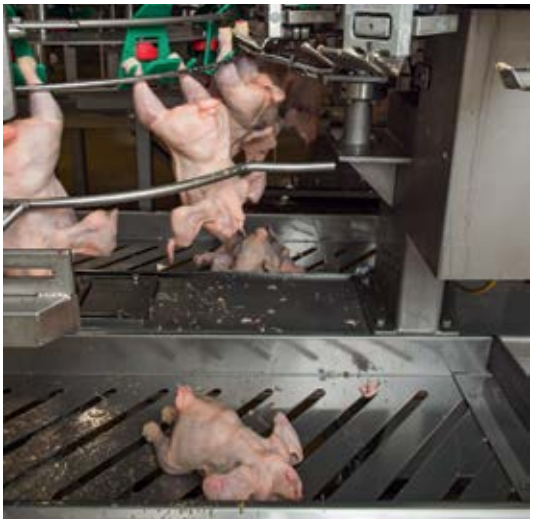
What abnormality is this?

This is a split breast muscle. It is a genetic disorder. There is nothing wrong with the meat quality, but it looks a bit odd.

CHAPTER 8:

Chilling and cutting up

After the veterinary inspection, the carcass is cooled and possibly cut up and deboned. The market for portioned and deboned meat is growing. Consumers are increasingly keen on ready-to-cook products. There is a range of slaughterhouse machines available for cutting up and deboning.



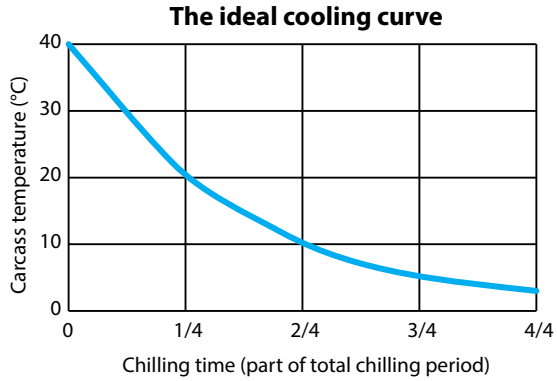
During the transfer from the evisceration line to the cooling line, sometimes a carcass might fall off. These are collected in clean stainless steel trays before hitting the floor and after rinsing and cleaning them, you can simply process them normally.

Chilling

Regulations usually require fast meat chilling to reduce bacterial growth (e.g. to below 4°C/40°F within six hours), depending on the size of the carcass. After that, the temperature must never exceed this limit value during further processing, transport and storage (EU Directive 92-116: core temperature < 4°C/40°F). Most slaughterhouses

chill carcasses before deboning. Chilling is not just a matter of lowering the temperature of the griller. It influences what the meat looks like, the shelf life, the tenderness, the water-holding capacity and the weight efficiency. The method you choose depends on the market demand, the costs and availability of water and the price of electricity. Chilling is always a combination of temperature and time. If you set the temperature too low you can cool quickly but there is a danger of freezing effects (especially combined with high air flow, which causes a wind chill effect).

The body temperature of the living animal is 40.5°C/105°F. During transport, this often even rises a little through stress and warming in the crates. The decrease in body temperature starts after neck cutting, while the outside of the broiler's body will be slightly warmed up again in the scalder. The temperature drops again in the plucker, and the cold water spray plays a role here too. After removing the internal organs (evisceration) both the outside and the inside have contact with relatively cool outside air.

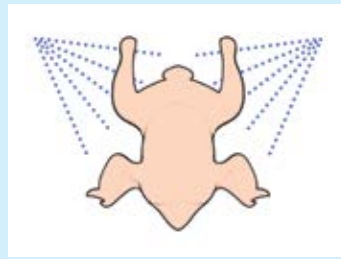


A handy rule of thumb for the ideal chilling curve: the temperature of the carcass in degrees Celsius is halved per quarter of the cooling period.

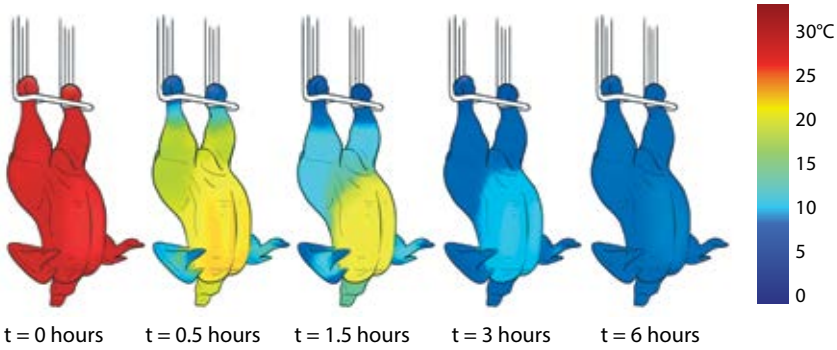
The most used chilling methods

Air chilling – This is mainly applied, after low-temperature scalding (epidermis on), in countries where water is expensive. Some moisture evaporates from the carcass (1-2%) during this process. This can be compensated to a large extent by moistening.

Immersing in cold water – This is done for 25 to 50 minutes in long chilling baths with a cold water counter flow, sometimes with added crushed ice.



Spray chilling – This is used especially after high-temp scalding (epidermis is removed) to prevent a brown meat discoloration. The amount of water absorption into the meat is between that of water chilling and air chilling.



The cold goes from outside to inside, so the skin cools down earlier than the inside (the thermal centre). So you always have to check the temperature in the core of the carcass.

Air chilling

Air chilling is the most commonly used carcass chilling method in Europe. Sometimes air cooling comprises two phases:

1. shock chilling for about thirty minutes – very cold air is blown onto the carcasses, so that the outside cools quickly
2. maturation chilling – a slow air flow at 0°C/32°F is blown over the carcass for 120 minutes, so that the inside also cools down. Using a less cold temperature allows the carcass to mature faster.

Checks – there are random temperature checks every hour. There is no assessment of the rigor mortis process itself.

At the beginning of the day the chilling unit is very cold and carcasses will cool down fast or too quickly. During the day, the chilling unit heats up a little from the warm carcasses going through it and the temperature and chilling speed stabilize. So the chilling speed might slightly decrease. Sometimes, if chilling is not going fast enough, supervisors will decide to hang fewer birds on the shackles at the beginning of the line.

The chilling process takes at least two hours. Space is saved by transporting carcasses backwards and forwards at multiple levels through the cold store. At the end of the chilling line, the carcasses go over to the distribution line. The total length of the chilling line is often more than 2.5 kilometres.

LOOK-THINK-ACT

What happened to this carcass?

This is a low-temperature scalded carcass of which the epidermis must be preserved. Nevertheless, the epidermis has disappeared locally, which becomes visible during air cooling. These places are somewhat darker and 'parchment-like'. Try to lower the scalding temperature and/or set the plucker less tight! Gas packaging can mask dehydration.

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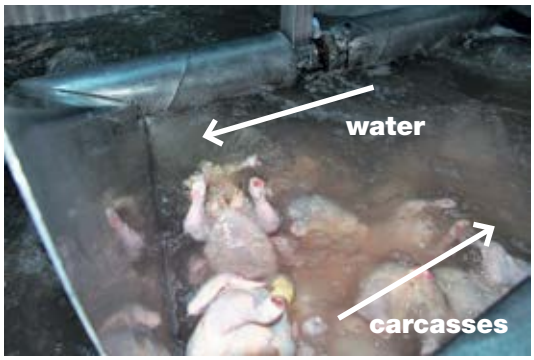
Spin chiller

In the United States and Brazil spin chilling is the most common method, in which carcasses are immersed in a cold water bath. The carcasses are also washed but that comes with a risk of bacterial contamination and cross-contamination occurring in the bath. Spin chillers can therefore only be used in countries that permit use of disinfectants in the cooling water. The second disadvantage of spin chillers is that carcasses absorb quite a lot of moisture from the ice water during the process. The weight gain (6-12% immediately after cooling) is difficult to control, so very variable. But most of the moisture absorbs into parts that are removed afterwards, e.g. the neck skin. The weight gain in valuable parts (breast fillet, leg fillet) is limited. The grillers remain dripping for a long time. In the water bath the residence time varies, so grillers may become mixed with grillers of another flock. The labour needed is another disadvantage, because you have to re-hang the carcasses on the line after the spin chiller.

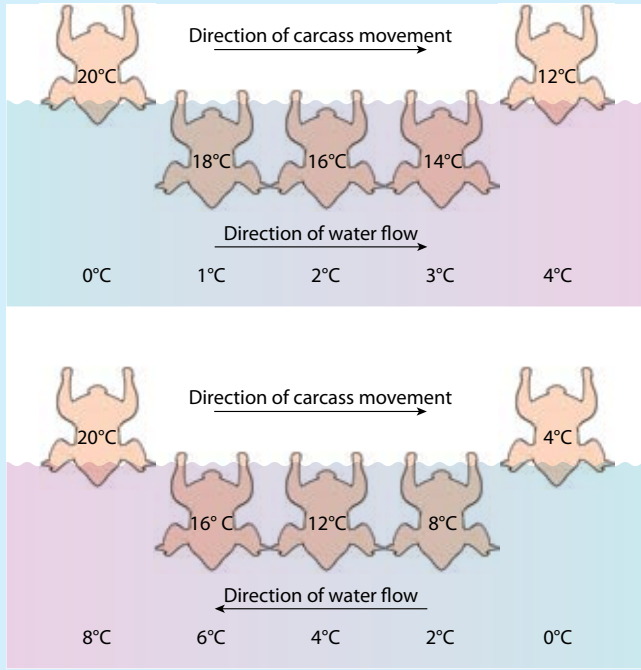
Putting carcasses in an ice bath is a simple chilling method. But carcasses will not cool so well, because they are not in motion.



A spinchiller or screw-chiller is a large metal tank (10-20 m long, 2 m wide) with a large auger running its entire length. The tank contains water, often with flake ice. The auger slowly moves the carcasses through the tank. This takes at least an hour.

Applying an ice spray for extra cooling is an option to speed up the process. Slush ice is sprayed directly onto the carcass and thus extracts heat from the carcass (through the effect of its low temperature and the thawing process of the ice itself).

Counterflow principle



When immersing carcasses in cold water like in a spin chiller, you preferably use the counterflow principle (see figure above, lower section). This works efficiently. It means that the tank and the carcasses finish the run in the cleanest water. The cooling effect is enhanced by water turbulence, e.g. from air blown in at the bottom. The turbulence must not be too great, because it can cause water absorption into the carcass. The temperatures in the figure are not real values, but just illustrations.

After chilling

To avoid fillets becoming tough during cooking, you can only debone when all the energy is dispersed from the muscles. This takes about six hours, depending on the energy content (glycogen) in the muscles at the time of death, the fasting time and the stress level the broiler underwent. After chilling, the carcasses are weighed, sorted by weight and then packed, divided or deboned. Computer programs can help decide what is economically best to do with each carcass. That depends on the price of a whole carcass and of the individual parts, and the market demand for a certain day/period. The machine is set based on the results.

Carcass stretching

The rigor mortis process causes the wing muscles to contract a little. Video analysis sometimes produces an erroneous image of a carcass, because the wings remain hanging low on some while they spring back on others. You see this particularly among young broilers, and it depends on the degree of rigor mortis. This is why carcasses are stretched after cooling to allow proper assessment. As soon as a muscle is cut away and therefore not forcibly stretched, it contracts again. The meat is then difficult to get off the bone. The problem affects carcasses that are to be cut up but is less important with whole carcasses.

The best way to measure the temperature is to measure with a long, sharp temperature sensor inserted into the deepest breast muscle. The standard is maximum 4°C/40°F within seven hours after killing the bird.

The carcasses are stretched after chilling to be able to cut them well. You also prevent the wing tips from hanging in front of the chest during a camera analysis. This can be incorrectly 'seen' as a breast bleeding, because wing tips are usually slightly redder in colour.

Determining when to debone

After rigor mortis, degradation of proteins by enzymes (proteolysis) begins. This is the maturing phase. This protein breakdown makes the carcass easier to debone because bonding between meat and bone decreases. At the same time, the protein breakdown degrades the internal structure of the fillet, and that causes deterioration in meat quality. So you have to find an optimal balance between the timing of deboning (it should be easy) and maintaining fillet firmness. Proteolysis slows down at lower temperatures so protein breakdown goes slow in the plant.

Grading

After the weighing line, the carcass is either dropped in the correct weight box or transferred to a cut-up line. In this respect, it is very important to keep slow-growing broilers separate from the regular birds. These different types should not be mixed. Each slaughterhouse has its own quality classification based on its own insights and the customers' wishes. Usually the system is geared to the customers' sales requirements and payment system. Classification into A and B quality is the most common.

- A-quality – these are undamaged and intact carcasses with no abnormalities. These carcasses do not need any trimming.
- B-quality – these carcasses have damage or lesions and show abnormalities that must be removed for the customer.

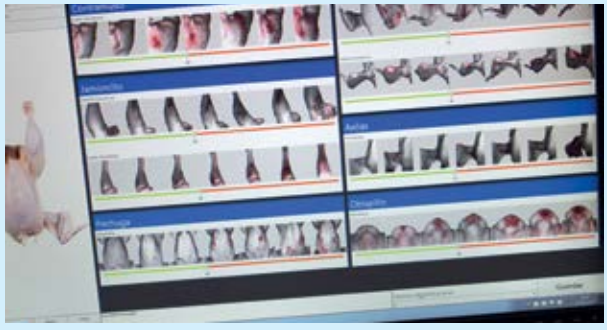
Categorization into A and B is often based on video analysis of the whole carcass. But carcasses are also sorted into A and B category on the cut-up line, using manual, visual assessment.

B-quality: these carcasses are damaged or have lesions and abnormalities that do not fit the requirements of the customer.

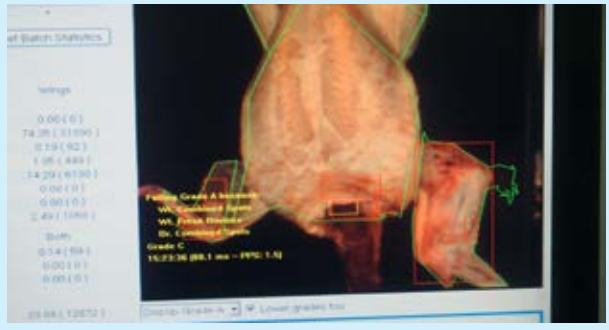
Classification using video analysis

Firstly, there is a video made of each carcass.

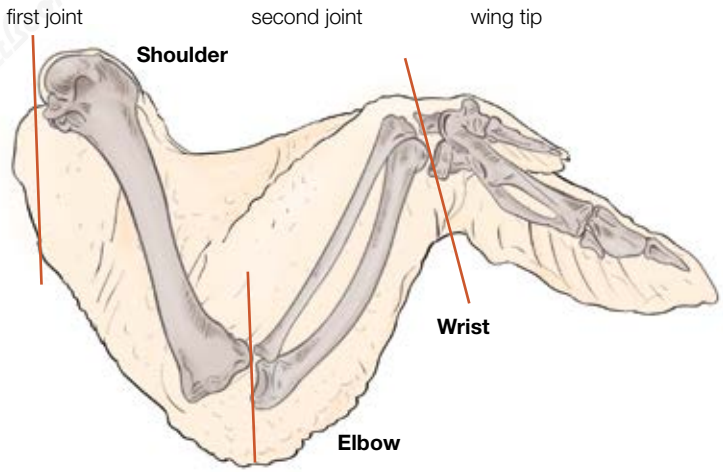
The images are then analysed.



The analysis is compared with parameters set in the system (green = approved, red = rejected).



A full image of a carcass with red outlines around points of deficiency. This results in the carcass not making class A and even being given a C.



The wing cutter works with the anatomical parts of the wing, so that it does not cut through bone.

Wing cutter.

The wings have been removed in a number of steps.

Further cutting up

The carcasses for cutting up go to the cut-up line, where they go firstly through the wing cutter. This device can cut the wing tip, the second section (at the elbow joint), the first section or the entire wing separately. During operation, this can be switched on and off individually for each individual carcass. The wing tips are almost always cut off. There is no meat on them and they often still have small feathers attached.

Setting the cutting machines on the cut-up line is very precise. Every gram cut incorrectly costs money. For example, if the machine takes a piece of breast with the wing, it means financial loss. Conversely, taking a piece of meat from the back with the fillet actually earns more. Breast cap cutters must be adjusted so that the whole fillet is on the breast cap. The machines are set centrally, but manual fine-tuning is possible on the line itself.

Abnormal carcass position on the shackle

An abnormal carcass position can cause disruptions to the process. Carcasses can be in an abnormal position because of the following:

- hanging on a single leg
- not pushed far enough into the shackle
- leg abnormalities (e.g. fractures, dislocations, growth deformities)
- wing abnormalities (e.g. fractures or pop-outs)

The machines on the cut-up line are actually set for intact carcasses that hang correctly on the shackles. An error at the start has consequences for the rest of the process.

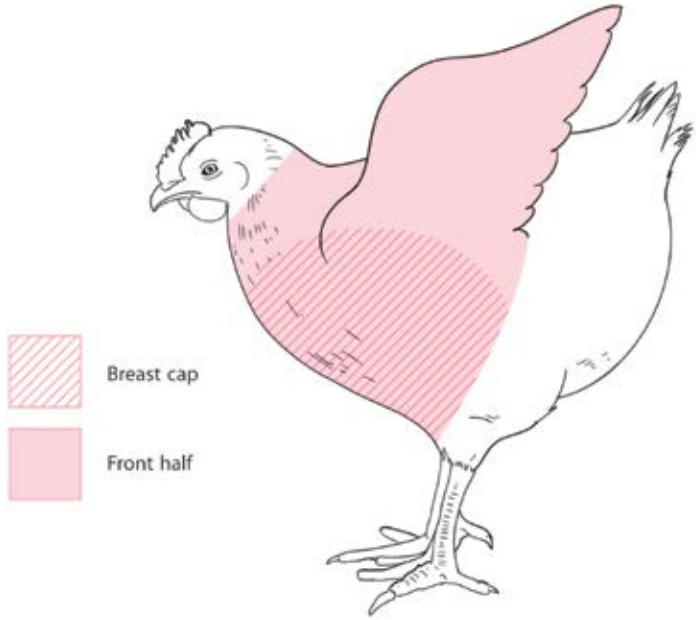
Front half, back half

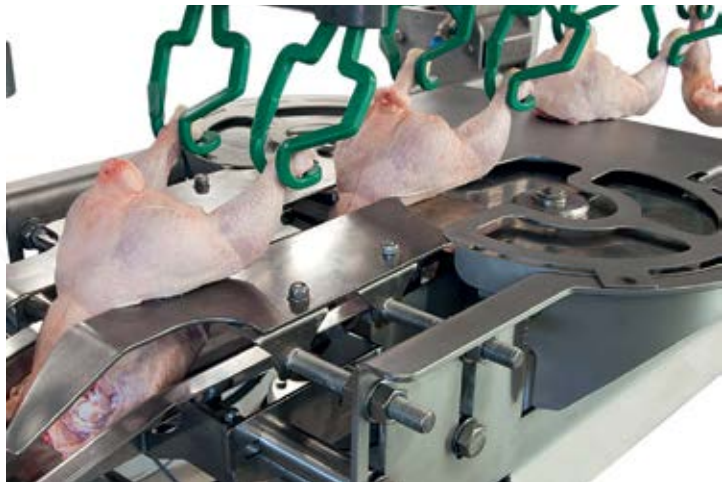
The front half cutter cuts the carcass behind the rib cage, through the spine, dividing it into two halves. The front part of the carcass comprises the sternum with the breast fillet. Sometimes the wings are needed to allow removing the breast fillet at a later stage. The back half or the saddle can be divided into two thigh/leg cuts or two legs and a back piece.

Front half and breast cap

There are two methods for removing the breast fillet. They differ in whether or not the breast wall is cleaved:

- **Front half** – the cut goes through the spine, just behind the last rib. The front half covers the entire thorax with breast muscles (fillets), the sternum, ribs and thoracic vertebrae. Sometimes the wings are still attached. You can then put this part of the carcass on a deboning system.
- **Breast cap** – the cut goes through the rib cage, and the length of the remaining ribs is adjustable here. The spine with the upper part of the ribs is removed. The breast cap includes the breast muscles (fillets) with the sternum and the lower parts of the ribs.





A front half cutter.

A breast cap cutter. The entire spine is still intact with this cut.

The breast cap is placed manually on a holder for further processing.

Sternum (keel bone)

The sternum is separated by the breast bone cutter (keel bone cutter or keel bone harvester). After filleting and processing, it is further processed and used for products such as lipstick. The skeletons themselves go into crushers after separating and are then used in products such as smoked sausages, the chemical industry or health products, e.g. glucosamine. You can determine a chicken's age by the degree of ossification of cartilage in the keel bone. To do this, you check the flexibility of the sternum tip.

Automatic breast deboning.

Fillet

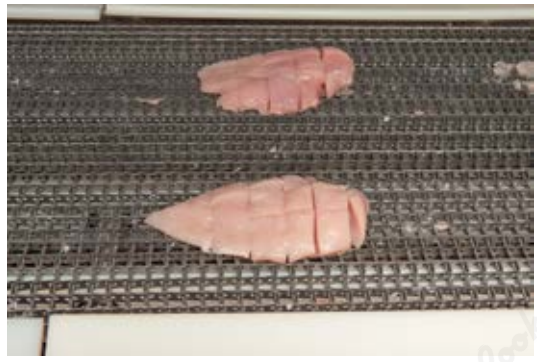
A knife makes an incision under the breast meat to be able to remove the breast fillet.

After machine cutting, the fillets are removed manually in this system and the inner fillets are left behind to be removed in the next step.

If the breast meat is removed there is still residual meat. The aim is to keep that to a minimum.

The fillets are automatically scanned to determine how the fillet can be cut optimally.

Cutting is possible with knives, but is often done with a powerful jet of water. So, the fillet is cut up with a minimal risk of cross-contamination and minimal loss of meat.



The cut fillet on the conveyor belt.

Meat remains of bones are removed under high pressure. This is called mechanically separated meat (MSM) or mechanically deboned meat (MDM). This MDM comes from breast caps.

After the removal of meat residues via an MDM machine, bone parts and cartilage remain. These were breast caps.

After removal of the breast cap, the legs, including lower back, remain. Here the back piece is removed from the legs.

Then the legs are separated.

The thigh is separated from the drumstick.

The drumstick stays on the line, the thighs fall into a collection bin.

Deboning legs

Some parts of the chicken are sold on the bone but there is an increasing need for deboned meat. This is a lot of work manually, but modern techniques make accurate removal increasingly possible.

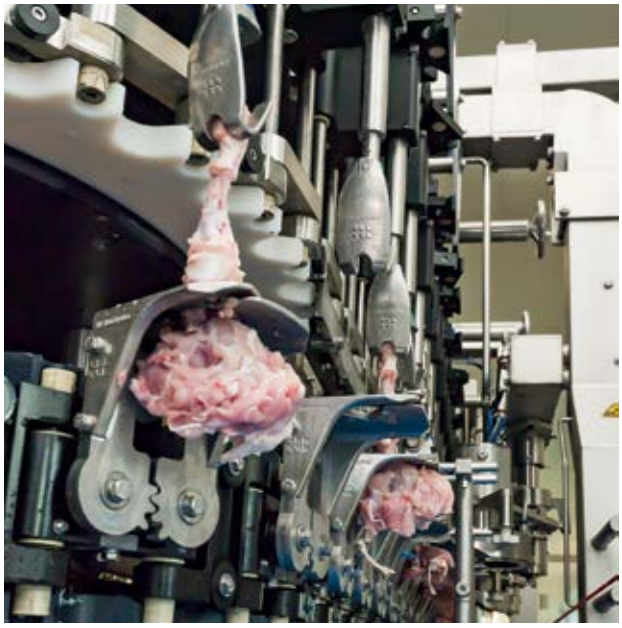
Glucosamine

There is a lot of glucosamine in the sternum, because of its high cartilage content. This can be extracted and used as a dietary supplement for cartilage and joint disorders. Glucosamine can improve the resilience of cartilage between the joints.

A 'tulip' can be made from the first wing section. The flesh on this wing section is cut loose from the bone and rolled up, so that it looks a bit like a lollipop. In Indonesia these are called 'dragon feet'.

An X-ray scan determines where the bones are in the leg.

The equipment can make the perfect cut through the joint based on the scan. The upper leg can then be removed.



The meat is then stripped from the lower leg.

This way you keep a nice and bone-free piece of leg fillet.

Preservation of poultry meat

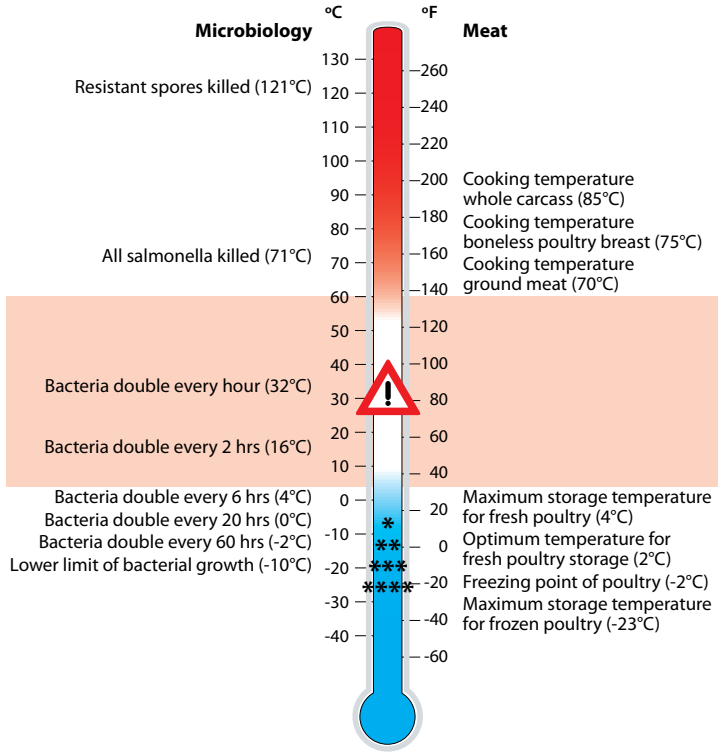
Meat is a highly perishable food due to the fact that it contains nutrients, has a pH that is suitable for most bacteria and has abundant amounts of free water. It is therefore susceptible to deterioration by microbial growth, chemical change and breakdown by endogenous enzymes. Fresh meat can only store for 1-2 days. In order to maintain quality, a good preservation method should be applied. The most common options are:

- Chilling
- Freezing
- Heating
- Curing (salt/pickle)
- Drying (jerky)

Storage periods for poultry meat

Preservation method	Shelf-life
None	1-2 days
Chilling < 4°C/40°F	1 week
Freezing at -12°C/10°F	2 months
Freezing at -18°C/0°F	4 months
Freezing at -24°C/-11°F	8 months
Freezing at -30°C/-22°F	10 months

The storage period is considerably extended by freezing the product. So it makes the product better suited for export or long-term storage.



Temperature has a huge effect on bacterial growth. The so-called Danger zone lies between 4°C and 60°C (40-140°F). Below that range bacterial growth is slowed down or stopped. Above that temperature bacteria die and when kept at a high temperature for long enough this will sterilize the product.

Chilling/refrigeration

This is a widely used method for short-term storage. Most important is that the cold-chain should not be broken. The meat may not exceed 4°C/40°F during processing, handling and storage. The relative humidity is generally kept at 90%. To prevent it becoming too warm, you can insure a 'cold reserve' by cooling the meat below 4°C/40°F. This will help to bridge any time the meat is in an area above 4°C/40°F, for example in a cutting room with a maximum temperature of 12°C/54°F.

Make sure that the meat is kept for the shortest time possible in areas that are too warm, e.g. by preventing stock build-up in a processing area:

- do not deliver excessively large quantities at the same time;
- transport cut-up meat to a cooling area as quickly as possible.

Meat due to be further processed. At 8.5°C/47°F the temperature is too high and this batch should be refused.

Larger ice crystal on the surface: a result of slow freezing.

Also during storage and transport, the temperature has to stay way below zero.

Cryonic freezing is a very fast method using very cold gases. Gases such as nitrogen (N_2) and carbon dioxide (CO_2) are liquefied or condensed and then used.

Freezing

Freezing the poultry meat is a simple and good option for preserving poultry meat. It doesn't kill micro-organisms, but stops growth and retards the action of enzymes. The meat retains most of the nutritive value during storage. During the thawing process a small amount of nutrients can be lost in the drip that inevitably develops.
Freezing extends the storage period to weeks or months. Even under optimal conditions, meat should not be stored for more than one year.
Global trade heavily depends on frozen storage for keeping and shipping meat.

- Fast freezing (to -20°C/-4°F within one hour) results in the development of various small ice crystals, uniformly throughout the tissue. Drip loss during thawing is low in fast freezing. The small ice crystals also lead to a desired lighter colour as compared to slow frozen meat.
- Slow freezing (desired temperature within 3-72 hours) results in the formation of larger ice crystals on the surface, damaging the muscle tissue.

Types of freezers

- Blast/air freezing: -10 - -30°C /14 - -22°F
- Plate freezing: often done for freezing individual portions to -10°/14°F
- Liquid immersion/spray freezing: the product is first packaged and then immersed in liquid or sprayed.
- Cryonic freezing: very fast method using liquefied gases.

Blast type freezes generally have temperature of -10 to -30°C (14 - -22°F). The meat product moves over a spiral band through the freezer.

Heating

Heating kills micro-organisms (depending on temperature, time and various other factors) and can extend the shelf life of poultry meat, as long as no recontamination takes place. So directly after heating the meat has to be packed in a sterile way in order to make it less perishable. Under refrigerated circumstances this meat could be stored for 3-6 months.

There are two levels of heat used for microbial inactivation:

- Pasteurization at 60-90°C/140-195°F inactivates some of the spoilage and most of the non-spore forming food poisoning microorganisms. It extends the shelf-life but the product must be refrigerated or preserved by other means.
- Sterilization at temperatures > 100°C /212°F achieves sterility whereby food products can be stored at room temperature for long periods of time.

Methods of heating

- **Hot air heating** is frequently used to heat meat. To increase heat transfer and prevent browning of the surface and crust formation, moisture is added to the hot air in industrial ovens.
- **Water heating** (boiling, canning). Water is a much better medium to transfer heat than air, but temperature cannot be as high.
- **Oil frying** allows very high cooking temperatures (175°C/350°F). Besides preservation, it contributes to taste, requires less preparation (convenience food), and assures the breading sticks to the meat. Higher temperatures increase the risk of total polar material (TPM). TPM is an indicator for chemical deterioration of frying fats.

Canning

Canning is done by applying heat to a sealed food container in order to destroy micro-organisms. This is a special case of heating inside a package and the temperatures used are above 120°C/250°F: thermal sterilization of the product in the hermetically sealed container. It preserves the sensory attributes such as appearance, flavour and texture to a large extent. The shelf life is at least 2 years at ambient temperature.

A spiral oven is a compact and efficient way of hot air heating.

Water heating can be done outside or inside packaging. When cooking without a package, the meat interacts with the water and liquid/flavour compounds can be transferred into or out of the product. Processed meats (sausages, marinated meat) are usually packaged in moisture proof casings prior to putting them in hot water. In this case the chicken filet has been steam cooked to preserve taste and after this put in vacuum packaging.

Oil frying. The conveyor belt moves down into the oil. Inside, a second belt pushes the meat product down to prevent it from floating away.

Other ways of preservation:

- **Smoking**. Sawdust or hardwood combusted at a temperature of about 300°C/570°F. The smoke generation is accompanied by the formation of numerous organic compounds (aldehydes, ketones, organic acids, phenols, etc.) and their condensation products. The phenols act as bacteriostatic. Formaldehyde acts as a bactericidal compound. The preservation is also due to surface dehydration.
- **Drying/dehydration**. Removing water makes nutrients unavailable to the micro-organisms. Mechanical drying involves the passage of hot air with controlled humidity. Freeze drying (drying by sublimation) maintains the quality of the meat better. The meat is first frozen to -40°C/-40°F and then dried under vacuum for 9-12 hours.
- **Irradiation**. Radiation is the emission of energy in the poultry meat. This can destroy the micro-organisms by fragmenting their DNA molecules. This takes place without a significant rise in temperature of the meat. It is therefore referred to as cold sterilization.

In a drum, the meat is marinated for flavour. The main goal is to add taste, but in some cases it has a slight preservative effect as well.

If pH of the product is too low, the seasoning might not stick well to the surface of the product.

Curing

Salting meat was widely used before the days of refrigeration. In addition to the preservative effect it also adds flavour and colour to the meat. The main ingredients include sodium chloride (common salt), sodium nitrite, sodium nitrate and sugar. Salt inhibits the growth of spoilage bacteria by dehydration and alteration of osmotic pressure. It also slows down the action of enzymes.
As for flavour and texture: salt reacts with fatty acids to enhance the flavour of cured products and it contributes to the tenderness of the product.
In order to make poultry meat shelf stable, a concentration of 10-15% of salt should be used. This is much higher than the 0.5-1.5% salt commonly used in most meat products, which is insufficient to preserve the products on its own. But together with other additives and heating this can still significantly extend the shelf life.

Nitrates and nitrites are permitted at levels of 500 ppm and 200 ppm respectively. Three main reasons of using nitrate/nitrite:

1. inhibiting the growth of harmful micro-organisms such as *Clostridium botulinum* and other spoilage micro-organisms.
2. stabilizing the pink meat colour
3. contributing to flavour development and inhibition of oxidation flavour.

Phosphates can alter pH, cause a salt imbalance outside bacterial cells and affect cell membranes and has therefore a preservative function.

Sugar works in a similar way to NaCl (common salt), but a concentration six times more is needed to get the same effect. This is not common for meat preservation. More commonly, sugars are added to fermented meat products as a substrate for lactic acid bacteria and thereby indirectly assist in microbial inhibition. Sucrose or dextrose are mainly used for this purpose.

Organic acids are used for marinating and they have a lowering effect on pH thereby inhibiting microbial growth. Also, natural spices improve shelf life, such as: oregano, cinnamon, clover, mustard and sage.

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Further processing

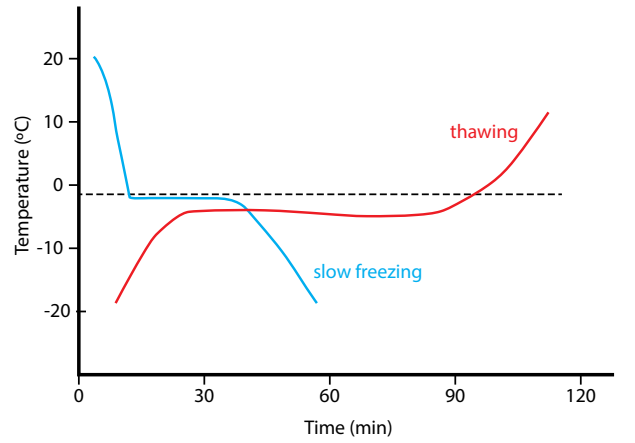
After cutting up, the carcass is ready for further processing. Sometimes this happens in the slaughterhouse but often at specialized companies. This could be simply brining/marinating the meat but also other more complex operations, such as forming meat into burgers and meatballs, dividing it into small pieces for nuggets, making sausages or ground meat for roulades, pre-cooking, and smoking, deep-frying, slicing or special packaging.

The raw materials are either fresh or from frozen meat. This could be heated, restructured, ground or coated and marketed fresh or frozen. Without going into details about all possibilities, some topics regarding quality control will be mentioned here.

Boned products, such as chicken wings, are often processed fresh and heated. This gives a nice colour to the bone after the cooking process. When frozen raw materials with bone are cooked, the bones become grey and dark coloured. In this way you can assess whether fresh or frozen raw materials were used.

Freezing and thawing

Poultry meat is transported over long distances as frozen meat. Before further processing, thawing has to take place. Thawing is a process that takes more time than freezing, due to difference in thermal conductivity between ice and water. During thawing a thin layer of insulating water forms around the frozen meat, slowing down the process. This also means that there is more time for chemical and microbial changes. Therefore this process needs to be done under very controlled conditions. Never thaw at room temperature in order to prevent extensive microbial growth.



Frozen meat should be properly thawed, before processing. Otherwise the pasteurisation will not have the desired effect.

Temperature check of incoming fresh meat. The temperature should not exceed 4°C/40°F. So this meat is OK: 3.7°C/39°F

This meat has been steam cooked and is frozen again. To check whether the temperature is correct inside the product, a small hole is drilled to be able to insert the thermometer. With -17.9°C/0°F, this is OK.

The different layers of a coated meat product are clearly visible. From left to right: formed meat, pre-dust, batter, breading and fried product.

Forming of meat products before further processing. Each piece is exactly the same weight and size.

Sometimes the forming machine has a variety of forms to suggest a 'natural' variation in the final products.

Battering and breading

A lot of products are battered and breaded. Fresh 'schnitzels' and chicken nuggets are examples of battered and breaded products.

Pasteurization

The raw materials often come from outside in a cooled state. So at reception the temperature is measured. Above 4°C/40°F means rejection of the raw materials!

Before any processing takes place it is common to have a pasteurizing step in the process. This decreases the microbial load on the meat, since - although refrigerated - bacterial growth might have taken place in the time past between slaughter/thawing and processing. This step is necessary to 'reset' the microbiological status to a low level. Pasteurization is done in a hot air oven.

Forming

Sometimes the raw materials are used as they arrive, but very often a forming step takes place. The raw materials are formed into a desired shape. The requirements of many industrial customers are that all products don't only look the same, but also have the exact same weight: portion controlled weights.

High pressure formers mould the meat until the desired shape is reached, then it is pressed out of the mould.

A low pressure former uses only air pressure to push the product out of the mould. The latter has become commonplace in recent decades.

Pre-dusting and battering

The meat is covered with a fine coat of flour or very fine bread crumbs as a first layer (pre-dust). The pre-dust sticks to the moist surface of the meat. The pre-dust often contains seasoning and spices as well. This is important as this first layer is best protected against the frying/heating operation that might have a negative effect on the taste of these seasonings.

Batter, or wet coating, consists of a wet solution to coat the product and create a base for adhesion of the next layer of dry bread crumbs.

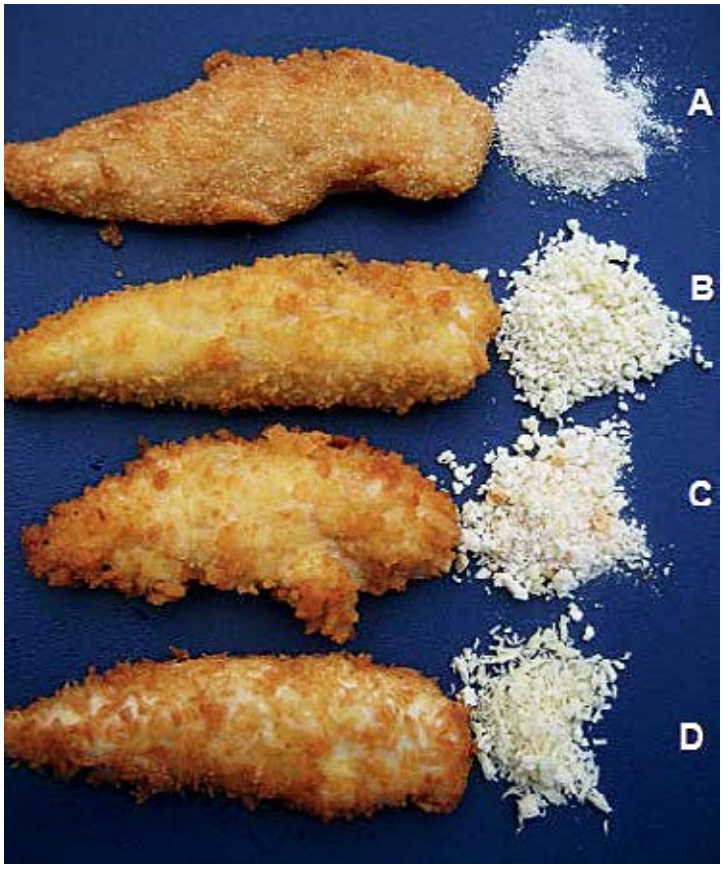
Pre-dusting of the meat with flour. This is not necessary for all products.

Battering. A liquid batter is applied in order to stick the breading.

Allergen protocols

In processing very strict protocols are essential as well. Using colour coded materials helps preventing mistakes. In this case you are only allowed to use the yellow equipment for allergen free products. The green equipment you can use for the other products (such as pre-dusted with flour = gluten). Red equipment is only used for waste (e.g. cleaning, meat that dropped on the floor).

Breading/dry coating with crumbs.



Example of breading of food products: A flour, B cracker type, C American/ home-style, D Japanese style breading.

Breading

Breading creates a unique appearance and texture to the product. It also increases volume and weight of the product. The type of breading can range from a simple flour to structured baked crumbs. The dry breading material sticks to the sticky batter on the product. The material is often expressed in mesh size.

- Fine breading (> 60 mesh = particle size < 0.25 mm): the pick-up of these materials is low compared to medium and coarse size breading. And there is a risk of clumping.
- Medium breading (20-60 mesh = particle size 0.25-0.84 mm): this has a higher pick-up speed and forms a nice uniform coverage.
- Coarse breading (< 20 mesh = particle size > 0.84 mm): these crumbs can provide the highest amount of pick-up, but will sometimes result in a poor coverage compared to fine or medium crumbs. It provides a crispy texture because of its larger size.

After the primary processing the meat can be packaged in the high risk area as a fresh product, or go through a frying step before being packaged (and often frozen) in the high risk area.

Bad coating of a product.

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Frying and cooking

Frying 'solidifies' the coating on a product and develops a nice gold colour on the surface. It cooks the meat and provides the unique texture and feel in the mouth. And of course it inactivates micro-organisms.
The oil has a temperature of 185-195°C (365-383°F). The product can also be partly fried (par-fry, e.g. only 30 seconds on 190°C/375°F) just to cement the breading to the surface before freezing it, but it then remains more perishable.

Cooking is a way of preserving the meat, but the cooking should be done thoroughly. These parts are not fully cooked. This is a health risk.

Frozen breaded wings. Most breaded products are presented to consumers in a frozen form.

With an objective colour scale you can assess the colouring of the fried products.

People that move from the raw meat area to the high risk area should change clothes, wash hands and disinfect. Even if they have changed clothing already when entering the processing plant. This clothing might be clean compared to the 'outside world'. But compared to the level of hygiene in the high risk area, this clothing is already very dirty!

Once entering the high risk area, you have to change your hair net. However, removing the hair net you used in the raw material area means that contaminations might fall out of your hair or the hair net. So put a new hair net on top of the old hair net.

Only personnel that is authorised should be able to enter a high risk area. With entry passes this can easily be implemented.

High risk area

After the first processing step, the meat has been heated (pasteurized) or cooked (fried). This means the microbiological load has been minimal to none. And the aim is to keep it that way!
So after this the product is moved to a high risk area. Hygiene status in this area is very high.
In the high risk area a positive pressure situation is created so air (with micro-organisms) can go out, but will not enter the area.
People are an enormous risk factor in the high risk area. Remember that every time you work in a high risk area, you should wear a suitable and adequate outfit, but in the high risk area there are even stricter rules.
When moving from the outside world or from the raw materials side of the processing plant, you have to go through the hygiene sluice.
When moving in the opposite direction: from high risk to raw, this change of clothes and hair net is not necessary.

Pressure meters indicate the positive pressure in the room. But there is also a very practical method to check overpressure: hold a piece of paper vertically in on a position in between a high pressure room and low pressure room. The paper should be dragged towards the low pressure area by the outgoing airflow!

Packaging

Most meat products are packaged. Before they leave the slaughterhouse, the packaging protects the product against damage and contamination. And the packaging serves as a marketing tool (e.g. it carries a brand logo, advertisements or preparation instructions). The product is weighed and then the weight, the price and the expiry date (7 days) are printed on the packaging. There is also a track and trace code on the product, so that the origin can be found in case of abnormalities. This is required by regulations, and within quality programmes, like HACCP, IQS, etc.

MAP

Many foodstuffs are packaged in a gas mixture (MAP – Modified Atmosphere Packaging). If meat is packed in normal air with oxygen, spoilage occurs quickly. Replacing the air with an inert or other gas reduces or delays oxidation reactions and microbiological spoilage, and extends the shelf life. Oxygen scavengers may also be used to reduce browning due to lipid oxidation by halting the auto-oxidative chemical process.
The modification process generally lowers the amount of oxygen (O_2) in the headspace of the package. Oxygen can be replaced with nitrogen (N_2), a comparatively inert gas, or carbon dioxide (CO_2).

Types of packaging and their characteristics

	Air-permeable overwrap	Vacuum skin packaging	MAP (CO_2 and N_2)
Advantages	Consumers familiar with packaging; high product visibility; lowest cost; multiple sizes on same equipment	Long storage life before display, high product visibility	Long storage life before display
Disadvantages	Short display life; leaky package	Display with purple colour	Purple display colour in MAP; bloom may be inconsistent on exposure to air after removal from MAP.
Shelf life at 4°C/40°F	2-7 days	60-90 days	30-60 days
Drip loss	8-10%	2-5%	1-5%

Packaging in air-permeable overwrap.

Air tight packaging of frozen meat. This to be kept on a temperature of -18°C/0°F.

Pseudomonas

Pseudomonas bacteria play a major role in meat decay, and the main cause is a high storage temperature. Pseudomonas bacteria cause the green discoloration of meat during spoilage. Pseudomonas bacteria are inhibited by using CO_2 or vacuum packaging for meat. They are also inhibited by irradiating the meat with gamma or X-rays (but this is not common in poultry slaughterhouses).

An absorbent pad in the packaging will absorb some drip loss. This is attractive to the consumer, but the drip loss itself is not prevented, of course.

Moisture at the bottom of the packaging is the result of drip loss.

Moisture droplets on the packaging are often just condensation and not a quality characteristic. At worst, the meat might have been slightly too warm during packaging.

Drip loss

With packaged meat, you will find a certain amount of yellow, watery fluid that has leaked from the meat. Do not confuse this with condensation. That is moisture that arises when your meat is put into airtight packaging when it is too warm. Cooling condenses the moisture in the air inside the packaging. You can recognize this process by moisture droplets on the inside of the packaging. The economic loss from moisture exudation (drip loss) can rise to considerable amounts! In a slaughterhouse that kills 100,000 birds daily with a carcass weight of 2 kg, it can amount to 4,000 kg of moisture with a drip loss rate of 2%. In fact, a great proportion of the loss occurs in packaging. In such cases, the consumer actually pays for this loss (i.e. they get less meat). It also has a negative effect on shelf life. Moisture offers an excellent environment for pathogen development.

The changes of muscle structure after the onset of death:

1. Immediately after death, the muscle structure is intact.
2. After 5-12 hours the connective tissue around individual muscle fibres starts losing its function.
3. After 12-24 hours there is complete loss of connective tissue function around the muscle fibres and the muscle as a whole, and clear spaces develop around cells.

Key influencing factors:

- acidification rate after death
- final pH
- state of muscle fibre membranes (oxidation and freezing)

Antioxidants and drip loss

Phospholipids are the main constituent of cellular membranes in all cells, including muscle fibres. Antioxidants, such as vitamin E, can prevent oxidation of phospholipids after death, so that there will be no holes in the membranes. And that means no leakage or deterioration cellular fluid, and drip loss is prevented.

Tracking and tracing

An important part of the whole process of poultry processing is tracking and tracing. This is necessary for reasons of food safety. If anything goes wrong with the quality you should be able to trace the product back all the way to the source, in a short period of time (within 24 hours). Within the slaughterhouse the flock tends to stay together, but once packaged in small units, it could go anywhere.

And fraud has to be excluded. So besides coding, anti-tampering is essential. There are various ways to obtain this.

All products in the supermarket can be traced back to the producer within four hours. This is managed at flock level. Otherwise you might have to throw away a slaughterhouse's production for an entire day. The information goes directly with the products.

To guarantee quality, there is a sticker placed over the strip that keeps the box closed. As soon as this 'anti-tamper' seal is broken, the slaughterhouse cannot guarantee the quality of the content any longer.

Here the origin of the meat is printed on the strap, so an extra sticker like on the top images is not necessary anymore.

The label contains important information for the consumer but also for traceability to source: expiry date, batch code, storage advice, nutritional value, type of animal husbandry.

CHAPTER 9:

Health and safety

Safety of the product and slaughterhouse employees is very important. If this is poorly managed, there can be public health risk. Biosecurity is an essential part of the entire process, from poultry farm to consumer.

Hygiene and safety

In view of hygiene and safety, slaughterhouse construction and the layout of all its components requires careful consideration. Here you should consider the following:

- smooth walls without corners and seams
- smooth floors, on which employees have sufficient grip
- machines that are easy to clean properly, and with shielded parts
- well-thought-out walkways that prevent carcass contamination
- a good overview and good lighting
- well-thought-out waste water disposal, always towards the 'dirty' areas

Many of these matters are laid down in national and international regulations or in customer requirements.

Machines in the slaughterhouse need to be lubricated. Food grade lubricants can be used to prevent contamination of products. By using these kind of lubricants there is no public health risk.

Foreign material in the product

A consumer who buys poultry meat does not want to see anything else in the packaging. So, any foreign material must be removed. In some cases other product-specific materials, e.g. bone residues are acceptable but iron, plastic, wood, etc. are not. Detection is done at the end of the process. Doing it in between does not make much sense, because metal, etc. could still get in. The only guarantee that a product is really free of metal, is a check after packaging when nothing else can get in.

Metal detectors are important for food safety and to prevent damage to the slaughterhouse equipment. Simple detectors or magnets can detect iron. Iron is clearly visible with a bone detector. The metal may originate from the broiler farm, but also from machines in the slaughterhouse and of course via employees. Employees are not allowed to wear watches, rings and other jewellery. Protocols for maintenance technicians are very strict – if a maintenance mechanic replaces 10 bolts, he or she MUST also return 10 old ones.

Metal detection takes place after packaging and sealing. Here a crate in which a metal-containing material was deliberately deposited as a test is separated.

The reason for an alarm is often merely a staple in a plastic crate. For example, someone who used the crate previously stapled a note on it. This disrupts the system. That is why staplers are not permitted in slaughterhouses.

Here a crate in which product containing foreign material is detected is discharged via a pneumatic system on a lower conveyor belt.

Other foreign material

Non-ferrous metals such as copper are more difficult to find. Low energy X-rays offer a solution for detecting other materials such as hard plastic, glass or bone splinters. When it detects something, the system sounds an alarm, takes a picture and the product is dropped from the line. Foreign materials that are difficult to detect are actually the biggest problem in a slaughterhouse. This is even considered a bigger problem than microbial infections. Hygienic crate cleaning and disinfection are important but checking for damage is equally important. For this reason, the use of hard to detect wooden materials (e.g. cutting boards or pallets) is not allowed anymore.

Do not use damaged crates. Flakes can come loose and end up in the product.

Dragging crates over the floor can cause damage and plastic chips might break off. So always lift them.

Coloured crates must be used when processing cut-up parts. If you use white or transparent crates, a broken off piece will not be clearly visible.

Check incoming crates that will be used for product for both microbial quality and physical damage.

Clothing and equipment

Besides packaging materials, clothing and equipment are also a source of foreign material in the product. Earplugs, pens and hairnets, can easily end up mixed with the product.
Using equipment that is brightly coloured makes it easier to recognize when they may have contaminated the final product. Sometimes materials are also provided with a personal code. This makes the employee more responsible for the material. And if something is found, the employee can be addressed.

Also beard and hairnets can be equiped with a metal strip to make them detectable and don't end up in the product.

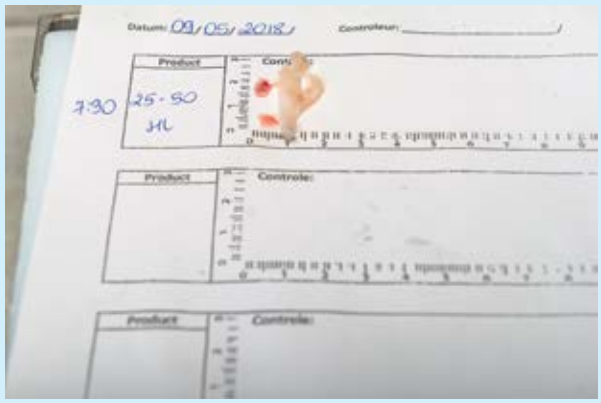
LOOK-THINK-ACT

You probably already saw the piece of blue glove, but do you see the white one?

Colour is an important alternative to metal detection for identifying foreign material among the product. You can see that clearly in this example of a piece of blue latex gloved and a white one that ended up in the meat.

To prevent foreign material from entering the meat, various utensils are made detectable, so that they are removed by the metal detector. Ear defenders/ear plugs containing metal are also used.

Product-specific materials



Besides foreign material, some product-specific materials are also undesirable. These include bones, feathers, litter, faeces, etc. After deboning, a record is kept of materials found. On the paper, bone splinters that the inspector has removed during a visual check (a sample inspection).

Through colour coding you can also compartmentalize the slaughterhouse. In this case, blue gloves are reserved for employees on the slaughter line and those on the cut-up line have a different colour. This prevents cross-contamination between departments.

Biosecurity

Good biosecurity is important in a slaughterhouse. Generally speaking, most people working on the cut-up line are highly exposed to contamination risks. Biosecurity is based on a few basic principles:

- reducing infection pressure
- preventing introduction
- preventing transmission

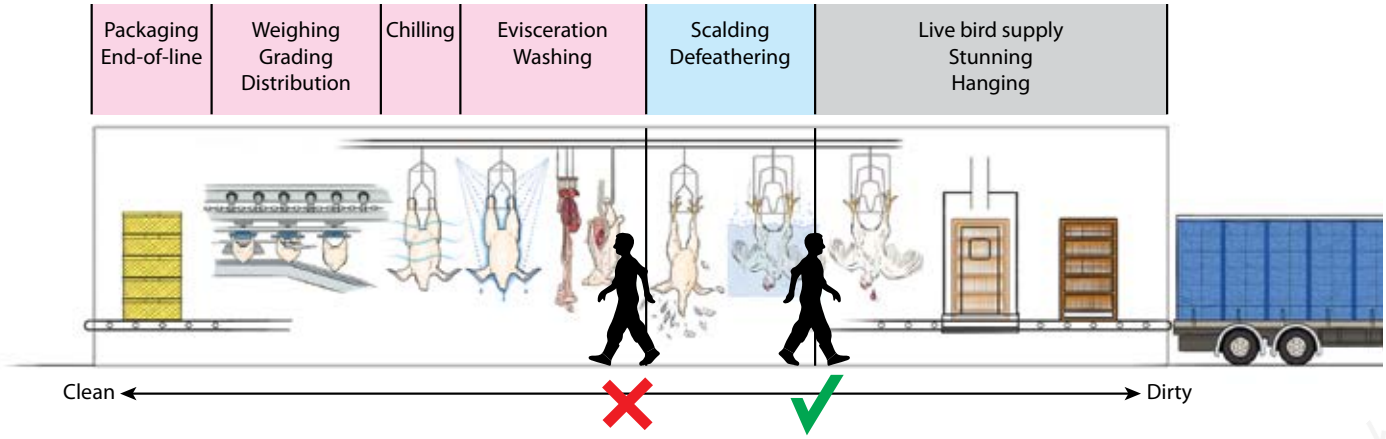
Preventing cross-contamination

The employees who work in the (dirty) support department have their own canteen, changing room and sanitary facilities to prevent cross-contamination between departments. The staff must wash their hands and forearms with soap, then disinfect them and clean and disinfect the footwear and aprons before leaving the department.

Employees must give continuous attention to communication about the protocols.

Logistic slaughter

To prevent contamination of healthy flocks, logistic slaughter applies at most slaughterhouses. This means that any flock that tests positive for Salmonella is slaughtered at the end of the day. A flock's status is known a day in advance (overshoe testing). Re-schedule the loading time to match the scheduled slaughter time. If the Salmonella contamination originates from *Salmonella typhimurium* or *Salmonella enteritidis*, the products must be heated, which increases costs and limits sales opportunities.

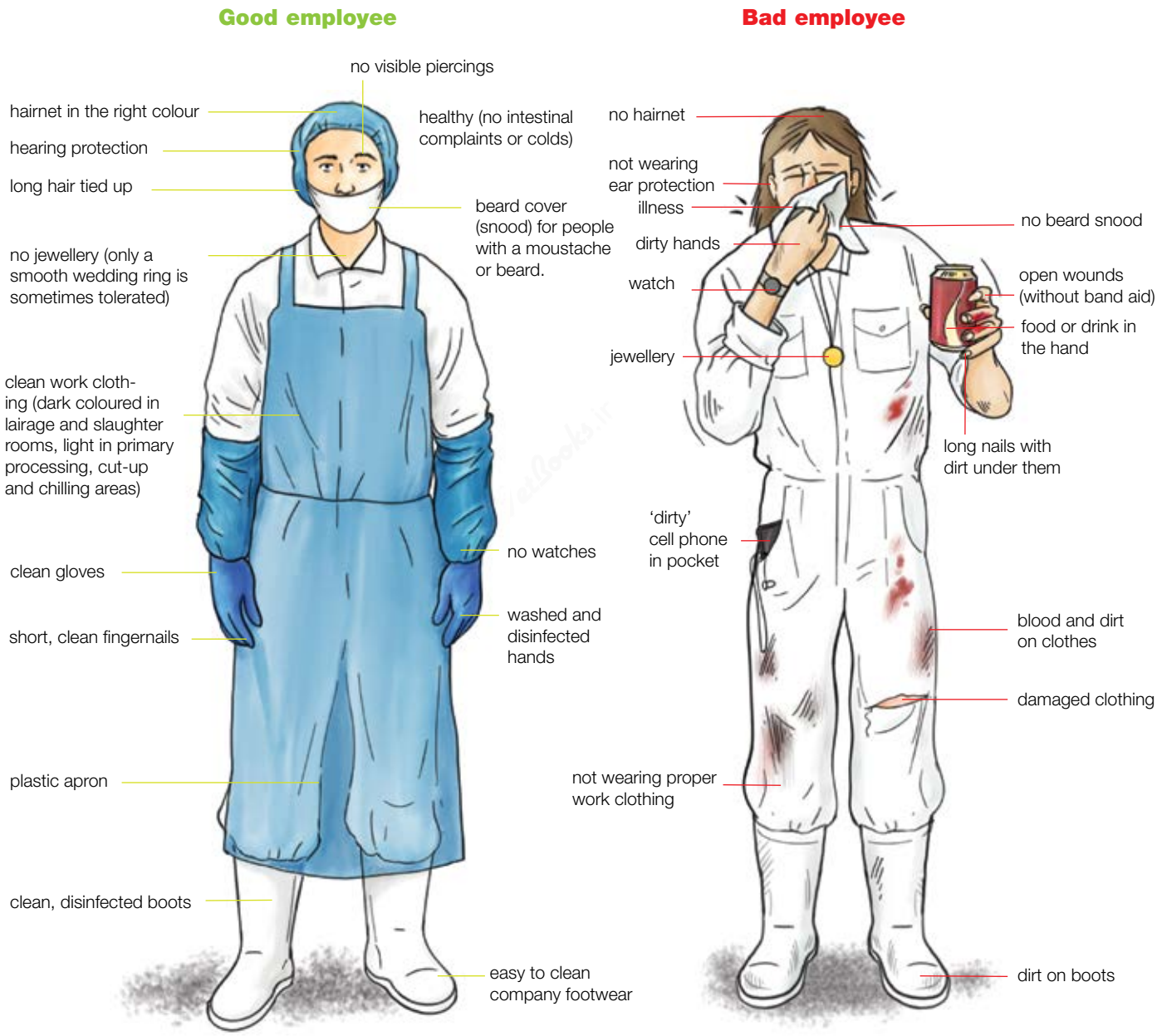


To prevent consumer products from being contaminated, a good walking route must be maintained. This means that both employees and visitors can only walk from clean to dirty, i.e. from the end of the line to the point where birds are first shackled.

Personal hygiene

Everyone who enters meat processing areas must be aware of the rules for personal hygiene and working conditions. So this not only applies to employees, it also includes temporary workers, contracted staff, inspection staff and visitors.

25 attention points for personal hygiene:



Hand washing facilities

Ensure that all work areas in the slaughterhouse have facilities to wash hands with warm water and disinfectant soap during work, before resuming work after an interruption, and after contacting dirty substances (including blood, faeces, intestinal contents, etc.).

The correct order is as follows:

1. wash hands with soap,
2. dry hands,
3. disinfection.

The taps must be operable with a knee, foot, infrared sensor, etc. (so not with hand or arm). This way you avoid touching a tap that you opened previously with dirty hands with your freshly washed hands.

Do not only provide a good washing area at the entrance to the slaughterhouse but also in each working area.

Provide clear instructions for washing facilities. The importance of hygiene cannot be emphasized enough.

Sanitizing hands after washing is important. Here, the light only goes green and the turnstile will only open when both hands are disinfected properly.

Here, the footwear is sanitized simultaneously with the hands.

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Hairnets

Hairnets are mandatory in slaughterhouses to prevent contamination with hair and skin flakes. This is a good opportunity for visually identifying employees. Employees of different departments or levels (new, experienced, managerial) wear different coloured hair nets or distinctive clothing, to make 'unauthorized walkers' easy to recognize. Using separate colours for trainees, new employees, expert staff, managers and inspectors offers a quick overview and clarity.

Besides hairnets, beard nets (snoods) are mandatory for employees with beards or moustaches. You can check yourself properly in the mirror.

Thoroughly clean footwear with brushes (automatic or not), water and a cleaning agent. The mirror allows you to check the bottom of your boots and clothing as a whole properly.

Colour coding can also be implemented for knives and other utensils. Colour is used to make materials easy to find when lost or damaged and colour-coding prevents cross-contamination.

First the bottom is cleaned and then the sides.

Healthy employees

Persons suffering from or carrying a disease that can be transmitted through food must not handle food or enter areas where food is handled, if there is any risk of direct or indirect contamination. This also applies to people with infected wounds, skin infections, skin conditions or who have diarrhoea. When a person with such a condition works in a slaughterhouse, he or she must report their illness or symptoms immediately to the company.

Hearing protection is obligatory, because there is a lot of noise in a slaughterhouse.

Some slaughterhouses have stool samples taken from their employees and tested for Salmonella once or twice a year.

An employee must dress well in the cold. The further along the line you are, the colder it is.

Employees at some slaughterhouses must complete and submit a health certificate. Employees who are potentially infected may not carry out any work where they can come into contact with the products.

If an employee is injured, this must of course be treated and covered. Besides that the band aids are coloured, they are also detectable by a metal detector.

These earplugs cannot easily be lost because of the wire that connects them. In addition, they contain a small amount of metal, which makes them detectable.

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Working conditions

Working in a slaughterhouse is not risk free. Consider the following:

- machines with many moving parts (fit safety guards)
- knife safety such as working with sharp knives (protective gloves on the non-cutting hand, forearm protection, girth aprons)
- fall hazard on platforms (use hand, knee or foot rails)
- slippery floors

Every employee must have proper instruction and training. That is why slaughterhouse employees do not change jobs quickly. Informing foreign speaking employees about safety is a problematic factor here. Repeat instructions frequently and preferably at times when you notice that something is not going well. It is better to give more frequent and brief instructions than a single long training session.

The knives hang in a metal cage when they are not used. This prevents someone cutting themselves and stops people walking with knives through the slaughterhouse.

All machines have one or more emergency buttons that can stop the machine immediately in case of emergency.

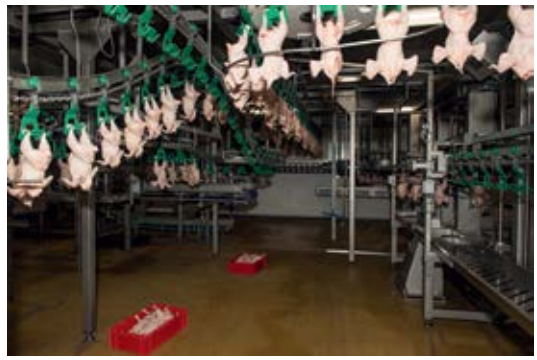
The wet carcasses and regular rinsing creates an environment in a slaughterhouse that is always moist. Signs such as these are not a luxury and should keep employees constantly alert.

Sturdy footwear is important for grip and must be able to withstand a knife that accidentally slips out of the hands ...

When you work with knives, a metal glove protects against cuts.

Working hygienically

Make sure that hands, tools and materials are regularly cleaned throughout the duration of work. Use the regular breaks for scheduled cleaning or add extra cleaning breaks to the schedule if necessary. At the end of the production process, clean all machine parts with hot water and disinfect them. Even when all the conditions are up to standard, the working method must be hygienic too. Ensure that hygienically defective carcasses or parts (e.g. ones that have fallen on the floor) are removed from the line and handled separately. Check how the hygienically defective carcasses or parts occur and eliminate the causes.



Carcasses that fall from the line are put in red crates here, and removed later.

Cleaning of protective clothing, also at regular breaks during the day.

The protocols specify who should wear what clothes and who is allowed to do what in the process. For instance this prevents employees working with the products touching dirty meat or the floor with their gloves.

Meat fallen on the floor

Meat that has fallen on the floor should never be thrown back on the conveyor belt. Each slaughterhouse has its own protocols on how to deal with this. This varies from processing it as waste material to making it fit for human consumption after treatment. These protocols are developed in collaboration with the public health authorities. Even though it might not appear so with the naked eye, floors in the slaughterhouse are inevitably contaminated with faeces, blood and micro-organisms. Meat that falls onto the floor absorbs these contaminants, especially if the floor is wet.

Contamination sources

Make sure that crates are always on pallets and never directly on the ground. This prevents crate damage and contamination of the meat in them.

Every employee must be able to rinse and disinfect his or her knife. This means disinfecting with water at a temperature of at least 82°C/180°F or by using a facility with demonstrably the same effect. When using water, you have to rinse the knife first and then disinfect it in water at 82°C/180°F. This applies to other tools and equipment too.

Even though there is a plastic bag in the crate to put the meat in, these crates should still be on a pallet. Damage and contamination must be prevented.

Keep the floor clean and dry during the work. This prevents product contamination and employees slipping on wet floors.

LOOK-THINK-ACT

Why are the lower crates empty and with a different colour?

Rinse water always flushes under crates during cleaning. This poses a risk of the meat and carcasses becoming contaminated with rinsing water. So, if crates are not on a pallet, make sure that the bottom one in each stack is always empty. Use a striking colour such as yellow or red for this particular crate. Using plastic sheets in the crates to package the meat also helps prevent rinse water ending up on the meat, and it prevents weight loss from evaporation too.

Cleaning

All areas of a slaughterhouse are cleaned and disinfected daily. This is usually night work. The cleaning process follows the line logistics, i.e. the slaughter line is already cleaned and disinfected while the cut-up line is still running. Checks and maintenance of the equipment are also done during this period. This is why a slaughterhouse can slaughter a maximum of 16 hours a day.

Points to consider when cleaning and disinfecting working areas:

1. Remove all meat and packaging materials from the area.
2. Collect the coarse dirt and dispose of it (as dry waste).
3. As a general rule, always work from top to bottom.
4. Rinse blood and feather residues away with warm water under pressure.
5. Apply the cleaning agent and let it work according to the instructions.
6. Rinse off the cleaning agent and loosened dirt with warm water under low pressure.
7. Visually check all surfaces for cleanliness. If any surfaces are not clean, do them again.
8. Allow the cleaned surfaces to dry slightly before starting disinfection.
9. Apply the disinfectant according to the instructions. Provide sufficient contact time.
10. Rinse all disinfected surfaces with water under low pressure so that no residues of disinfectants are present.
11. Make sure that the surfaces dry as quickly as possible (e.g. by setting work surfaces at an angle to drain and leaving the ventilation on).

First remove the coarse dirt before applying a cleaning agent.

The application of detergent after rinsing off coarse dirt.

Condensation on the ceiling. Prevent condensation from dripping on meat or work surfaces and thus contaminating the meat.

Do not immediately rinse off the cleaning agent, but allow it to soak in during the prescribed period for optimal results. After soaking you rinse everything thoroughly.

Floors, walls and equipment

Floors and walls must be well maintained, easy to clean and, if necessary, disinfect. This means that they must be made of impermeable, non-absorbent, washable and non-toxic materials. Materials that come into contact with food products must be well maintained, easy to clean and, if necessary, disinfect. This means that they must be made of smooth, washable, corrosion-resistant and non-toxic materials.

Hard-fired ceramic tiles are popular. A hard coating on the floor and walls is also possible, as well as hard, smooth plastic tiles.

Smooth or rough floor?

A rough concrete floor prevents employees slipping but it is not easy to clean. This floor is a continuous breeding ground for bacteria. Applying an epoxy coating on these rough floors is a good solution. A smooth floor is better from a hygienic point of view, but more dangerous for employees. So sometimes regulations involve a quest for a balance between working conditions and hygiene.

This board can easily be attached to a smooth wall. Because it can be taken off, optimal cleaning of both wall and board is possible.

In-line cleaning of shackles.

Cleaning the shackles

The shackles are stainless steel. Plastic cannot handle the powerful forces exerted here. Plastic shackles are sometimes used on the cut-up line (primary processing shackle). Chilling line shackles, distribution shackles and shackles for cuts are always plastic because they are cheaper and lighter. Besides, they often have a more complex shape, which makes plastic a more logical choice. The broilers have to be transferred from one shackle to another during the process, because other types are used in different departments. This comes with the added benefit of breaking the contamination chain. A dirty slaughter shackle would be absolutely unacceptable in other departments. As soon as a shackle is empty (after transfer) there is an opportunity to wash it before hanging the next broiler.

When forklifts drive in and out storage rooms and trucks, they spread dirt all over. Make sure floors are clean to start with.

Pests

Pest animals can serve as a vector ('means of transport') for micro-organisms. In poultry slaughterhouses, this mainly concerns flies, cockroaches, mice, rats and birds. So pest control is essential. Essential pest control measures include the following:

- Prevent creation of wet spots around the building or within one metre of the walls.
- Remove materials that are on the outside of buildings or within one metre of them. This includes any vegetation.
- Prevent pests from entering by using screens on any windows and doors that can be open during work.

No foodstuffs

The most important thing is to eliminate reasons for animals entering the slaughterhouse. Make sure that meat residues are cleaned up immediately. You should also clean up other edible goods and packaging materials in good time and regularly. Foodstuffs and residues in storage must also be inaccessible for pests. And pay attention to walls, roofing sheets and insulation material that can serve as nests and shelter.

Pest control measures

In case of a pest problem, take suitable extermination measures, such as setting out bait boxes and electric insect killers. Pesticides are poisonous substances, so take account of the risk of poisoning water and foodstuffs when setting them out. Record the location of the pesticides on a plan of the building so that you can check and refresh it, and keep a record of uptake by pests.

Make sure you have self-closing doors and that closed doors have no openings for pest access. This also applies to ventilation openings and cable or pipe transits.

A fly problem like this is unacceptable. It raises the question of what is in the bags and why they are not stored in a closed container.

Fly traps can help catch flies but with the abundance of food in a slaughterhouse, you will never catch them all. Prevention is the main means of control.

Apply adequate pest control, but avoid poisons being close to products. This is a rat trap that does not use poison. In HACCP protocols the frequency of checking these devices should be described.

Control of pests. Bait boxes with poison are placed outside as well as inside the building.

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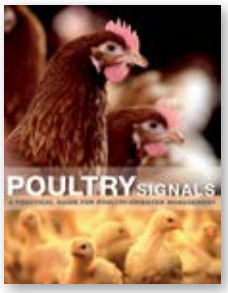

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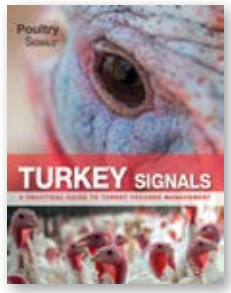

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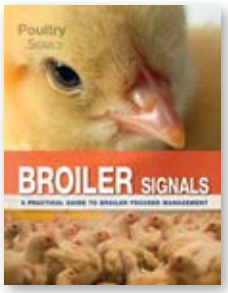

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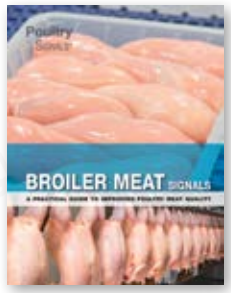

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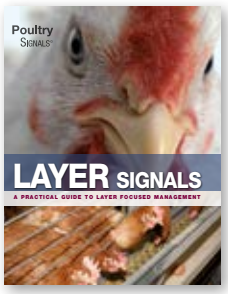

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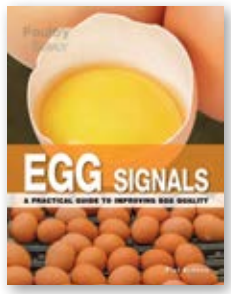

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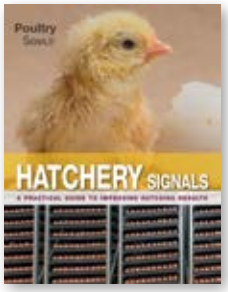

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