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THE INFLUENCE OF GENETIC FACTORS AND PRE-SLAUGHTER HANDLING ON THE QUALITY OF POULTRY MEAT®

Wpływ czynników genetycznych oraz obrotu przedubojowego na jakość mięsa drobiowego®

Currently, Poland is the largest producer of broiler chicken meat in the European Union. This dynamic increase in production was possible due to the development of production technology, the use of appropriate genetic material, optimization of nutrition and provision of appropriate environmental conditions for chicken rearing. High growth rate allows the production of cheap meat thanks to refining the above-mentioned factors. However, the intensive rearing conditions of birds negatively affect the physiological processes of chickens, which consequently increases the risk of meat quality defects and causes increased mortalities. It should be remembered that all of these factors influence on the quality of meat, creating its technological, microbiological and sensory quality.

Key words: broiler chicken, genetic factors, pre-slaughter handling.

Obecnie Polska jest największym producentem mięsa kurcząt brojlerów w Unii Europejskiej. Ten dynamiczny przyrost produkcji był możliwy dzięki opracowaniu technologii produkcji, zastosowaniu odpowiedniego materiału genetycznego, optymalizacji żywienia i zapewnieniu odpowiednich warunków środowiskowych dla odchowu kurcząt. Tak wysokie tempo wzrostu umożliwia produkcję taniego mięsa dzięki dopracowaniu wyżej wymienionych czynników. Intensywne warunki odchowu ptaków negatywnie oddziałują na procesy fizjologiczne kurcząt, co w konsekwencji zwiększa ryzyko wystąpienia wad jakościowych mięsa i jest przyczyną zwiększonych upadków. Należy pamiętać, że wszystkie te czynniki mają wpływ na kształtowanie jakości technologicznej, mikrobiologicznej oraz sensorycznej mięsa drobiowego.

Słowa kluczowe: kurczęta brojlery, czynniki genetyczne, obrót przedubojowy.

FACTORS AFFECTING THE QUALITY OF POULTRY MEAT

The quality of poultry meat is created, among others, during a series of changes (including the most important proteolytic and glycolytic ones) taking place in poultry muscles after slaughter. It is caused by many factors. The quality of broiler chicken meat is created throughout the entire production cycle. By "production cycle" is meant not only the broiler fattening period (from the insertion of chicks to slaughter), but also the handling of meat after slaughter (storage of meat, transport and properly conducted heat treatment) [39].

Meat quality can be divided into three basic elements: technological, microbiological and sensory quality. Technological quality includes parameters such as meat acidification (pH), colour parameters (CIE LAB L*a*b*), natural drip loss and cooking yield. The microbiological quality can be understood also as minimizing the risk of infection by using appropriate technological processes that can minimize this risk. Sensory quality, on the other hand, is the general product features and properties that determine the ability to meet the various needs of the consumer perceiving them through the prism of different sensory quality characteristics. Exemplary attributes determining the sensory quality are the external appearance, colour, odour, flavour, texture, tenderness, juiciness and overall quality of the product [41].

Factors that affect the quality of poultry meat can be divided into two main groups: genetic and environmental factors. Genetic factors include: species, line (referred to as genotype related factors), and gender and the age of the

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bird. Environmental factors, on the other hand, include: pre-slaughter handling and slaughter as well as housing and feeding conditions for birds, as well as slaughter and processing conditions for meat [41].

GENETIC FACTORS

The 25–45% of genetic factors determine the quality of poultry meat [32]. As mentioned earlier, genetic factors include: species, breed (poultry is more commonly referred to as "lines"), sex and age of the animal.

For broiler poultry, broiler chickens are produced the most; hybrid meat lines of Domestic hen (*Gallus gallus domesticus*) and broiler turkey; hybrid meat lines of Domestic turkey (*Meleagris gallopavo gallopavo var. domesticus*).

The increase in demand for poultry meat production obliged producers to ensure its high supply. Therefore, intensification of poultry production began. As a result of intensive crossing and genetic selection in the last 60 years began to receive genetic hybrids of meat breeds. The lines formed in this way are characterized by rapid growth (high daily growth), high value of feed conversion coefficient, low slaughter age and high slaughter capacity [3]. The most popular lines of fast-growing broiler chickens include: Ross 308, Ross 708, Cobb 500 and Cobb 700. In addition to fast-growing bird lines, there are also slow-growing hybrids, such as: Hubbard, Rowan Range, Cobb Sasso, Poulet de Bresse (France) and slow-growing Hubbard roosters (Label Rouge®). Slow-growing line birds are often kept in slow-range or restricted systems. Thanks to these maintenance systems, their well-being is significantly improved, as they can exhibit behavior characteristic of burrowing birds (searching for food in the soil and active movement). Contemporary consumers are increasingly aware and sensitive to animal welfare. Research in Germany shows that 56% of respondents show interest in bird welfare, and 82% would pay more for free range chickens [25]. Increased physical activity of birds kept in organic farming (free range) in comparison to conventional maintenance results in an increase in the share of muscle tissue and a decrease in the fat content in chicken carcasses [7].

The sex of chickens is another factor affecting meat quality. Differences in breast muscle colour and skin thickness depending on sex were noted. Breast muscles of cocks were characterized by greater saturation towards the red colour (higher value of the colour parameter a*) in relation to chickens [26]. The skin of cocks is thinner but contains more protein (collagen and elastin) and less fat than in chickens. This makes the skin of the cocks more durable and less susceptible to damage. As the birds ages, the protein content increases and the collagen fibers become stronger. With the age of the chicken, the thickness of the subcutaneous fat layer increases. As a result, the skin of chickens is more susceptible to injury than the skin of cocks. This applies in particular to birds that have high energy feeds [43].

The age of the birds determines the sensory quality of the meat [43]. The juiciness of meat decreases between 9 and 16 weeks of age, while the intensity of taste increases. Another attribute of sensory quality that is created and reaches its optimum at a later age of birds is odour [15]. It was on this basis and on the basis of an analysis of the French consumer market that the 'luxury' (and brand) poultry farming Label Rouge® was created. Table 1 presents the slaughter age of selected fast and slow growing breeds [1, 8, 20].

Table 1. Slaughter age of selected fast and slow growing breeds

Tabela 1. Wiek ubojowy wybranych linii kurcząt brojlerów szybko oraz wolno rosnących

Breed (line)	Fast growing	Slow growing	Slaughter age [days]
Ross 308	+		35-50
Ross 708	+		35-50
Cobb 500	+		35-50
Cobb 700	+		35-50
Hubbard		+	min. 63
Rowan Range		+	min. 63
Cobb Sasso		+	min. 91
Poulet de Bresse		+	min. 85
Male Hubbard (Label Rouge®)		+	81-110

Source: On the base [1, 8, 20]

Źródło: Na podstawie [1, 8, 20]

The factor that differentiates chickens of fast-growing and slow-growing lines is also the diameter of the muscle fiber. Slowly growing bird muscles have more thinner muscle fibers (hyperplasia). Consequently, such meat has greater water holding capacity. In contrast, fast-growing chicken muscles are often characterized by shorter muscle fiber cells with a larger diameter (hypertrophy). The result is less water-holding capacity in meat. On the other hand, free-range birds are more "runaway". This results in smaller glycogen reserves remaining in the muscle tissue, which results in a higher final pH value. As a result of the higher pH value, we get meat with a darker colour and a higher water holding capacity.

Tenderness is a very important attribute by consumers. The age of animals plays a very important role in creating it. Young animals due to relatively thin muscle fibers are characterized by higher meat tenderness than in older animals. In addition, an important element is the degree of collagen maturity and its ability to dissolve. That is why broiler meat, which is slaughtered at around 6 weeks of age, as a young slaughter poultry, is distinguished by satisfactory tenderness [22]. Studies show that slow-growing poultry, slaughtered at a later age, are generally characterized by meat with poorer tenderness. Therefore, meat from slow-growing chickens is not always desired by consumers.

Genetic factors have a huge impact on the level of sensitivity and the way the nervous system reacts to various stress factors [29]. Stress factors significantly affect the quality of broiler chicken meat. Fast-growing chicken lines that reach slaughter weight at a very early age are particularly sensitive to stress factors [19]. Połtowicz [30] showed that Starbo chickens had a higher pH15 (15 min post mortem) of breast muscles compared to other broiler lines; at the same time at a similar pH24 value (24 h post mortem) in all assessed genetic lines. This indicates a slower glycolysis course in these chickens,

while a higher pH may indicate that Starbo chickens are more resistant to stress factors [30].

ENVIRONMENTAL FACTORS

The environmental factors in 55-75% determine the quality of poultry meat [32]. Keeping chickens in conditions of intensive production is associated with the occurrence of stress factors. Environmental factors with potential stressors (nonspecific stimuli that induce a condition in individuals exposed to them as stress) are pre-slaughter, slaughter, bird housing and feeding [36].

Pre-slaughter handling and slaughter

The broadly defined pre-slaughter procedures with birds is of key importance in creating meat quality [42]. Ante-slaughter turnover is a series of activities from the beginning of pre-slaughter starvation on a poultry farm, to catching, loading, transporting chickens, ending with unloading at the slaughterhouse. During the entire pre-slaughter handling, birds are exposed to a number of stress factors that they do not encounter during rearing (sudden lack of access to feed and water, contact with people, violent movement, change of housing, disorder of the flock hierarchy, noise, movement and adverse ambient conditions). It is worth adding that the strongest stress responses are caused by emotional and polyietiological factors. Polyethiological factors are when several negative factors act at one time. One of the examples of such stress is the pre-slaughter handling [48]. The very change in the environment in which they find themselves causes that they feel fear, which is undoubtedly the main stress factor [48]. Frindt et al. [13] stated that differences in individual animal responses to a given stress factor differ significantly even within the same species. In addition, genetic factors play a huge role in creating sensitivity and how the nervous system reacts to various types of stressors [29]. Intensive genetic selection of broiler chickens aimed at achieving the largest possible muscle growth in the shortest possible time can lead to form, among others the "stress syndrome" [24].

Pre-slaughter starvation

Pre-slaughter starvation is an essential element of pre-slaughter handling. Starvation consists in putting the birds away from the feed (usually by raising feeders). This procedure is intended to empty the gastrointestinal tract of birds (mainly the esophagus and goiter) from residual digestive tract. Pre-slaughter starvation also reduces contamination of the feathers and legs of birds with feces [16]. The pre-slaughter period when starvation begins is extremely important. In the case of broiler chickens, the onset of starvation is included between 8 and 12 hours after slaughter [43]. It should be remembered that pre-slaughter starvation includes not only the period of withdrawal from feed and water until the birds leave the house, but also transport and waiting for broilers for slaughter. Shorter starvation time than 8 hours causes that the birds are fed (digestive tract filled with digestive content). This is an adverse occurrence, because during slaughter at the stage of plucking and evisceration, the filled digestive tract is susceptible to mechanical damage. Which, as a consequence, may cause it to tear and contaminate the carcasses with food content, and this may cause microbial contamination. Prolonging starvation may result in stressful behavior in birds, such as eating litter, coprophagia or even cannibalism [11]. In addition, the unnecessary extension of the duration of pre-slaughter starvation causes losses in slaughter capacity. Weight loss can range from 0.3 to 0.6% of live weight for each hour of prolonged starvation [4]. In addition, long starvation of birds causes depletion of glycogen, resulting in increased muscle pH. Pre-slaughter starvation for more than 36 hours has been shown to significantly reduce the pH of breast and femoral muscles and glycogen levels [23].

Catching and loading

The next stage of pre-slaughter handling, which causes stress in birds, is undoubtedly catching and loading broilers in transport containers. It is practically the first, greater contact of chickens with people. In order to minimize stress in birds, the broiler should be caught and loaded efficiently and respecting animal welfare principles. Due to the fact that the vast majority of Polish poultry farms use manual catching of chickens, the occurrence of wing damage is a frequent occurrence. The blood vessels of the wings are also damaged, which causes the formation of bloody ecchymoses (runaways) at their tips. These wounds result from the intense movement of the wings by birds, which in turn is the result of moving them in a non-physiological position; holding his head down [21]. In addition, incompetent grasping of broilers by the legs causes damage (joint dislocations and even fractures). Scaring and chasing birds in a small space causes their excessive accumulation. This contributes to an increase in cases of scratches and skin damage [17]. The capture of chickens is the least automated process in all ante-mortem proceedings. However, in many countries mechanical harvesters for catching poultry have been successfully used for years. Automated bird capture reduces stress levels, shortens the period of tonic immobilization, and allows you to restore normal heart function in less time [10]. In addition, some breeders use blue light when catching poultry. Light of this colour has a calming effect on birds. Placing birds in transport containers should be done with caution. The maximum capacity of the containers must not be exceeded, as crowding of birds hinders the free circulation of air in the cage. This crowding may cause heat stress. Therefore, often when loading poultry, fan batteries are used, which forcing the air movement to avoid overheating of birds at the stage of waiting for transport [43].

Transport and unloading

Of all the pre-slaughter stages, transport is the most aggravating factor which negative effect on the chicken [28]. During transport, broilers can be exposed to a number of adverse stress factors, such as lack of food and water, adverse temperature (too low or too high) and microclimate, vibrations, movement, shocks, impacts, noise, and disruption of the social balance of the herd. These stressors may cause birds to experience stress, including heat stress, which has a significant impact on the decrease in the meat's pH value, and thus its colour [45]. It has been shown that stress during transport has an impact on slaughter performance and on the quality of the carcasses. There is a lot of research on transport stress and its impact on slaughter performance and broiler chicken meat quality. It is obvious that the weight loss of birds during transport varies and depends, on the season of the year,

the number of birds placed in transport containers, the method of pre-slaughter starvation, species, body weight, and naturally the method and time of transport [44]. Weight loss in the first two hours after loading is 0.75%, and after each subsequent hour 0.30%. During transport, the total weight loss should not exceed 3%, as losses these reduce the slaughter performance. The extent of these losses is related to the duration of transport [33]. The microclimate that prevails in the middle of transport (especially temperature) is the main factor that causes an increase in the mortality of birds during transport, a decrease in their welfare level; consequently, it causes a decrease in meat quality. Heat stress is one of the major stress factors during transport that broilers are exposed to. Temperature that fluctuates around 17°C may have relatively little effect on chicken mortality. However, higher temperatures favor deaths [46]. Considering the above, birds should be transported in the colder times of the day (early morning, late evening or night). Vehicle semitrailers should be well ventilated during the summer months. It has also been observed that the occurrence of heat stress in broilers causes a decrease in the total protein content in the muscles, while not affecting the carcase fat [42].

In studies [34] have shown that the duration of transport plays an important role in creating the tenderness and juiciness of poultry meat. In winter, during three hours of transport, juiciness decreases compared to one-hour transport by 3.7% (thigh muscles) and 3.4% (pectoral muscles). In the summer, however, the worst juiciness of meat was in birds, whose transport to the slaughterhouse took 4 hours. Compared to one hour transport, it decreased by 4.5% (thigh muscles) and 4.7% (pectoral muscles). The most tender tenderness was seen in the meat of these chickens, whose transport took 1 hour. According to [31], prolonged physical activity before slaughter may contribute to the improvement of poultry meat tenderness. Transporting broilers to the slaughterhouse should not take longer than 2 hours, but the maximum allowed time is 6 hours. After transport, the birds should not be tired, so you should transport them carefully (avoiding unnecessary shocks), there should not be more than 12 birds in one container [27]. If we are dealing with transport over considerable distances, the so-called pre-slaughter rest should be applied before slaughter. Determining the duration of this rest is not easy, because the return of the animal's body to physiological balance is possible if the correct conditions are provided. Chickens should be slaughtered after a minimum of 1 hour, but a maximum of 4 hours of ante-mortem resting. It should be remembered to provide birds with adequate air exchange during rest in order to properly oxygenate them [27]. It should be noted that too long transport and strong stress cause increased energy demand in birds. Naturally, with a lack of access to feed during transport and a short period of adaptation of the body to the prevailing conditions, there is an increase in the intensity of glycolysis. Slaughtering animals in this condition will cause post-mortem glycolysis disorders that appear in meat as a defect in PSE [44].

All factors causing stress in birds during transport and unloading can cause many injuries to chickens. Such as: scratches, bruises, fractures of the legs and wings, blood splash, haematomas and even death caused by exhaustion of the body, or suffocation. Contusions are the most numerous group. Almost 90% of bruises occur 12-18 hours before slaughter [40]. The formation of bruises and hence ecchymosis is favored by high ambient temperature, because the bird's blood vessels are then more dilated and are more easily damaged. It was also observed that 31.4% of bone fractures in broilers arise during unloading of chickens from transport containers and hanging them on the slaughter line; in the case of electric stunning [18]. It is not possible to eliminate stressors that affect broilers during transport, even in the best organized transport chain. However, care should be taken to ensure that the birds are as humanitarian and safe as possible, using appropriate, adapted means of transport. During transport, remember also about the loading density standards for animals. Minimizing stress factors related to loading, transport, unloading and hanging on the slaughter line (in the case of electric stunning) it is necessary to ensure high-quality meat and, above all, to ensure a high level of bird welfare.

Slaughter

Slaughter greatly affects the quality of poultry meat. Slaughter consists of many closely related stages. Slaughter stages include: stunning (electric, gas, LAPS), bleeding (preceded by interruption of the most common cervical blood vessels), cutting off the head, burning, plucking, eviscerating and cooling the carcasses. Appropriate conduct at each of these stages largely determines the quality of the meat. Undoubtedly, one of the phases of slaughter that most significantly affects the quality of meat is stunning.

Stunning

Stunning animals is designed to prevent animals from moving. They can be easily and safely maintained during slaughter. At the same time, it prevents sudden convulsions after cutting the vessels. However, the most important reason for stunning animals before slaughter is to ensure animal welfare during slaughter by depriving them of awareness, reducing pain and suffering to a minimum [9, 47]. There are several methods for stunning broiler chickens. Among them we distinguish electric and gas methods and stunning using low atmospheric pressure (LAPS).

Methods of electric stunning can be divided into: stunning in a water bath and individual stunning. The most widespread is electric stunning in a water bath (80% of stunned birds in the EU; [12]). This method involves immersing the heads of animals suspended in the stirrups of the suspended conveyor in a brine bath and at the same time exciting the flow of electric current depending on the voltage, impedance of the birds and the resistance of the medium in which the broilers are immersed. As a result, it stimulates the brain and causes epilepsy, which leads to a gradual loss of consciousness and pain sensitivity. Another way to stun poultry by using electric current is to paralyze only the bird's head. For this purpose, two dry electrodes are attached to both sides of the bird's head placed in the funnel nest (in automated lines) or manual electrode attachment [43].

Controlled stunning methods in a controlled atmosphere CAS (Controlled Atmosphere Stunning) in industrial slaughter of poultry are an alternative to methods based on the flow of electric current. They are used mainly to improve animal welfare, employee safety as well as to improve meat quality. These methods are based on subjecting the birds placed in the

slaughterhouse to a gas mixture (with different proportions of O2, CO2, N2 and Ar) in a one-stage or two-stage sequence. When using a one-stage process, a low (less than 2%) oxygen is added to the mixture, and when two stages are used; in the first, a mixture of gases with anesthetic effect (e.g. 40% CO2 and 30% N2 and O2 each) is administered, and in the second mixture causing death by asphyxiation (increase of CO2 content to 80%, lack of O2) [38]. It should be added that we distinguish two variants of this type of stunning: continuous and periodic operation.

The LAPS (Low Atmosphere Pressure Stunning) method is analogous to the gas stunning method, but instead of introducing a gas mixture into the chamber, oxygen is gradually removed, leading to suffocation. This method is not yet approved in the EU, but it is used in the United States [8]. The LAPS (Low Atmosphere Pressure Stunning) method is analogous to the gas stunning method, but instead of introducing a gas mixture into the chamber, oxygen is gradually removed, leading to suffocation. This method is not yet approved in the EU, but it is used in the United States [43].

The methods of stunning birds described above have advantages and disadvantages (Tab. 2). Due to the fact that the LAPS method is not used in Poland, it has not been enabled to Table 2.

Incorrectly performed stunning of animals has a huge impact on the decreasing of meat quality. The most damage to carcasses is noted in the case of electric stunning. These injuries include, but are not limited to: fractures of the sternum and wings, damage to the capillaries in the pectoral muscles („spraying" with blood on the muscle surface; blood splash), the appearance of cramps and bloody ecchymoses as a result of rupture of blood vessels and muscle damage [43]. In order to prevent the occurrence of the above problems, the gas stunning mentioned above is increasingly used. In addition, as previously mentioned, to calm the birds, blue light is used in the livestock warehouse, and stunning should be done in such a way as to minimize the impact of stressors to a minimum [35].

Chicken slaughter without stunning is also used worldwide (so-called Halal slaughter). It is used in Muslim countries and has a religious background. In the case of restrictive slaughter of Halal, any form of stunning is not allowed, and the cessation of cervical blood vessels by the shochet is interrupted with full animal awareness [14]. Kosher slaughter (used in Judaism) still has similar principles. In addition, salted meat after slaughter is used to remove as much blood as possible from kosher slaughter, as it is considered unclean [6].

Bleeding and head cutting

Bleeding is intended to remove blood from the chicken's body (about 50%), which in turn leads to its death. This occurs as a result of disruption of the blood vessels located in the broiler's neck. This process is carried out on the slaughter line using automatic knives. The exception is ritual slaughter, where cutting is done manually by a qualified shochet. Better bleeding efficiency is used for high frequency current stunning than for gas stunning [2, 39]. Naturally, the best level of bleeding is provided by ritual slaughter methods, but due to their controversy they are not widely used. After bleeding (about 180 s), the head is cut off and used for blood disposal [43].

Scalding

The purpose of scalding poultry is to facilitate the next stage of slaughter, i.e. plucking. This facilitation is the result of loosening the feather bags. The scald is carried out mainly by immersion in devices called scalds. The slaughtered birds are immersed in water at the appropriate temperature for a specified period of time, which allows them to loosen their feather bags. There are two main types of burns: low temperature (50-53°C for 60-180 s; used when processing burrowing poultry) and high temperature (55-65°C, up to 90 s; mainly used for water poultry) [35, 39]. Incorrectly performed scalding can have a major impact on the quality of meat. Too low temperature and/or too short duration of the process may cause carcass damage caused by the need to carry out more intense later plucking. On the other hand, too high temperature and/or too long burn time may cause partial denaturation of muscle proteins seriously reducing carcass quality [5].

Plucking

Plucking is used to deprive birds of feathers. It is carried out in automatic pluckers, equipped with rubber „fingers". Improper, too intense picking leads to carcass damage. In addition, a process that is not intensive enough results in the remaining feathers on the carcasses [2]. Such feather

Table 2. Advantages and disadvantages of electrical and gas stunning

Tabela 2. Zalety i wady oszałamiania kurcząt brojlerów elektrycznego i gazowego

Electrical stunning		Gas stunning	
Advantages	***Disadvantages***	***Advantages***	***Disadvantages***
cheap	„unfriendly" to birds (hanging live animals on shackles)	provides more „comfort" for birds	gas and installation costs
takes up little space in the slaughterhouse	hematoma in pectoral muscles (EU requirements for electrical current use for stunning)	smaller range of damage to blood vessels	takes up a lot of space in the slaughterhouse
relatively technologically uncomplicated	ergonomics (hanging live birds on shackles are complicated)	broilers are hung on shackles after prior stunning	more technologically advanced system
	risk of carcass damage (e.g. caused by flapping wings)	the birds are unloaded after stunning (depending on the system)	longer period from stunning to plucking (worse plucking results)

Source: On the base [43]

Źródło: Na podstawie [43]

residues mean that chicken carcasses have to be nipped or tan in order to thoroughly remove any remaining plumage. The visual assessment of carcasses depends on the correctness and effectiveness of plucking [39].

Evisceration

Evisceration, i.e. gutting, involves removing the guts from the carcass. This is done using automated gutting spoons after the carcasses have passed the evisceration line. At this stage, offal is separated from post-slaughter waste for disposal. Veterinary inspection takes place before disposal. Incorrectly conducted evisceration may lead to microbiological contamination of carcasses, especially in the case of fed birds (with poorly carried out pre-slaughter starvation) [37]. At the end of evisceration, the carcasses are rinsed with pressurized water (outside and inside) to remove any entrails [39].

Chilling

There are three basic methods for cooling poultry carcases after slaughter: immersion (immersion) water, air and mixed air with sprayed water (fog) or spraying. The most common is the air (wind deflector) method. This method gives the best results in terms of reducing natural drip loss during meat storage [39]. Comparison of the pros and cons of chilling methods for poultry carcases is presented in Table 3.

CONCLUSION

Genetic and environmental factors (including pre-slaughter handling) have a huge impact on the development of technological, microbiological and sensory quality of poultry meat. Genetic factors, such as the appropriate selection of genetic material, lines, sex or slaughter age of birds play an important role in creating the quality of poultry meat. The key determinants affecting the quality of poultry meat are numerous environmental factors, including a number of operations during pre-slaughter handling and slaughter. Pre-slaughter handling and slaughter are one of the main stressors, which consequently affect the quality of poultry meat. One of the most stressful pre-slaughter handling operations is undoubtedly the transport of birds to the slaughterhouse. On the other hand, stunning birds before slaughter and chilling the carcasses are slaughter operations having a huge impact on the quality of meat. Incorrectly carried out pre-slaughter operations handling and slaughter decreases the quality of the meat. This is showed by negative changes in the pH value of meat, colour parameters, the appearance of a large amount of natural drip loss. These changes indirectly lead to decreasing of technological, microbiological and sensory quality as well as various quality defects of poultry meat.

Table 3. Advantages and disadvantages various methods of chilling poultry carcasses

Tabela 3. Zalety i wady różnych metod wychładzania tuszek drobiowych

Chilling methods	Immersion (in water)	Air	Mixed (combine air method with water spray or water dispersed in the fog)
Advantages	– the fastest and most effective – uniformity and brightening of the carcass colour – carcass weight increase (increase in post-slaughter efficiency)	– eliminating water consumption to chilling – reduced microbiological risk – lower drip loss (in comparison to immersion)	– reduction of cooling time (evaporative chilling) – reducing the amount of water consumed (in comparison to immersion) – spraying the surface prevents weight loss – higher carcass production rate (in comparison to air) – no discoloration of the epidermis – reduced microbiological risk – no excessive absorption of "foreign water" by carcasses
Disadvantages	– huge water consumption (6 dm^3 per carcass) – formation of drip loss during packaging and distribution of poultry meat – running the dripping process – carcass absorption „foreign water" from the cooler – the possibility of cross microbial infections – limited product stability in the case of chilled distribution of poultry	– higher cost (than immersion) – longer process duration – causes increased skin discoloration and external defects – no "foreign water" retention	– higher cost (than immersion)

Source: On the base [39]

Żródło: Na podstawie [39]

PODSUMOWANIE

Czynniki genetyczne i środowiskowe (w tym obrót przedubojowy) mają ogromny wpływ na jakość technologiczną, mikrobiologiczną i sensoryczną mięsa drobiowego. Czynniki genetyczne, takie jak: odpowiedni dobór materiału genetycznego, linii, płci lub wieku ubojowego ptaków odgrywają ważną rolę w kształtowaniu jakości mięsa drobiowego. Kluczowymi determinantami wpływającymi na jakość są liczne czynniki środowiskowe, w tym szereg operacji podczas postępowania przed ubojem jak i po uboju. Obrót przedubojowy i ubój są jednym z głównych stresorów, które w konsekwencji wpływają na jakość mięsa drobiowego. Jedną z najbardziej stresujących operacji przedubojowych jest bez wątpienia transport ptaków do rzeźni. Ponadto, oszałamianie ptaków przed ubojem i schładzanie tuszek są etapami, które mają ogromny wpływ na jakość mięsa. Nieprawidłowo przeprowadzone czynności przedubojowe i ubój obniżają jakość mięsa. Przejawia się to pogorszeniem wartości pH mięsa, parametrów barwy, pojawieniem się dużej ilości wycieku naturalnego. Zmiany te prowadzą pośrednio do obniżenia jakości technologicznej, mikrobiologicznej i sensorycznej, a także pojawienia się różnych wad jakościowych mięsa drobiowego.

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