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THE IMPACT OF *ANTE-* AND *POST-MORTEM* FACTORS ON THE INCIDENCE OF PORK DEFECTIVE MEAT – A REVIEW*

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Abstract

The occurrence of defective meat depends on factors affecting meat quality at the various stages of meat production. Defective meat has a broad definition and includes any property of meat that will dissatisfy end-users. For consumers the main meat quality features are colour, taste and texture (tenderness and juiciness). For processors and butchers very important are technological quality features: water holding capacity, pH, content of connective tissue, fat and protein. The functionality of defective meat is limited. The risk of incidence of defective meat is a result of the combination of *ante-mortem* and *post-mortem* factors. The *ante-mortem* factors are linked with the procedure at the lairage, the slaughtering factors, such as the method of stunning, and the *post-mortem* factors, including processing of meat carcasses. The *ante-mortem* factors such as genotype, gender, breeding conditions, nutrition, transport conditions, stress, weather conditions and the methods of slaughter are considered of primary importance for the quality of pork. It is estimated that 40% of meat defects are due to the procedure at the lairage. The impact of stressors causes a loss of weight of the pigs, contributes, in extreme cases, to the death of porkers, increases the risk of incidence of defective meat. Mixing animals from different herds is the cause of stress which leads to aggression and fights between animals. Limiting the stress factors is essential for improving the quality of pork. The applied stunning method affects the quality of meat. Physical stress during electrical stunning is associated with risk of an accelerated *post-mortem* glycolysis, contributing to the rapid decrease in pH. In comparison with the electrical method, stunning with carbon dioxide causes less stress in swine. In order to reduce the occurrence of defective meat, bleeding should be carried out as soon as possible directly after stunning. Deterioration of the quality of meat in the production chain can occur at any stage and is most often associated with the lack of compliance with the standards. The studies on the improvement of livestock breeding, transport and marketing carried out over a number of years contributed to the introduction of international standards and, consequently, to the reduction of quality and quantity losses in pork.

Key words: pork meat, DFD, PSE, pre-slaughter handling, slaughter procedures

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Pork quality is assessed subjectively by consumers who make purchasing decisions paying attention to the colour of meat, the leakage of meat juice in the package, or the content of fat. The first opinion is based on expected features at buying stage. The second opinion is the experienced quality, characteristic after consumption. Overall judgement which covers expectations and satisfaction, if positive, encourage consumer for next purchase (Grunert et al., 2004; Grunert et al., 1996; Darby and Karni, 1973).

A very important aspect is the technological meat quality which covers the parameters such as pH, colour, water-holding capacity (WHC), fat and protein content essential for meat processing (Xiong, 2014; Tornberg, 2013; Pearce et al., 2011).

An objective assessment of meat quality is made by manufacturers. Such an assessment is essential for the detection of defective meat.

The selection of pigs conducted in recent years by farmers was aimed to increase meatiness. The rise of meatiness was not simultaneous with the improvement of meat quality. The risk of meat defects such as deterioration of the water-holding capacity, increased drip loss, exudation, and uneven, too light or dark colour increased (Huff-Lonergan and Lonergan, 2005; Briskey et al., 1959; Wismer-Pedersen, 1959). It was also recognized that pigs most predisposed to PSE were very frequently highly muscled (Cassens, 2000).

The main defects of pork are PSE (*pale*, *soft*, *exudative*) and DFD (*dark*, *firm*, *dry*) (Murray and Johnson, 1998; Sellier and Monin, 1994; Warner et al., 1993, Monin and Sellier, 1985). In the first case, the meat is pale, watery and features increased drip loss. In the second case, the meat is dark, firm and dry. Less known are RSE defects (*red*, *soft*, *exudative*), when the meat is red-pink, soft and watery, or RFE defects (*red*, *firm*, *exudative*), when the meat is red-pink, firm and watery and ASE defects (*acid*, *soft*, *exudative*), when the meat is acid, soft and watery (Kaufman et al., 1992). These defects most often occur in the most valuable parts of meat carcasses. The deterioration of the quality of meat results in economic losses.

Issues concerning meat defects were the subject of many studies. Combinations of different factors including intrinsic such as genetics and extrinsic such as environmental effects, production and processing can influence meat quality. They distinguished the *ante-mortem* factors, linked with the procedure at a lairage, the slaughtering factors, such as the method of stunning, and the *post-mortem* factors, including the processing of meat carcasses. The *ante-mortem* factors, such as genotype, gender, breeding conditions, nutrition, transport conditions, stress, weather conditions and the methods of slaughter are of key importance for the quality of pork. The *ante-mortem* handling is easier to modify than the triggered biochemical reactions which continue *post-mortem* (Honkavaara, 1989). It is estimated that the defects of meat are in 40% due to the procedure at a lairage. Of major importance for meat quality are: the stunning method, the time from stunning to bleeding, the bleeding position, the scalding method and the cooling conditions (Berg, 2010). To obtain high-quality pork, it is necessary to ensure the proper procedure at all stages of meat production (D'Souza, 1998).

Detection of defective meat and quality assurance programmes

Early detection of meat defects reduces economic losses, enables the elimination of pigs with a genotype associated with an increased incidence of defective meat. To this end, quality standards were introduced to the food production sector, e.g. "Certus" in Belgium or "QS label" in Germany. The breeders of pigs and pork producers joining the quality assurance programmes declare compliance with the quality standards and are subject to regular, independent inspections. Apart from breeders and meat producers, also feed manufacturers, transport companies and lairages were included in the quality assurance programme. The quality assurance programme covers the whole meat production chain "from farm to shop". In January 2015, the "QS label" involved a total of 108,935 companies from Europe, mostly from Germany (98,072), the Netherlands (40,704), Austria (2174) and Belgium (1804). The number of producers and companies participating in the quality assurance programmes gradually increases. In 2014, 40 new firms joined the group of 140 Polish companies covered by the "QS label" programme, which is an increase by approx. 30% (www.certus-info.be, www.q-s.be).

It is difficult to clearly determine the impact of individual factors on the occurrence of defective meat. The most important seem to be the factors occurring during loading, transport and unloading. The *ante-mortem* stress can be divided into the long-term stress caused by the factors related to the loading, mixing and transport of animals, and the short-term stress resulting from the factors affecting pigs at a lairage. It is believed that the long-term stress factors are responsible for the increased incidence of DFD defects, while the short-term stress has an influence on the occurrence of PSE and RSE defects (Rosenvold and Andersen, 2003).

Pigs that have been exposed to chronic stress show reduced energy reserves prior to slaughter and, as a result, the pH_{24} of their meat shows high values (Tarrant, 1989). In the case of retainment of energy reserves by pigs, the immediate stress preceding slaughter has the major influence on the quality of the meat. It contributes to a significant decrease in pH, the meat has a pale colour and a reduced water-holding capacity (WHC) (Tornberg, 2013; Pearce et al., 2011).

In the studies by Hambrecht et al. (2004 b), pigs treated during the *ante-mortem* period in a way causing stress were found to have a higher level of lactic acid in the muscles, and the pork featured an increased drip loss and a lighter colour. The level of lactic acid can be taken as an indication of *ante-mortem* stress impacting the quality of meat. In the study of Przybylski et al. (2005) it has been shown that glycolytic potential (GP) and lactate measured in biopsy samples as well as *post-mortem* are correlated with meat quality. Based on the results of their investigations and other authors' reports, Edwards et al. (2010) recommended measuring the level of lactates in the blood collected in the process of bleeding as a potential indicator of the *ante-mortem* pig treatment conditions influencing pork quality.

Transport

The loading density of transported pigs can also affect meat quality. A too high density (<0.4 m^2/100 kg) prevents the pigs to lie down, leading to aggression and fighting, resulting in injuries (Van de Perre et al., 2010). On the other hand, pig trans-

port with a low density factor is the cause of pig injuries due to falls (Nanni Costa et al., 1999). In 2005, in order to protect the transported animals, a European directive was introduced setting out the loading density.

It was agreed that the load factor should not exceed 0.425 m^2/100 kg of pig weight, so that the transported animals could stand or lie in their natural positions (EU Directive 95/29/EC and Council Regulation (EC) No. 1/2005). Van de Perre et al. (2010) in their studies analysed the conditions of transport of 12,725 pigs. The pig load factor from 0.39 m^2/100 kg to 0.45 m^2/100 kg resulted in a higher pH of the pork in 30 minutes after slaughter, compared with the meat of the transported animals for which the load factor exceeded this range (Nanni Costa et al., 1999).

On the basis of the studies by Guàrdia et al. (2004), the density factor of 0.425 m^2/100 kg should be recommended when the transport takes longer than three hours. In the case of transport lasting less than three hours, the reduced loading density increases the occurrence of PSE defects. Similarly, in the case of DFD defects, their dependence on the loading density was also proven. Guàrdia et al. (2005) found that a reduction in the loading factor from 0.5 to 0.37 m^2/100 kg resulted in a decrease in the occurrence of DFD defects by 11%. A higher loading factor favoured the uncontrolled movement of pigs during transport and created the conditions where the animals started to fight.

The impact of transport conditions varies depending on the type of farming. Pigs from outdoor breeding show lower levels of aggression during transport and during stay at the lairage, resulting in a lower incidence of injuries. Barton Gade (2008) found a low frequency (1%) of occurrence of PSE defects in the pigs from outdoor breeding.

An acute *ante-mortem* stress can lead to the consumption of energy reserves, which in turn may cause a rapid drop in the *post-mortem* pH and the occurrence of PSE defects. Loading and unloading are the most stressful elements in pig transport that affects the meat quality. A range of potential stimuli which may cause stress in the transported animals should therefore been taken into consideration (Rosenvold and Andersen, 2003).

In the studies by Guàrdia et al. (2005), a higher incidence of DFD defects was found in the pigs which had been transported in cars provided with a metal floor. This type of floor also favoured a more frequent occurrence of PSE defects. On a metal floor, the animals might easily slip, the noise level was higher, and the pigs had difficulties to adopt a relaxed position. Changing the metal floor to polyester resulted in a reduction of the risk of slipping, lowered the noise level, and, what is more, the polyester floor functioned as a heat insulating layer. The changes resulted in a decrease in the incidence of PSE defects by 1.5%. A similar effect can be obtained by introducing hydraulic jacks, instead of metal ramps (Guàrdia et al., 2004).

The *ante-mortem* procedure

Mixing pigs from different herds, both in transport and at the lairage, is a cause of stress which leads to aggression and fights between animals (Terlouw et al., 2005; Guise and Penny, 1989). As a result of the stress, the activation of the sympathetic part of the autonomic nervous system increases and the hypothalamus–pituitary

gland–adrenal cortex becomes stimulated, resulting in an increased secretion of adrenaline and noradrenaline. The increase of catecholamine intensifies muscle metabolism which contributes to the observed *post-mortem* pH decline and the heightened drip loss (Foury et al., 2011).

The influence of stress on the occurrence of defective pork is confirmed by the results of D'Souza et al. (1999). The researchers proved the association of aggressive behaviour and the resulting injuries with the increased incidence of defective pork. It was observed that in the case of mixing pigs from different herds at the lairage, their pH_{24} exhibited higher, more frequent DFD defects, while PSE defects were rare.

The use of electric-shock prods in the mixed herds had no effect on the muscle glycogen content, while in the meat of pigs coming from one herd, the glycogen content was lower (D'Souza et al., 1999). Low glycogen reserves before slaughter were causing a darker colour in meat and a low drip loss, which contributed to an increase in the frequency of occurrence of DFD meat (Terlouw et al., 2005). Van de Perre et al. (2010) examined the factors affecting the quality of pork during 90 transports of a total of 12,750 pigs, and showed that the *ante-mortem* stress level was dependent on the frequency of use of electric prods at the lairage.

The researchers also found that the stress occurring during transport, affecting meat quality, can be evaluated on the basis of the noise level measured in decibels or the percentage of pigs showing exhaustion (Van de Perre et al., 2010).

Length of stay of pigs at a lairage

It is believed that the optimum time of stay of pigs at a lairage should range between 2 and 3 hours. It is the time of regeneration, essential for reducing the impact of the stress associated with transport. After two hours of staying at a lairage, the animals cease fighting and become quiet (Van der Wal et al., 1999). Slaughter started immediately after transport results in a higher incidence of PSE defects in meat. In contrast, the prolonged stay of pigs at a lairage results in a greater number of injuries and bruises.

In the studies by Guàrdia et al. (2005), an extension of the time of stay at a lairage by more than three hours was found to increase the occurrence of DFD defects. The meat of the pigs which had lived at the lairage for 9 hours showed DFD defects in 18.6%, while for the time of three hours, this value was 11.6%. In the cases where pigs had remained at the lairage overnight, the percentage of defective DFD meat increased to 24.9%.

Factors related to the conditions prevailing at a lairage may also be of importance for the quality of the obtained pork. These are, among other things, the size of pens, the number of animals per pen, the kind of barriers, type of flooring, or noise level. The role of noise as a factor influencing negatively meat quality was confirmed in many studies. The high level of noise, the strange, unfamiliar sounds that are heard by pigs during loading, unloading and transport are the cause of increased stress (Van de Perre et al., 2010).

Elimination, or if this is not possible, reduction of the stressors is essential for improving the quality of pork. Based on the number of tests taking into account the behaviour of slaughter animals, Grandin (2006) developed the rules of conduct

that could significantly reduce the stress occurring in animals. These include, *inter alia*, installation of proper partitions or barriers protecting the staff and the operating equipment, the use of appropriate lighting so that there are no reflections, the use of a ventilation system to eliminate gusts in the opposite direction to the movement of the animals. Corridors, doors and partitions should be wide enough to allow free passage of animals. Opening the door should be quiet and smooth, the noise must be reduced to a minimum.

The impact of weather conditions on meat quality is not easy to assess. Van de Perre et al. (2010) found a higher pH in the meat during the summer months and an increased incidence of PSE defects (Van de Perre et al., 2010). Similar results were obtained by Guàrdia et al. (2004), who analysed the transport of 15,695 pigs and found a nearly doubled frequency of incidence of PSE defects in the summer months (6.5%).

This phenomenon was explained by an increased sensitivity of pigs to heat, which was perhaps due to the lack of sweat glands. In the studied population, the frequency of occurrence of PSE defects was by about 0.5% higher in males (Guàrdia et al., 2004). Interesting results were obtained by O'Neill et al. (2003). In the test of 4560 pigs, they determined the average incidence of PSE defects during the year at 25.5%. In winter, the incidence of PSE defects increased to 33%, on average.

The highest rate (39%) was recorded during the Christmas period (November to January). Also a higher pH_{45} was observed in winter. The researchers explained the results as being due not only to the weather conditions, but also to the seasonality effect of increased rate of slaughter. Due to the increasing demand for pork in the winter months, the frequency of slaughter increases, which may exacerbate the stress exerting a negative impact on the quality of pork.

Table 1. The impact of *ante-mortem* factors on the occurrence of defective meat (↑-increased, ↓-decreased)

Factor	Incidence of defective meat	Authors
Long-term stress	DFD↑	Rosenvold and Andersen (2003)
Short-term stress	PSE↑, RSE↑	Rosenvold and Andersen (2003)
Low density loading factor (m^2/100 kg)	PSE↑*DFD↓	Guárdia et al. (2004); *Guárdia et al. (2005)
Transport of free range pigs	PSE↓	Barton Gade et al. (2008)
Transport of mixed pigs from different herds	DFD↑ PSE↓	D'Souza et al. (1999)
Prolonged stay at a lairage	DFD↑	Barton Gade (2005)
Summer	PSE↑	Van de Perre et al. (2010); Guárdia et al. (2004)
Winter	PSE↑ *DFD↑	O'Neill et al. (2003); *Guàrdia et al. (2005)
Prolonged *ante-mortem* fasting	DFD↑	Murray et al. (2001)
Females, castrates	DFD↑	Guárdia et al. (2005)
Males	PSE↑	Guárdia et al. (2004)

The researchers observed no effect of the season on the incidence of DFD defects, although the highest incidence of DFD defects was found in November (1.3%) (O'Neill et al., 2003). Based on an analysis of transport of 3075 pigs, Guàrdia et al. (2005) found a 3.4% higher incidence of DFD defects in the winter months. DFD defects were observed most often in females – 4.6%.

The impact of *ante-mortem* factors on the occurrence of defective meat is diversified (Table 1).

Other *ante-mortem* factors (*ante-mortem* fasting, gender)

In many countries, pigs are not fed for 12–15 hours prior to transport, which aims to reduce the risk of microbial contamination during slaughter. In addition, it is known that feeding animals prior to transport causes increased mortality during transport (Rosenvold and Andersen, 2003).

The *ante-mortem* fasting is a standard procedure designed to reduce the risk of meat contamination with intestinal content. It is also important for the quality of pork. In the studies by Guàrdia et al. (2005), the lowest incidence of DFD defects was found in the pigs which had been deprived of food for 14 to 22 hours. A prolonged fasting increased the aggressive behaviour of pigs, which contributed to an increase in the incidence of DFD defects (Murray et al., 2001).

In the studies by Guàrdia et al (2005), an about 7% higher incidence of DFD defects was found in the examined females and castrates than entire males. The explanation can be sought in higher energy reserves in pig muscles or differences in metabolism between genders. As a result of frequent aggressive behaviour of hogs, they were better adapted to stress and the regeneration processes probably occurred faster. Another explanation comes from the observations by Pérez et al. (2002), concerning a greater sensitivity of females to physical stress.

The method of slaughter

The method of stunning depends on the size, species, applicable legal regulations, and the requirements of the meat industry, and should ensure humane treatment of animals. In the case of the slaughter of pigs, there are two methods of stunning: electrical and with the use of carbon dioxide gas.

Many countries have adopted a rule that pigs are stunned before bleeding, so that the animals are unconscious and do not feel pain. Bleeding must be carried out within 30 seconds after stunning in order to avoid accidental regaining of consciousness by pigs (Becerril-Herrera et al., 2009). The applied method of stunning affects the quality of the obtained meat.

Electric stunning causes a physical stress and is associated with an accelerated *post-mortem* glycolysis, resulting in a rapid decrease in pH (Van de Perre et al., 2010). The modified electric stunning method, with head-to-back or head-to-sternum electrode positioning, is considered to be more humane. In this case, an electrical impulse causes ventricular fibrillation leading to an immediate arrest of blood circulation. So stunned animals rarely regain consciousness before bleeding.

The head-to-back electrode positioning causes less injury to a stunned pig (Wotton et al., 1992). However, too much electric shock energy can cause fracture of the

spine (Channon et al., 2002). A shorter time of an electric shock reduces bruising, but on the other hand, an insufficient degree of stunning results in the appearance of sudden movements of the body (Wotton et al., 1992).

Channon et al. (2003 b) found an increased incidence of PSE defects in the meat of the pigs stunned with the application of a nineteen-second electric shock to the head, in comparison with the four-second stunning and carbon dioxide stunning. It is believed that a prolonged application of electric current causes protein denaturation, and increases drip loss.

Stunning pigs with carbon dioxide has a positive effect on meat quality. O'Shea et al. (1995) showed that stunning with carbon dioxide results in a reduced incidence of bruises and bone fractures associated with convulsive movements, compared to the pigs stunned by the electric method. After stunning with carbon dioxide, the pigs remained motionless for at least 60 seconds, thereby increasing the safety of the lairage staff.

Compared to electrical methods, stunning with carbon dioxide is associated with less stress in swine, resulting in a better quality of the pork. In the studies by Channon et al. (2002), the application of electrical stunning was associated with an increased *post-mortem* glycolysis and a higher reduction of pH in relation to carbon dioxide stunning. The meat of the pigs stunned electrically was characterized by a paler colour and an increased drip loss.

However, no decrease in the incidence of PSE defects (Channon et al., 2002) was observed. In the studies by Channon et al. (2003 b), compared with carbon dioxide stunning, a more frequent occurrence of PSE defects was found only in the case of electrical stunning with a higher energy (50 Hz, 1.3 or 2.0 A). The researchers also confirmed the less common occurrence of bruises and bone fractures in the CO_2 stunned pigs.

According to the EC Council Regulations No 1099/2009, the content of carbon dioxide in the gas mixture used for stunning pigs should exceed 80%. Higher concentrations of carbon dioxide (more than 80%) enhance the effectiveness of stunning, contribute to the lowering of pH. The studies by Antosik et al. (2011) demonstrated that stunning with 92% of CO_2 compared to 88% of CO_2 was connected with a higher pH_{24} and a darker colour of the pork.

Based on the content of lactate in the blood reflecting the level of *ante-mortem* stress, Nowak et al. (2007) evaluated the effect of various concentrations of CO_2 and the exposure time in the stunning of pigs. The use of 90% of CO_2 in the gas mixture resulted in lower levels of lactates, compared to 80% of CO_2. Also the extension of the exposure time from 70 to 100 seconds was found to reduce the blood lactates (Nowak et al., 2007; Hambrecht et al., 2004 a). The exact time of exposure to carbon dioxide for the relevant concentrations has not been precisely defined so far. We recommend the use of carbon dioxide for more than 70 seconds (Nowak et al., 2007).

There are few reports on stunning pigs with the application of gases other than CO_2. In the studies by Raj et al. (1999), 90% of argon was used for stunning pigs. In comparison with 80–90% of carbon dioxide, argon caused longer-lasting convulsive movements. The addition of 30% of carbon dioxide and 60% of argon resulted in the

shortening of the duration of convulsive movements. The use of argon is limited due to, among other things, the high costs.

The *post-mortem* procedure

It is recommended that pig carcases be hung by the pelvis (obturator foramen), which causes stretching of sarcomeres to a larger extent than if the carcasses were hung by the Achilles tendon (Channon et al., 2014).

In order to reduce the occurrence of defective meat, bleeding should be carried out as soon as possible after stunning, and the stunning time should not exceed 20 seconds (Przybylski et al., 2011).

Some authors recommend electrical stimulation, which aims to increase meat tenderness. It also prevents the occurrence of cold shortening, which can be due to a rapid cooling of carcasses. It is believed that electrical stimulation increases the temperature of the muscles and accelerates the metabolic reactions occurring in them after slaughtering. It is believed that a faster decrease of pH obtained in this way, before lowering the temperature, provides the right conditions for the metabolic processes occurring in the meat. On the other hand, too fast glycolysis induced by electric stimulation can contribute to an increased incidence of PSE defects (Warriss et al., 1995). In the studies by Channon et al. (2003 a), an increased drip loss was found in the meat of the pig carcasses stimulated by a 200 and 400 mA current.

No influence of electrical stimulation on the occurrence of PSE defects has been found (Channon, 2003 c). According to Channon et al. (2003 a), the application of a current of 150 mA for 30 sec., two minutes after bleeding, was considered an effective way of improving the quality of pork for consumption, without affecting the colour of the meat and drip loss.

The speed of cooling

The speed of cooling pork affects the occurrence of defects in the meat. Quick lowering of meat temperature after slaughter is considered by some authors as one of the measures to prevent the occurrence of PSE defects (Przybylski et al., 2016). Rapid cooling slows metabolic processes and reduces the drop in pH.

In the studies by Springer et al. (2003), the conventional cooling of pig carcasses (2°C) was compared to accelerated cooling. The temperature of –32°C was applied for 60, 90, 120 or 150 minutes, then 2°C for another 24 hours. The accelerated cooling had a positive impact on those quality parameters which determined PSE defects. An increase in pH and water holding capacity was reported. Parameters such as: colour, texture, firmness were improved. There was no reduction in the sensory characteristics of the examined meat. Different results were obtained by Hambrecht et al. (2004 a), who compared the conventional cooling of halothane gene-free pigs to accelerated cooling at –15°C for 15 min, –10°C for 38 min, and –1°C for 38 min.

The researchers showed no differences in the quality of pork, depending on the methods of cooling (Hambrecht et al., 2004 a). In the studies by Kerth et al. (2001), accelerated cooling was found to result in a reduced incidence of PSE defects in the meat of the pigs with halothane gene. If the rate of temperature decrease in the muscles is too high, cold shortening may occur, which may adversely affect the water-

holding capacity (WHC). This may be due to the direct impact of lowering the temperature on muscle metabolism and on the changes in water distribution in the tissue.

Conclusions

The variety of factors that affect the meat quality indicate the need to develop and abide by the relevant rules concerning the breeding, slaughtering and processing of meat products in the chain from producer to consumer. Reducing the impact of negative *ante-mortem* factors in accordance with the principles of good animal welfare goes along with raising meat quality. The scope of the *ante-mortem* biochemical reactions is influenced by *ante-mortem* treatment and impacts on the conversion of muscle to meat, as well as determines the quality of the meat. *Post-mortem* factors do not alter significantly the effects on meat quality attributes that are the result of the pre-slaughter treatment, but contribute to the improvement of the quality of the product offered to the consumer. The increase in consumer awareness, expectation of high-quality food products obtained in accordance with the ethical standards force the food manufacturers to search for new solutions not only to restrict the presence of defective meat, but also to improve significantly the quality of the meat products.

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