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THEORETICAL BASICS AND TECHNOLOGICAL CHARACTERISTICS OF PORK WITH TYPICAL SYNDROMES

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Abstract. In the practice of meat processing, pork is often characterized by such syndromes as PSE (pale, soft, exudative), DFD (dark, firm, dry) and RSE (reddish-pink, soft, exudative). They worsen the perception of meats and have a negative impact on their technological properties in the production of meat products. In the total amount of pork used as raw material, meat with PSE and DFD syndromes features up to 50%. Studies have shown that PSE pork differed from quality meat (NOR) in a less elastic texture, the cut surface was soft, exudative, pale pink in color, and DFD pork was distinguished by a darker color. Compared to NOR meat, the pH value of pork DFD decreases during storage, while that of pork PSE increases. By appointing optimal feeding rations with the minimum necessary use of veterinary preparations, minimizing the causes of pig stress, choosing rational slaughter methods and regimens, it is possible to limit the impact of PSE syndrome and other common meat defects and improve pork quality.

Key words: Pork defects; Technological characteristics; PSE meat; DFD meat; RSE meat.

INTRODUCTION

Known typical syndromes of muscle raw materials of animal origin cannot be considered factors of its deterioration and unacceptability for human consumption. However, the syndromes of meat to varying degrees worsen its consumer and technological performance. In particular, a characteristic parameter according to which the quality of meat is visually assessed is its color. Usually, the consumer chooses bright red meat, although different muscles have slightly different hues. Indeed, a change in the color of the meat may indicate a loss of freshness, since an increase in bacterial contamination on the floor finds its expression in the discoloration of the meat until it acquires a grayish tint. Meat color is also affected by production factors that determine the ratio of myoglobin (purple red), oxymyoglobin (bright red), and metmyoglobin (brown red). The main production factors influencing the quality of pork are the type of muscle, pre-slaughter stress, temperature, pH, storage conditions and duration – see the chart in Figure 1 (Rosenvold, K., Andersen, H. 2003; Verbytskyi, S. 2011).

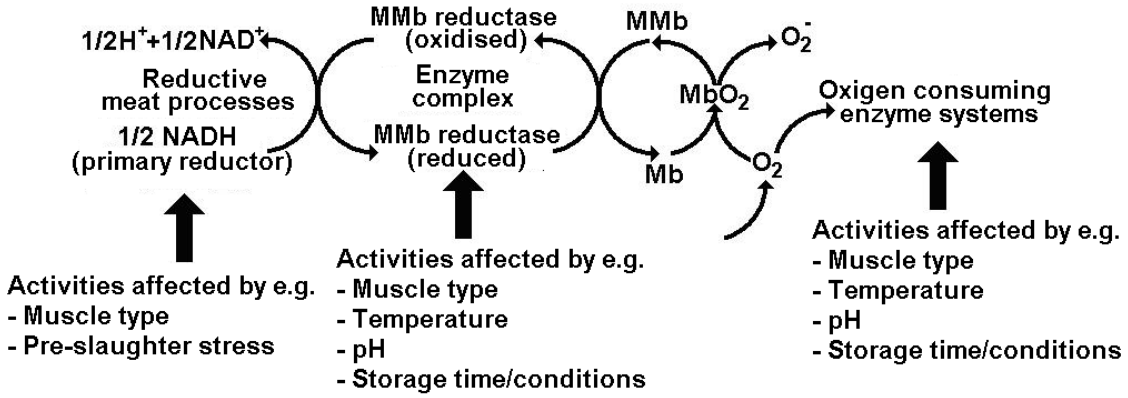

Figure 1. *Influence of oxidation processes on the activity of metmyoglobin reductase in meat, which indicates a change in color. Designations on the scheme: Mb – myoglobin (purple-red meat color); MbO_2 – oxymyoglobin (bright-red meat color); MMb – metmyoglobin (brown-red meat color) (Rosenvold and Andersen, 2003) – adopted in (Verbytskyi, 2011)*

Theoretical and practical problems of the occurrence of pork syndromes PSE, DFD and RSE are the subject of numerous thorough studies, including in recent years (Senčić, D., Samac, D. 2018; Socha, S. et al. 2020; Oshchypok, I.M. 2022). In the 1960s, industrial pig farmers actively practiced high carbohydrate diets to limit the negative effect on quality of high pH values after 24 hours of storage, which manifested itself in the occurrence of DFD syndrome due to prolonged pre-slaughter stress and, accordingly, limited formation of lactic acid salts. However, studies conducted then have shown that even a short-term pre-slaughter restriction in feed almost eliminates the positive effect characteristic of diets with an increased content of carbohydrates, and a certain improvement in the quality of pork due to the restriction of the DFD syndrome may be accompanied by the development of the PSE syndrome. The water-holding capacity of meat is acceptable when following a diet high in fat and protein – from 17 to 18% and from 22 to 24%, respectively. At the same time, the content of carbohydrates in the feed should be limited to 5%. The described diet is characterized by a decrease in glycogen stores in the muscles, at the same time, the influence of the animal genotype is quite significant. Also, to improve reproductive ability, vitamin E was added to the diets – as it was observed, it also had a positive effect on the stability and color intensity of meat, as well as on its ability to store.

The use of magnesium in diets can lead to browning of pork and other color problems. Also, the cause of darkening or redness of meat may be the presence of vitamin D3 in the diet. The addition of alfalfa extract to the feed (2 g per 1 kg of feed) contributed to the acquisition of a color acceptable to consumers, which did not change during 6 d of refrigerated storage (Karwowska, M. 2008). The duration of pre-slaughter restriction in feed affects the course of biochemical processes in the muscles and, accordingly, the quality indicators of pork. Lengthening the duration of ante-mortem feed restriction increases the pH value after 45 h after slaughter, limits moisture loss, somewhat improves tenderness, and has very little effect on meat juiciness (Sterten, H. et al. 2008). If the use of antibiotics, hormones and other veterinary drugs is limited to normatively determined amounts, this does not significantly affect the quality of meat. In particular, with regard to antibiotics, this is confirmed by studies (Frank, J.W. et al. 1997). Although feed products and feed additives can have a negative impact on the quality of livestock products, studies (Novhorodska, N. 2014) showed that the introduction of vitamin and mineral premixes into animal feed did not worsen the physicochemical composition of meat and its sensorial indicators such as odor, color, tenderness.

In pigs, the stomach of which has a single-chamber structure, fatty acids, minerals and vitamins, in particular vitamin E, are present in the feed, and quickly enter muscle and adipose tissues. All of these substances affect the quality of meat, and components like fishmeal give pork an uncharacteristic taste and smell, which can make the meat unfit for consumption (Verbytsky, S. 2011).

Meat color problems cause porcine stress syndrome during transport and just before slaughter (Vitali, 2021). In the worst case, with certain genetic characteristics, animals may die. Less affected pigs are slaughtered, but their meat is inherently prone to PSE, becoming watery pink, later gray or grey-green, and soft (Sebranek, J.G., Judge, M.D. 1990). Raw materials lose too much moisture, therefore, during heat treatment, meat products become unattractive to consumers due to dry and hard texture, and moisture loss negatively affects the yield of finished products and causes a porous structure on the cut, uneven coloring, the formation of wet spots in the package, etc. In order to somewhat reduce the negative effects of the syndrome PSE accelerated cooling of pork is practiced. In this case, RSE syndrome of meat takes place – the signs of meat are the same as in the case of PSE syndrome, except for the color, which is a natural red-pink (Вербицкий, С. 2014).

More rarely, porcine stress syndrome causes darkening of the meat and other signs of DFD syndrome, primarily a firm consistency. DFD meat is less resistant to bacterial contamination. It can be stated that the cause of the PSE syndrome is short-term stress immediately before slaughter, and the DFD syndrome is the pre-slaughter restriction of the animal in feed, the conditions of transportation to the slaughter site, and other long-term stress factors. Transportation of pigs for slaughter at a distance of 100 km or more is accompanied by a significant loss of live weight (3.23%) and reduces the yield of meat, and also has a negative impact on its physical and chemical parameters. According to studies, the transportation of pigs over a distance of 100-110 km caused a decrease in bound moisture and this figure

was 55.89%, while for the meat of pigs transported over a distance of 40-45 km – 58.63% (Matsiuk, A. 2021). Sometimes porcine stress syndrome results in yellowing of muscle tissue and a decrease in pH values. Also, the muscles of pigs that are unstable to the stress syndrome have a higher temperature. This causes a more intense denaturation of proteins involved in the processes of oxidation and, accordingly, increased oxidation of meat in its surface layers (Kopylova and Verbytskyi, 2015). The quality of pork is negatively affected by transporting animals in multi-deck trailers due to excessive crowding and insufficient ventilation, excessively steep unloading ramps, etc. To reduce the likelihood of stress, shorten the duration of transport and ensure that the temperature and humidity of the air correspond to physiological norms – this also applies to slaughter. An increase in the concentration of adrenaline compounds in the blood of pigs can be caused by excessive use of electric prods. As a result, glycogenolysis is intensified, the breakdown of glycogen causes the formation of glucose, that is, the quality of the meat goes worse (Lynch, P.B. et al. 1998).

Based on the principles of humane treatment of the animal and for technological reasons, immobilization should be carried out quickly and painlessly – then it is possible to avoid bruising, bone fractures and the consequences of other physical injuries during the slaughter (Álvarez Álvarez, D. 2002). The most common methods of immobilization of pigs in the world practice are electrical stunning and immersion in a gaseous environment, mainly in a carbon dioxide environment. In domestic practice, electrical stunning is the most common method of immobilizing pigs, it should be performed in such a way that the electrical shock to the animal's nervous system allows for safe and effective exsanguination (Velarde, A. et al. 1999; Lastra Santos, F.G. 2020). Pork obtained from animals immobilized by electric current is characterized by a worse water-holding capacity and a greater number of cases of PSE syndrome detection, this method of neutralization leads to a more intensive decrease in the pH of the meat immediately after slaughter, but after 24 hours after its completion, the pH value of meat obtained from animals immobilized by electric current and in a gaseous environment does not differ. It is generally believed that electrical stunning leads to more significant stress in animals and is accompanied by a more intense energy metabolism in the muscles, and immobilization in a gaseous environment is less likely to cause an increase in blood pressure and, accordingly, less likely to rupture blood vessels and form hematomas on the carcass (Kopylova, K.V., Verbytskyi, S. 2015). There is another opinion: immobilization by immersion in a gaseous environment leads to hypercapnia, hypercalcemia, hyperglycemia, an excessive increase in the content of lactic acid and a deterioration in other blood parameters. Consequently, there are disturbances in the normal circulation of gases and acids, that is, there is reason to speak about the unsatisfactory condition of the animal (Becerril-Herrera, M. 2009), and during the practical delivery of animals to the gas neutralization chambers, they also experience significant stress (Sindhøj, E. et al. 2021).

MATERIALS AND METHODS

To perform a complex study, 184 pork samples were used, including 54 pork samples with signs of PSE syndrome and 30 samples featuring DFD. Experiments were carried out on the sensorial determination of color, odor, consistency and juiciness of meat on the cut, the condition of tendons, fat, broth according to the National Standard of Ukraine (DSTU 7992, 2015), as well as the pH value determined by the potentiometric method using a pH-meter 150 according to (DSTU ISO 2917, 2001). The study of pork was carried out immediately after slaughter, 12, 24 and 48 hours after its completion (НовгородськА, Н.В. 2016).

RESULTS AND DISCUSSION

The performed sensorial evaluation of pork carcasses made it possible to identify three main groups of carcasses with different sensorial indicators, which were normal (NOR) in terms of quality or differed in the presence of PSE and DFD syndromes (Table 1).

Table 1. *Appearance, cut and texture of pork*

Meats	Appearance	Cut	Texture
Pork of NOR quality	Covered with a crust of drying, the color is pale pink or pale red	Muscles on the incision are slightly moist	Dense, elastic; when pressed, the hole is quickly leveled
Pork with PSE syndrome	Color pale pink	The muscles on the incision are very hydrated	Slightly elastic
Pork with DFD syndrome	Dry with a pronounced drying crust, the color is dark red with a brownish hue	Muscles on the cut are dry	Slightly hard to definitely hard

The most preferred, from the sensorial point of view, there were carcasses of the NOR group. The meat obtained from them had an elastic texture, a light red color, and a well-defined pleasant odor characteristic of pork. Meat with signs of PSE was characterized by a less elastic texture, the cut surface was soft and exudative, and the color was pale pink. Meat with signs of DFD was distinguished by a darker color.

We also studied the pH index and the post-slaughter dynamics of this indicator depending on the presence/absence of predominant pork syndromes (Table 2). In general, the pH value of the meat during the first days after slaughter corresponded to the standards for the pork categories NOR, PSE and DFD. Throughout the post-mortem period, meat acidity was higher in DFD-deficient samples. It should be noted that the determination of the pH value refers to the widely used express methods of continuous quality control of meat raw materials. The results of these studies allow timely receipt of information on the actual / potential food safety of meat, as well as its technological suitability – including whether the meat belongs to the PSE and DFD categories.

Table 2. *Dynamics of pH index of pork after slaughter*

Meats	Time after slaughter, h			
	1	24	72	144
Pork of NOR quality	5.89 ± 0.07	5.77 ± 0.07	5.64 ± 0.06	5.32 ± 0.05
Pork with PSE syndrome	5.72 ± 0.05	5.54 ± 0.05	5.64 ± 0.06	5.84 ± 0.03
Pork with DFD syndrome	6.49 ± 0.06	6.15 ± 0.06	5.81 ± 0.05	5.60 ± 0.04

From Table 2 we see that after 1 h after slaughter, the pH value in DFD pork exceeded the indicated indicator of meat of the NOR category – by 10.1%, after 24 h – by 6.5%, after 144 h – by 5.2%. Consequently, the differences in pH between normal pork and meat of the DFD category decreased during storage, between meat of the NOR category and pork with PSE syndrome – increase. In general, the quality of pork with DFD and PSE syndromes is worsening during storage. This worsening in quality is especially pronounced after 72 h storage of pork.

CONCLUSIONS

From the practice of meat processing, it is known that the syndromes of meat PSE (pale, soft, exudative) meat), DFD (dark, firm, dry) and RSE (red-pink, soft, exudative) significantly worsen the perception of cuts and negatively affect the technological properties of meat raw materials. First of all, this applies to PSE pork, which can account for up to a third of the total volume of this type of meat. The duration of the pre-slaughter restriction in feed significantly affects the quality indicators of pork. At the same time, by properly taking into account a number of technological factors: by prescribing optimal feeding rations with the minimum necessary use of veterinary preparations, minimizing the causes of

stress in pigs, adding rational methods and modes of immobilization, it is possible to significantly improve the quality of pork. By improving the conditions for transporting animals to the place of slaughter and keeping before slaughter, it is quite realistic to minimize the causes of meat quality deterioration associated with pig stress syndrome. Also, the improvement of the commercial quality of pork would be facilitated by a wider distribution in the domestic practice of neutralizing animals in a gaseous environment, which the vast majority of experts consider not as stressful as immobilization with electric current. Accelerated cooling of carcasses with PSE syndrome allows, to a certain extent, to improve the presentation of pork, which, with such processing, acquires a natural red-pink color.

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