CHANGING OF BEEF QUALITY IN THE PROCESS OF STORAGE

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Abstract. Meat samples (*m. longissimus dorsi*) taken from 31 half-carcasses of young crossbred bulls (the average hot carcass weight was 309,3 kg) produced by crossing Black-and-White (BW) cows with Limousine (Lim) bulls constituted the experimental material. They were put into vacuum polyethylene bags and stored at a temperature of 0-2^o C. A meat quality analysis was made 3, 7, 10 and 14 days after slaughter. During 14-day aging a slight growing tendency was observed in the percentage of dry matter, fat, crude protein and ash, as well as a significant increase in the content of soluble proteins and non-protein nitrogen. It was also noted that the water-holding capacity of meat improved, and that its color became lighter. The process of aging had a positive effect on the organoleptic properties of beef, but their satisfactory level was observed as late as after 10 days aging of meat.

Keywords: beef, storage, meat quality.

JAUTIENOS KOKYBĖS KEITIMASIS LAIKYMO PROCESE

Santrauka. Tyrimui buvo pasirinkti mėsos mėginiai (*m. longissimus dorsi*) paimti iš paskersto jauno 31 mišrūno buliuko, išvesto kryžminant juodmarges (BW) karves su Limuzinų (Lim) buliais, skerdenų puselių. Skerdenos vidutinė masė buvo 309,3 kg. Skerdenos puselės buvo laikomos 0 - 2 laipsnių temperatūroje vakuume polietileno maišeliuose. Mėsos kokybė tirta praėjus 3, 7, 10 ir 14 dienų po skerdimo. Brandinant mėsą 14 dienų pastebėta sausos medžiagos, riebalų, žalių baltymo ir pelenų kiekio, išreikšto procentais, didėjimo tendencija, o taip pat žymus tirpiųjų baltymų ir nebaltyminio azoto kiekio padidėjimas. Tyrimais nustatyta, kad laikymo trukmė pagerino mėsos vandens rišlumą. Mėsos mėginių brandinimas iki 10 - ties dienų teigiamai įtakojo jautienos organoleptines savybes.

Raktažodžiai: jautiena, laikymo procesas, mėsos kokybė.

Introduction. Due to its properties, after cattle slaughter meat is characterized by reduced consumer quality (an exception is only DFD meat). Its culinary, technological and nutritive values develop as a result of biochemical processes referred to as “aging”.

The studies conducted so far show that the rate and range of changes taking place during meat aging may be modified by using different physical (temperature, pressure, electrical stimulation) (Cheftel and Culioli, 1998; Fernandes and Beraquet, 2001; Korzeniowski et al., 1998), chemical (activation of proteolytic enzymes by introducing Ca ions) (Budsławski and Drabent, 1972; Wheeler et al., 1993) and biological methods (application of enzymes of microbiological, plant and animal origin) (Lawrie, 1998). However, the majority of these methods are not used on a large scale in the meat industry due to certain technological problems and the need to investigate their effect on the process of aging and meat quality. That is why the most common, although expensive, method of beef aging is storing whole carcasses, their halves, quarters or packed culinary elements at low temperatures for several days (Parrish et al., 1991). Nevertheless, also in the case of this method it is difficult to determine the optimum aging time, allowing to obtain best-quality meat. The aim of the present studies was to determine changes in the quality of beef during 3, 7, 10 and 14 days of cold aging.

Material and Methods. Meat samples (*m. longissimus dorsi*) taken from 31 half-carcasses of young crossbred bulls produced by crossing Black-and-White (BW) cows with Limousine (Lim) bulls constituted the experimental material. The experimental animals were purchased by the Meat Plant “Morliny” from the same producer. The identification of crossbreeds was based on mating certificates and their characteristic color. Before slaughter bulls were kept for ca. 20 h in a lairage. The average hot carcass weight was 309.32 kg (s=38.15).

After chilling for 48 hours at a temperature of 0 - 3^o C, all carcasses were subjected to cutting. 4 samples of the dorsal muscle (*m. longissimus dorsi*), each weighing ca. 300 g, were taken from right half-carcasses, from the area of the last four thoracic vertebra, in order to evaluate meat quality. They were put into vacuum polyethylene bags and stored at a temperature of 0-2^o C.

A meat quality analysis was made 3, 7, 10 and 14 days after slaughter. Fresh (after ca. 15 minutes) cross-section area of the samples was used to determine meat color (1 point – light, 8 points - dark) and marbling (1 point – invisible, 5 points – very well visible). Then part of each meat sample was used for a taste-panel evaluation. The other part was minced and used for determination of the basic chemical composition and physicochemical properties.

An analysis of the basic chemical composition of meat included the determination of the percentage of dry matter, crude protein, fat, ash, soluble protein and non-protein nitrogen (after protein precipitation with trichloroacetic acid) by conventional methods

(Budsławski and Drabent, 1972). Its physicochemical properties, i.e. pH (a pH-meter manufactured by the “Radiometer” company, with an electrode GK 23311C), color brightness (spectrometer “Spekol” with a remission attachment R 45/O, at a wavelength of 560 nm) and water-holding capacity (Grau and Hamm, 1952) were also determined.

The sensory evaluation was based on such parameters as aroma, palatability, juiciness and tenderness of cooked meat (Baryłko-Pikielna et al., 1964) and tenderness and juiciness of fried meat. (Wajda and Daszkiewicz, 2001) The taste-panel evaluation was made by a 5-person team characterized by higher than average sensory sensitivity, according to a 5-grade scale.

Statistical calculations were done using computer program *Statistica* 5.5, on the basis of a one-factor analysis of variance in an orthogonal design. The statistical significance of differences between means for groups was determined by the Duncan test.

Results and Discussion. The optimum organoleptic, technological and nutritive properties of culinary beef depend on many factors. The process of its aging is among the most important ones. Changes in the quality of beef after 3, 7, 10 and 14 days of aging at a temperature of 0-2^o C were analyzed in the present studies.

Table 1 presents also the results of an analysis of the basic chemical composition of meat. Changes in the percentage of dry matter during cold storage were slight; its noticeable increase was observed only after 14 days of aging, but the differences between means for groups were statistically non-significant. This was caused by small changes in the content of fat, crude protein and ash in beef after various periods of aging. A growing tendency in the content of these components was noted in meat stored for a longer time, but the differences between means for groups were small, although their statistical significance was confirmed in the case of crude protein and ash. An increase in the proportion of dry matter in meat during cold storage was also reported by Meller et al. (1998) and Sobina (1998). In their opinion its higher concentration was caused by water losses resulting from drip, which was also observed in own investigations.

Table 1. **Basic chemical composition (%) and marbling (points) of meat**

Specification	Stat. measur.	Ageing time (days)			
		3	7	10	14
Dry matter	$\bar{x}$	24,25	24,29	24,29	24,41
	s	0,94	1,14	0,69	0,90
Fat	$\bar{x}$	1,14	1,21	1,37	1,30
	s	0,89	0,73	1,06	0,61
Marbling	$\bar{x}$	1,82	1,87	1,98	1,82
	s	0,74	0,56	0,69	0,58
Crude protein	$\bar{x}$	21,54^{ab}	21,87^{a}	21,89^{b}	21,64
	s	0,76	0,57	0,52	0,43
Soluble protein	$\bar{x}$	5,58^{Aa}	5,61^{bc}	5,79^{Ab}	5,77^{ac}
	s	0,32	0,21	0,21	0,32
Non-protein nitrogen	$\bar{x}$	0,426^{AC}	0,439^{BD}	0,458^{AB}	0,465^{CD}
	s	0,023	0,024	0,019	0,041
Ash	$\bar{x}$	1,08^{ABa}	1,19^{Ab}	1,13^{abc}	1,18^{Bc}
	s	0,09	0,12	0,08	0,08

Values followed by the same letters differ significantly, ABCD-P$\leq$0.01, abc- P$\leq$0.05

The process of beef aging was accompanied by a significant increase in the content of soluble proteins and non-protein nitrogen. Statistical calculations confirmed that their proportion was significantly higher in meat after 10 and 14 days of aging than after 3 and 7 days. The increase in the amount of soluble protein was caused by gradual degradation of muscular, including myofibrillary, proteins, leading to their fragmentation and higher solubility. Advanced proteolysis is connected with accumulation of non-protein nitrogen compounds, which is reflected by a higher non-protein nitrogen content. Very similar results, concerning changes in the nitrogen fractions of meat subjected to cold storage, were obtained by Feidt et al. (1998), Meller et al. (1998), Nowak et al. (2001) and Sobina (1998).

One of the basic requirements which should be satisfied by culinary beef is adequate acidification, as its low pH constitutes a barrier to the development of harmful bacterial microflora. As a consequence, such meat can undergo aging for several days. The average pH value of the beef examined (Table 2) was relatively low (ca. 5.4) and did not change much during storage. Its very slight increase, noted after 14 days of aging, could result from the accumulation of alkaline products of meat autolysis.

Small changes were also observed in the brightness of meat color after different periods of aging (Table 2). Spectrocolorimetric measurement of this parameter showed a tendency towards a lighter color of beef stored for a longer time.

It was found that meat stored for 10 days was characterized by better water-holding capacity (determined by the Grau-Hamm method) than meat stored for 3 and 7 days – in the latter case it was at a very similar level (Table 2). A further tendency towards its improvement was observed after 14 days of aging. The difference between the average area of juice drip after 14 days of aging, and after 3 and 7 days, was statistically significant. It seems that the improvement in the water-holding capacity of meat, noted as the time of its storage was extended, was determined both by water losses and proteolytic changes in meat proteins. Similar tendencies concerning the physicochemical properties of meat after different periods of aging were also observed in previous research (Litwińczuk et al., 2001; Meller et al., 1998; Mitchel et al., 1991). Apart from a significant improvement in the water-holding capacity of meat, they also confirm a tendency towards its color brightening during storage, and a slight pH increase at the final stage of aging.

Table 2. **Physico-chemical properties of meat**

Specification	Stat. measur.	Ageing time (days)			
		3	7	10	14
pH	$\bar{x}$	5,37	5,35	5,37	5,43
	s	0,21	0,20	0,19	0,23
Colour brightness (%)	$\bar{x}$	11,29	11,58	12,13	11,84
	s	1,53	1,59	1,54	2,28
Colour (points)	$\bar{x}$	5,15	5,34	5,13	5,27
	s	0,97	0,92	0,91	0,93
Water-holding capacity (cm^2)	$\bar{x}$	$8{,}40^{a}$	$8{,}43^{b}$	7,96	$7{,}69^{ab}$
	s	1,06	1,03	1,32	1,44

Values followed by the same letters differ significantly, ab-$P \leq 0.05$

The process of culinary beef aging is aimed at achieving adequate sensory properties, required by consumers, i.e. aroma, palatability, juiciness and, first of all, tenderness. The results of a taste-panel evaluation of meat are presented in Table 3. During 14 days of beef aging, no changes were noted in its aroma, whose intensity and desirability turned out to be optimal. A positive effect of aging was also observed in the case of palatability. Samples stored for 10 and 14 days were characterized by much better taste than those stored under the same conditions for 3 and 7 days; the differences between means for both its intensity and desirability were confirmed statistically.

The results of the studies conducted so far (Akinwunmi et al., 1993; Wheeler et al., 1998) show that the method and temperature of thermal treatment have a significant influence on the sensory properties of meat. This is connected, among other, with the amount of cooking losses accompanying this treatment. This is a well-known fact that the amount of cooking losses is negatively correlated with meat tenderness and juiciness (Guignot et al.,, 1994) Therefore, in order to characterize properly tenderness and juiciness of culinary beef, it is recommended to apply thermal treatment similar to that used while preparing this kind of meat for consumption (i.e. frying and roasting instead of cooking). In the present studies juiciness and tenderness of meat were evaluated in a traditional way, i.e. after sample cooking according to the method given by Baryłko-Pikielna et al. (1964), and after sample frying according to the method proposed by Wajda and Daszkiewicz (2001).

Table 3. **Organoleptic properties of meat (points)**

Specification	Stat. measur.	Ageing time (days)			
		3	7	10	14
Aroma-intensity	$\bar{x}$	5,00	5,00	5,00	5,00
	s	0,00	0,00	0,00	0,00
Aroma-desirability	$\bar{x}$	5,00	5,00	5,00	5,00
	s	0,00	0,00	0,00	0,00
Taste-intensity	$\bar{x}$	$4{,}65^{Aa}$	$4{,}56^{BC}$	$5{,}00^{AB}$	$4{,}94^{Ca}$
	s	0,65	0,68	0,00	0,17
Taste-desirability	$\bar{x}$	$4{,}65^{Aa}$	$4{,}56^{BC}$	$5{,}00^{AB}$	$4{,}94^{Ca}$
	s	0,65	0,68	0,00	0,17
Juiciness	$\bar{x}$	3,65	3,63	3,84	3,84
	s	0,58	0,53	0,70	0,60
Tenderness	$\bar{x}$	$3{,}81^{Aa}$	$3{,}90^{B}$	$4{,}16^{a}$	$4{,}44^{AB}$
	s	0,57	0,65	0,55	0,62
Juiciness*	$\bar{x}$	$4{,}90^{AB}$	$4{,}52^{A}$	$4{,}40^{BC}$	$4{,}74^{C}$
	s	0,33	0,51	0,55	0,44
Tenderness*	$\bar{x}$	$3{,}61^{ABC}$	$4{,}19^{Aa}$	$4{,}47^{B}$	$4{,}74^{Ca}$
	s	0,69	0,61	0,48	0,34

Values followed by the same letters differ significantly, ABC-$P \leq 0.01$, ab- $P \leq 0.05$

* - evaluation of fried meat

On average the score for juiciness of fried meat was by ca. one point higher than that for juiciness of cooked meat. This proves that cooking losses were higher during cooking. No considerable changes in juiciness were observed during aging of cooked meat, but there was a slight tendency towards its improvement after 10 days of sample storing. As regards juiciness of fried meat, it was the best (statistically significant differences) at the beginning (after 3 days) and at the end (after 14 days) of aging. Its gradual deterioration could be caused by juice drip during storage, whereas its improvement at the end of the aging process could result from structural protein changes and tenderness changes, as there is a close correlation between tenderness and juiciness of meat. According to Armstrong et al. (1966) the more tender the meat, the faster juice secretion during chewing, so the meat seems more juicy.

This opinion was confirmed by the results of meat tenderness evaluation made in the investigations. Tenderness of both cooked and fried meat improved considerably as the time of storage was extended. As a consequence, tenderness of meat aging for 14 days was the best, which was confirmed statistically. Such an improvement in this property during the aging process results from the effect of non-lysosomal (calpains) and lysosomal (cathepsins) proteolytic enzymes on myofibrillary proteins, leading to structural changes in muscular tissue (Schwägele, 1999). Similarly as in the case of juiciness, fried meat was given more points for tenderness than cooked meat. This proves once again that thermal treatment affects the organoleptic properties of meat.

An evaluation of the sensory properties of beef made in the studies, showing their distinct improvement during aging, is consistent with the results obtained by other authors (Augustini and Fischer, 1999; Campo et al. 1999; Meller et al., 1998; Mitchel et al., 1991). It also indicates that in the case of culinary beef the aging process should last for at least 10 days (at a temperature of 0-2^{o}C) if the meat is to be characterized by good consumer qualities.

Conclusions

1. During beef aging for 14 days a slight growing tendency was noted in the percentage of dry matter, fat, crude protein and ash. These changes were connected with juice drip observed during cold storage. The content of soluble proteins and non-protein nitrogen increased significantly, which suggests progressive degradation changes in muscular proteins caused by their proteolysis.

2. As the time of aging was extended, the water-holding capacity of meat improved and its color became lighter. It seems that the improvement in the water-holding capacity of meat was determined both by water losses during storage and proteolytic changes in meat proteins.

3. The process of aging had a positive effect on the organoleptic properties of beef. Its palatability and tenderness improved considerably, do did juiciness at the end of aging. An evaluation of the sensory properties of beef made in the studies shows that in the case of culinary beef the aging process should last for at least 10 days (at a temperature of 0-2^{o} C) if the meat is to be characterized by good consumer qualities.

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