Gel and Emulsion Stability of Meat Treated with Pyrophosphates and Carbonates by Enhanced Addition of Water

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Introduction

Functional properties of meat change during its storage after the slaughter. The best gelling and emulsification properties meat has directly after the slaughter (1, 6, 11). Contraction process leads to their deterioration. Salt addition may enhanced them (2, 7, 8, 13). Hitherto particular significance was attributed to phosphates, which favourable influence on meat functional properties was related to dissociation of actomyosin complex, to the liberation of α-actinin from the cytoskeletal of the muscle, and also to the increasing pH-value (3, 7, 10, 11). Since several years larger attention has been attracted to carbonates (4, 5, 12). They, first of all, increase the pH value of meat and influence its buffer capacity. They however do not possess such properties as phosphates and do not change the structure of muscle proteins so much.

Objectives

The aim of the study was to compare gelling and emulsifying properties of pork and beef treated with pyrophosphates and carbonates, by enhanced addition of water in various times after the slaughter.

Material and Methods

Lumbar part of m. longissimus dorsi from three pig and beef carcasses was used for the experiment. Selected muscles had no symptoms of PSE, DFD or any other defects; had normal quality. First evaluation of meat was performed around 2 h after the slaughter for both species. Next analyses were performed in case pork 24 and 144h and in case of bovine muscles - 48 and 168h from the moment of the slaughter. Meat evaluation comprised measurements of pH value, gelation and emulsion stability and its basic composition (protein, fat, water and dry matter (DM) content). Each time after mincing the meat was divided into three portions. To each one 2% sodium chloride, 0,0125% sodium nitrate and 0,03% sodium ascorbate was given in the water solution (60% to the amount of meat). The first portion containing only these salts was named as a control (C). To the second (P) – 0,18% of sodium pyrophosphate plus components from the C sample were added. Third portion in the place of pyrophosphates contained the mixture of sodium carbonates (MC). The pH value measurements were performed on meat during its selection for experiment (in pig carcasses 45 min. and in beef carcasses 1 h after the slaughter) and after salts addition. For this purpose the pH-meter type N 5123 equipped with combine electrode was used.

Measurements of functional properties of meat comprised evaluation of emulsion and gel stability in the model system. The evaluation of emulsion stability was performed through the measurement of amount of the thermal and centrifugal drip of oil and water from meat emulsion. The ratio of meat to water and to oil in the emulsion was 1: 7: 8. The emulsion was cooked to get in the geometrical centre of the sample 69^{0}C. Cooked sample was centrifuged at 700 rpm/min for 15 min. The emulsion stability was expressed by the emulsion stability factor (ES), which represented the ratio of amount of oil and water liberated from emulsion to the weight of the emulsion. The higher ES factor, the lower stability of emulsion.

To determine gel stability, 16g of salted meat was homogenised with 30 ml 0,67M solution of sodium chloride (8000 rpm for 1 min). The 5 ml of this homogenate was placed in the tube and heated at 70^{0}C for 10 minutes. After chilling (1h) the gel stability was evaluated by the measurement of the penetration force needed to break the gel by the fat ended rod (∅ 11,3 mm). The depth of penetration was 66% of the gel height. The rod penetrated the sample with the speed of 100 mm/min. The force of penetration (F) and the work involved in it (W) were recorded on Instron apparatus type 1140. Directly after the slaughter also the basic composition of meat was determined. Protein content was evaluated using Kjeldah's method, fat content by Soxhlet's method (Tecator equipment), but the measurement of water and dry matter content was conducted while drying the meat at 105°C to the constant weight.

All results were evaluated statistically using 2 x 3 factorial arrangement of treatments in a randomised complete block design. The Statistica Program was used to calculate the means and detection of the differences between them. Differences between means were analysed by Duncan`s Multiple Range Test (9).

Results and Discussion

The basic composition of meat from both species was similar, however the mean protein content in beef was slightly higher (about 0,4%) in comparison to the pork.

Almost no difference was found in the mean value of meat pH value directly after the slaughter (tab. 1). These values oscillated in the range of 6.70 to 6.80 in pig carcasses and 6.50 to 7.12 in beef. A bit lower pH values were observed in pork during its storage. The differences between the second (24 or 48h) and third term (144 or 168h) of the study, when compared to the mean values for pork and beef, ranged from 0.04 to 0.06 pH unit and were statistically not significant. The highest drop of the pH value, connected mainly with post-mortem changes in meat, was recorded directly after the slaughter (tab. 2). This was observed in all samples irrespective of the type of used additives, however the smallest were, when carbonates were used. In the following terms of the study, almost as a rule, additives increased the pH value. The highest increase of the pH value was ascertained, when curing salts contained carbonates (MC), a bit lower - when pyrophosphates were used (tab. 2). Independently, however, from the type of used salts, the lowest acidity of meat was observed directly after the slaughter. At this moment the best gelling and emulsifying meat properties was recorded, what confirmed observation of other authors (1, 6, 11). A bit lower compression force was involved to break gels made from beef in comparison to pork (tab. 3). The difference in this force for gels prepared directly after slaughter and 24h (pork) or 48h (beef) was usually higher than 50%. Only in case of treatment with carbonate, for both types of meat, gelling properties were almost the same independently of investigation time. The same was observed, when pyrophosphates were added to beef. However, when they were used for chilled pork, they increased the gelling properties of meat in comparison to C sample (about 60%), but did not improve the

gelation to the level of "hot" meat. Probable explanation of these differences between two types of meat is connected with another composition of fat from both species. Results of penetration work recorded during this test gave similar information to the force measurements.

Emulsion stability was less differentiated between these two kinds of meat (tab. 4). Slightly more stable, especially directly after the slaughter, were emulsion prepared from pork than from beef. The smallest differences were observed in samples treated with carbonates. In remaining groups of pork samples usually emulsion stability was around 7 to 25% higher than from beef samples. Emulsions from meat treated with carbonates revealed almost the same stability through the entire time of the study, although they underwent deterioration. The influence of pyrophosphates was almost negligible in comparison to the control sample. Usually storage of meat caused lowering of the emulsion stability.

Conclusions

- From two additives, pyrophosphates and carbonates, by enhanced addition of water to meat, the best results in improving gel and emulsion stability gave carbonates.
- Addition of pyrophosphates influenced mainly gelation of meat.
- Use of meat directly after the slaughter eliminates the necessity of using additional salts to meat beside sodium chloride.

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Table 1

Changes of meat pH value during its storage

Type of the meat	Statistical character-istics	Time after the slaughter		
Pork		45min.	24 h	144 h
	$\bar{x}$	6.73^{a}	5.41^{b}	5.46^{b}
	v (%)	0.76	0.21	0.59
Beef		1 h	48 h	168 h
	$\bar{x}$	6.79^{a}	5.45^{b}	5.52^{b}
	v (%)	4.59	2.43	1.38

Table 2

Changes of meat pH value after salts addition

Time after the slaughter (h)	Type of the sample		
	C**	P	MC
	Pork		
2	5.98^{a*}	6.04^{a}	6.30^{a}
24	5.41^{b}	5.54^{b}	6.12^{a}
144	5.51^{b}	5.77^{b}	6.25^{a}
	Beef		
2	5.85^{b}	5.86^{b}	6.36^{a}
48	5.42^{c}	5.54^{c}	6.08^{a}
168	5.47^{c}	5.60^{c}	6.16^{a}

a, b, c* - means of defined meat followed by various letters are different at $P \leq 0,01$;

C, P, MC** – see explanations in the material and methods

Table 3

Penetration force (F) and work (W) of gels from pork and beef

Time after the slaughter (h)	Type of the sample					
	C		P		MC	
	F (N)	W (J)	F (N)	W (J)	F (N)	W (J)
	Pork					
2	2.45^{b}	0.029^{b}	3.07^{a}	0.035^{b}	3.37^{a}	0.044^{a}
24	1.02^{c}	0.007^{c}	1.63^{c}	0.023^{b}	3.07^{a}	0.043^{a}
144	0.92^{c}	0.009^{c}	1.68^{c}	0.015^{c}	3.36^{a}	0.046^{a}
	Beef					
2	1.85^{a}	0.021^{b}	2.48^{a}	0.032^{a}	1.96^{a}	0.024^{b}
48	0.70^{b}	0.004^{c}	2.31^{a}	0.019^{b}	2.54^{a}	0.029^{a}
168	0.98^{b}	0.008^{c}	2.02^{a}	0.023^{b}	2.32^{a}	0.031^{a}

Table 4

Emulsion stability factor of pork and beef

Time after the slaughter (h)	Type of the sample		
	C	P	MC
	Pork		
2	22.08^{a}	20.18^{a}	19.78^{a}
24	28.46^{b}	29.13^{b}	25.31^{a}
144	29.73^{b}	30.87^{b}	24.58^{a}
	Beef		
2	23.58^{a}	25.17^{a}	20.73^{a}
48	30.04^{b}	30.31^{b}	21.95^{a}
168	27.19^{a}	38.57^{b}	23.25^{a}