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PHYSICOCHEMICAL CHARACTERISTICS OF CANNED "HOT" MEAT AS AFFECTED BY VARIOUS QUALITY OF PORK

Department of Food Technology of Animal Origin, Agricultural University, Poznań

Key words: hot meat, canned loin, physicochemical parameters of pork

Selected physico-chemical characteristics of model canned loin manufactured from the *longissimus dorsi* muscle of decreased (PSE) and normal quality, were measured whilst the production process took place immediately after slaughter and after 24 h chilling period of the carcases.

The use of hot meat in the meat industry results in an acceleration and shorter duration of the production cycles [4, 24, 30, 32], associated with certain modifications of the *post-mortem* processes occurring in the animal muscle tissue [5, 7, 27, 29, 31, 33, 35] and influencing subsequently its properties [17, 19, 24, 31].

An additional differentiation of the biochemical and physical traits of the products can result from the usage of raw material of various degree of muscle defects. Studies in this field are rather scarce and pertain mainly to the rate of curing salt penetration [28, 38] or an assessment of certain quality attributes of the products [13, 14, 30, 32], but they have usually been carried out on the chilled raw material.

The objective of the study reported here was the assessment of the selected physicochemical characteristics of model canned loin manufactured from the *longissimus dorsi* muscle of decreased (PSE) and normal quality, whilst the production process commenced immediately after slaughter and after 24 h chilling period of the carcases.

MATERIAL AND METHODS

Investigations were carried out on 57 hogs of the Biała Złotnicka breed of which the *longissimus dorsi* muscle was used both for the biochemical analyses and for the production of the model canned loin. The muscle was excised from the left halfcarcase between the 9th and 13th dorsal vertebra (immediately after slaughter), and between the 1st and 5th lumbar vertebra (after chilling period). The measurement of pH_1 and pH_2 values served as the main quality criteria of the muscle. In the muscle of normal quality pH_1 measured 45 min after slaughter was > 6.0, whereas in the PSE muscle the pH_1 was < 6.0. In both cases the pH_2 value measured after 24 h chilling of the carcase was < 6.2. Simultaneously, the glycogen content in the muscle tissue 1 h after slaughter was determined. On the next day, in the chilled carcases the measurement of the expressible water content was carried out. These both measurements were used as additional tests for the rate of the glycolytic changes and their effect on certain muscle properties of which the water holding capacity seemed to be the most important one.

The analytical methods and brining and pasteurization procedure was identical as described in previous paper [35].

The experimental results were subjected to statistical analysis under application of the analysis of variance for the single classification [12].

RESULTS AND DISCUSSION

Among the 57 Złotnicka hogs, 40 animals demonstrated the *longissimus dorsi* muscle of normal quality, whilst in the remaining 17 the symptoms of PSE were noted.

The mean values of pH_1 and pH_2 and the content of glycogen and expressible water in the loin muscle clearly differentiated these two groups of meat in regard to the rate of *post-mortem* processes and changes in the water holding capacity (Table 1). The experimental data are characteristic and typical for the PSE and normal muscles and are in agreement with the findings of other authors [3, 9, 15, 18, 19].

The use of muscles of different glycogenolysis pathway in the pro-

Table 1. Mean values of porcine muscle characteristics

Muscle characteristics	Normal muscle			PSE muscle			Test value	
	x	s	v	x	s	v	$F_{tab.}$ $\alpha = 0.01$	$F_{obl.}$
pH_1 value	6.45	0.24	3.74	5.61	0.30	5.37	6.87	132.4
pH_2 value	5.51	0.13	2.32	5.38	0.07	1.35	6.87	31.46
Glycogen Content (mg/100 g)	512.0	279.6	54.6	116.9	101.1	86.5	6.87	64.01
Expressible water content (cm^2)	7.04	1.16	16.44	10.37	1.72	16.57	6.87	145.1

duction of canned loin resulted in the weight changes of the product during brining and thermal processing.

The lowest weight gains of the *longissimus dorsi* muscle in the first technological operation mentioned above was observed in the watery muscles brined in the hot state (Table 2). An opposite relationship was noted in the processing of chilled muscles, however, the mean values of weight gain were higher in this case. The differences between the analysed groups of loins were statistically non significant, also when the

Table 2. Weight changes of pork loins during brining and thermal processing (%)

Characteristic	Processing technique	Normal muscle (N)	Watery muscle (PSE)	Total (PSE+N)
Weight gain during brining	C	0.59	0.11	0.45
	Z	0.39	0.76	0.50
Weight loss during thermal processing	C	7.68 ← xx →	11.16 ↑ x	8.81
	Z	7.86	9.42 ↓	8.37

↔ — the arrow indicates that the differences between groups are statistically significant
— x and xx indicate the level of satistically significant differences (x = 0.05, xx = 0.01)
No arrow indicates that the differences between the mean values of the compared groups are statistically non sign f cant
C — processing of hot meat
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weight gains during the brining procedure of chilled and hot muscles were compared, regardless of their quality.

Both in brining and during the thermal processing, the highest weight losses were observed in the group of loins produced from hot watery muscles (Table 2). The amount of gel found in the canned loins manufactured from PSE muscles was always higher than in the group of products made of meat of normal quality. This difference was statistically significant for the canned samples from hot meat ($P < 0.01$), as well as for weight losses of two loins of watery meat of various dates of production ($P < 0.05$).

These findings confirm the literature data [17, 23, 25, 29] that the weight loss or gel quantity are larger in the processed watery meat. The differences in gel quantity between canned meat manufactured from hot or chilled muscles were marginal (0.44%) and statistically non significant.

A relatively small weight differences in the loins of $pH_1 > 6.0$, processed hot or chilled should be pointed out. The probable cause of these findings could be the rapid immersion chilling of the *longissimus dorsi* muscle at +4... +6°C immediately after slaughter.

The brining procedure of all muscles was commenced around 1 h *post mortem*. In the case of the PSE muscle taken immediately after slaughter, the rapid decline of its temperature might result in an inhibition of glycolysis [6, 11], while in the normal muscles the cold contraction might occur [2]. This was found in the porcine *longissimus dorsi* muscle even in such a case when the pH was below 6.7, and its temperature below 15°C [2]. The following super-contraction might result in an increased thermal drip and weight losses during the brining procedure.

The differences in the rate of *post-mortem* changes in the muscles resulted also in the changes of pH, colour and tenderness of canned product (Table 3).

Table 3. Mean pH values and mean scores for colour and tenderness of the canned pork loin

Characteristic	Processing technique	Normal muscle (N)	Watery muscle (PSE)	Total (PSE+N)
pH	C	6.05 ↑ xx	6.03 ↑ xx	6.04 ↑ xx
	Z	5.99 ↓	5.96 ↓	5.98 ↓
Colour	C	3.41 ← xx	→ 2.94	5.23
	Z	3.50	3.19	3.40
Tenderness	C	4.17 ← xx	→ 3.73 ↑ xx	4.03 ↑ xx
	Z	4.27 ← xx	→ 4.00 ↓	4.18 ↓

↔ — the arrow indicates that the differences between groups are statistically significant
— x and xx indicate the level of statistically significant differences (x = 0.05 · xx = 0.01)
No arrow indicates that the differences between the mean values of the compared groups are statistically non significant
C — processing of hot meat
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The average pH value of canned loin produced from PSE muscles has always been lower than that of normal quality muscles (Table 3), both in the case of hot and chilled raw material.

The differences in the time of starting production influenced the pH changes in the muscles during pasteurization. Processing of chilled muscles resulted in an increase of pH in the loin, as it was also reported by other authors [21, 22, 40, 41], whilst in processed hot muscles a decline of pH of the product was observed.

Differences in the pH of loins from both quality groups, processed hot or cold, were statistically significant ($P < 0.01$).

Similar correlation was found in the same groups but without differentation of the raw material in regard to the *post-mortem* changes.

The loins made from watery muscles demonstrated a lighter colour (Table 3) as compared with those made from the raw material of normal quality. The difference in the sensory quality noticed for the canned loin produced from hot muscles was statistically significant ($P < 0.01$). Additionally, the loins produced from the hot meat were of slightly lighter colour. This finding was noticed during the analysis of the experimental results relating to all canned meat samples as well as to the particular ones, taking into account meat defects. The observed differences were, however, statistically non significant.

Similar correlation was found in the sensory testing of the tenderness of canned loins. The loins made from the low quality raw material were less tender in both hot and cold meat used for this production. The differences were statistically significant ($P < 0.01$). Simultaneously, it was noticed that the muscles processed in the hot state obtained lower scores. Particularly great differences were found in the PSE loins ($P < 0.01$).

Instrumental measurements of tenderness confirmed the results of sensory testing (Table 4). The lowest shear force was used in the chilled normal muscles and the highest one in the loins made from the watery muscles processed in the hot state. The statistical significance of differences was identical with that of the sensory tests of tenderness. The above results don't confirm the findings of Merkel [25] and Van Torij [36] who demonstrated that a lower shearing force was used for the cooked, canned products made from watery muscles.

Some other authors [24, 39] reported that the tenderness measured instrumentally was higher in the products made from hot raw material,

Table 4. Mean values of the shearing force (N/cm^2) and compression force (N/cm^2) and the ratio of the second to the first compression (in %) in the canned loins

Characteristic	Processing technique	Normal muscle (N)	Watery muscle (PSE)	Total (N+PSE)
Maximum shear force (N/cm^2)	C	36.82 ← xx →	44.48 ↑ xx	39.31 ↑ xx
	Z	32.16 ← xx →	38.02 ↓	34.07 ↓
Force of the first compression (N/cm^2)	C	73.76	77.33 ↑ xx	74.93 ↑ x
	Z	75.67 ← xx →	87.02 ↓	79.37 ↓
Force of the second compression (N/cm^2)	C	61.07	63.88 ↑ x	61.99 ↑ xx
	Z	63.25 ← xx →	73.52 ↓	66.60 ↓
Ratio of the second to the first compression in %	C xx	82.75	82.75 ↑ xx	82.75 ↑ xx
	Z	83.76	84.68 ↓	84.06 ↓

↔ — the arrow indicates that the differences between groups are statistically significant
— x and xx indicate the level of statistically significant differences (x = 0.05 . xx = 0.01)
No arrow indicates that the differences between the mean values of the compared groups are statistically non significant
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and it might be the case when comparing the pH of the product and of the raw meat. Such correlation was not observed in this study, although, the difference shown for the normal muscles was small and statistically non significant (Table 4). The planimetric evaluation of the plots from the recorder of the INSTRON 1140 apparatus revealed that the lowest shearing work was used in the case of loin made from the chilled muscle of normal quality, while the highest one in the case of loin made from PSE, hot muscle. Thus, the correlation noted in the measurement of the shearing force was confirmed, however, the differences between mean values were smaller and often statistically non significant. The shearing work needed for cutting the loin from hot muscle was significantly larger than for the canned loin made from the chilled muscle.

In the measurement of compression which demonstrates the strength of the connective tissue according to Harries [16] it was found that the elasticity of loins was lower and the cohesion higher in muscles of low pH_1 values and in the chilled ones (Table 4).

The experiments demonstrated that the greater contraction of watery muscles resulted in the increased toughness caused by myofibrillar proteins (measurement of shearing force) and in an elevated tension of the connective tissue which forms a structural net for the muscle fibres and is responsible for the cohesion and elasticity of the sample.

The inverse correlation between better tenderness of muscles taken 24 h after slaughter and their lower elasticity and higher cohesion should be clarified. In the measurements of tenderness by the Warner-Bratzler shear press, the main role is played by the myofibrillar proteins, whilst during compression by the connective tissue proteins [16, 37]. This indicates that the changes in the connective tissue, influencing tenderness, occur at a slower rate than in the myofibrillar fraction. The above findings confirm the results of other investigations on the changes in meat collagen solubility during the refrigerated storage [10], as well as the reports that the collagen in the canned product made from hot cured meat has been subjected to less pronounced degradation than that from cold brined [19].

Observations on the magnitude of work during compression of canned meat samples demonstrated similar correlations as in the measurements of the compression force (Table 5). The loins made from PSE muscles required the application of larger work both during the first and second compression, which pointed to their greater toughness and cohesion and lower elasticity. Thus, meat of a higher rate of *post-mortem* changes (PSE muscle) used in the production of model canned products was responsible for their poor quality. The use of hot muscles demonstrated even higher detrimental effect of wateriness on the physical and chemical properties of the product. The canned loins manufactured from

Table 5. Mean values of the shearing work (cm^2) and compression work (cm^2) and of the ratio of the second to the first compression in the canned loins

Characteristic	Processing technique	Normal muscle (N)	Watery muscle (PSE)	Total (N+PSE)
Shear work (cm^2)	C	9.45 ← x	→ 10.20	9.69 ↑ xx
	Z	8.89	9.56	9.10 ↓
Work of the first compression (cm^2)	C	5.96	5.87 ↑ xx	5.93
	Z	6.19 ← x	→ 6.65 ↓	6.34
Work of the second compression (cm^2)	C	1.87	1.89 ↑ xx	1.88 ↑ x
	Z	2.00 ← xx	→ 2.23 ↓	2.08 ↓
Ratio of the work of the second to the first compression (%)	C xx	31.61 ↑ xx	32.62	31.94 ↑ xx
	Z	32.90 ↓	33.89	33.23 ↓

↔ — the arrow indicates that the differences between groups are statistically significant
— x and xx indicate the level of statistically significant differences (x = 0.05 . xx = 0.01)
No arrow indicates that the differences between the mean values of the compared groups are statistically non significant.
C — processing of hot meat
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watery muscles, either hot or chilled, demonstrated a slightly higher acidity, lighter colour, lower tenderness and elasticity and greater cohesion. However, they were also accepted by the consumer panel. This might result from the use of poliphosphates in the brining procedure, since they, presumably, made the quality differences between loins less pronounced. However, as it was also reported by other authors [8, 25, 26] the effect of poliphosphates could not prevent the differences in the quality characteristics of the muscles.

It can be concluded from this study that:

— the use of the loin muscles of watery structure in the production of model canned meat of loin type resulted in a finished product of poorer quality, as shown in its physical and chemical characteristics compared with those of normal muscles;

— the canned product manufactured from hot muscles of normal quality demonstrated a higher gain during the curing procedure, and lower losses during pasteurization as compared with the loins made from the PSE muscle tissue;

— pH value of the canned loin made from the hot muscle was higher than that made from the chilled muscle. The use of watery meat resulted in a further acidification of the samples;

— the canned product made from watery muscle exhibited a slightly lighter colour and lower tenderness and elasticity associated with higher cohesion. This correlation was observed both in the hot and chilled raw material;

— the shearing force for the loin made from the hot meat was slightly higher than that used for the loin made from chilled muscle. This correlation was inverse in the analysis of the compression force indicating that the changes in the myofibrillar and connective tissue proteins were different;

— the values for the shearing and compression work were similar to the values of the shearing and compression force for all investigated samples.

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E. Pospiech

FIZYKOCHEMICZNE WŁAŚCIWOŚCI KONSERW WYKONANYCH Z MIĘSA CIEPŁEGO W ZALEŻNOŚCI OD JAKOŚCI MIĘŚNI ŚWIŃ

Instytut Technologii Żywności Pochodzenia Zwierzęcego, Akademia Rolnicza, Poznań

Streszczenie

Jakość surowca mięsnego znajduje swoje odbicie we właściwościach gotowego produktu. Niektóre z nich mogą się zmieniać w zależności od stopnia wychłodzenia mięsa użytego do produkcji.

Celem badań było określenie wybranych właściwości fizykochemicznych konserw wykonanych z mięsa ciepłego w zależności od jakości surowca oraz porównanie ich z tymi samymi cechami konserw z mięsa wychłodzonego.

Badaniom poddano 57 świń złotnickich białych, których mięsień najdłuższy grzbietu sklasyfikowano po uboju na dwie grupy: wodniste i normalnej jakości. Klasyfikacji dokonano na podstawie pomiaru pH w 45 min i 24 h od momentu uboju a także określenia zawartości glikogenu w 1 h po uboju i wody wolnej po 24-godzinnym schładzaniu tusz.

Surowcem do produkcji konserw był mięsień najdłuższy grzbietu. Polędwice produkowano z mięśni ciepłych i wychłodzonych, w niczym nie różnicując procesu produkcyjnego.

Analizowano zmiany ciężaru polędwic podczas peklowania i po procesie pasteryzacji, określano wartość pH konserw, ich barwę i kruchość a także ich niektóre właściwości reologiczne.

Stwierdzono, że konserwy wykonane z mięśni ciepłych o normalnej jakości posiadały wyższe przyrosty ciężaru podczas peklowania, a mniejsze ubytki podczas obróbki cieplnej w porównaniu z polędwicami z mięśni wodnistych. Wartość pH

polędwic z mięśni ciepłych o normalnej jakości była wyższa od pH polędwic wodnistych, te ostatnie charakteryzowały się gorszą kruchością i barwą a także większą twardością i mniejszą elastycznością.

Powyższe różnice zaobserwowano także dla konserw z polędwic wykonanych z mięśni wychłodzonych.

Stwierdzono, że właściwości fizykochemiczne konserw zależały od stopnia wychłodzenia surowca użytego do produkcji.