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PROPERTIES OF PIG MUSCLE TISSUE DEHYDRATED WITH ALCOHOL

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Samples of the pig *longissimus dorsi* muscle were dehydrated by immersion in an alcohol solution. The loss of weight in the dehydrated samples largely depended on the rate postmortem pH decrease in the tissue, it was correlated with a number of properties taken as criteria in the evaluation of meat quality.

Experimentation on muscle preparations giving a lot of information concerning muscle physiology are also quite frequently used in the meat research. The small, easily available whole muscles of rabbit [22], poultry [10] or even sheep [11], after having been prepared, are used to study the processes which might decide about the qualitative properties of the meat. Similar investigations are carried on the incubated segments of big muscles difficult to be examined in a complete state. Such segments have been used in the investigations into the swelling and the relationship between water holding capacity of muscular tissue and the osmotic pressure [20, 21],to study the development of the post-mortem shrinkage and changes in the isotonic and isomeric tension connected with it [2, 3, 7, 13, 15, 24] or to investigate the causal nexi between the metabolic processes, the time of *rigor mortis* completion and its intensity, related to meat tenderness [1, 4, 14, 15, 17, 23]. Using the shrinkage-regulating agents, the factors influencing tenderness of meat are investigated [5, 11, 16, 23]. In these studies a number of essential differences between the properties of muscles obtained from stress-sensitive or stress-resistant pigs, in which the phenomenon of PSE muscles is not identically frequent, has been found to exist [14, 15, 16, 17]. These are the differences in the rate of decrease of elasticity, tension force, electric activity, resting potential of the membrane and the accumulation of metabolites.

The aim of the present study was to observe the changes in muscular segments subjected to dehydration. Investigations were carried out to check if the amount of water lost by the pig muscle segment immersed in alcohol solutions is related to the degree of tissue PSE structure and if it is possible to study in this way post-mortem changes in some properties of the muscles, particularly changes in the water-holding properties of muscle proteins.

MATERIAL AND METHODS

Investigations were carried out on the *longissimus dorsi* muscle of pigs of Polish Large White breed and Polish Landrace breed which were kept at the Pig Progeny Testing Station under standard conditions [6], and than were slaughtered after they reached a weight of 85 kg. Block-shaped samples of approximately 1 x 1 x 4 cm dimension were cut from the muscle loins region between vertebra 1 and 4 along the fibres. The samples were weighed and then dehydrated immersing each of them separately being submerged, in 10 ml batches of ethyl alcohol solution in test-tubes stopped with a cork. After dehydration the samples were carefully dried on a filter paper and weighed again. Relative loss of weight was calculated from the difference between the two weightings.

To define the relationship between the concentration of the dehydrating solution and the loss of weight, identical samples were immersed in constant volumes of alcohol solution of 15%, 25%, 35%, 50%, 75% and 96% concentration. The rate of the dehydration process was studied by comparing loss of weight of identical samples put in 10 ml batches of solution for 2, 4, 6, 24 and 48 hours. For two successive experiments the same conditions, namely 75% alcohol solution and 16 hours immersion time, were used. In the first experiment samples taken from carcass 3 to 5 hours after slaughter were dehydrated, in the second one — samples taken 10 and 45 minutes and 48 hours after slaughter. In all casses pH was measured in the muscle 45 minutes after slaughter.

The results were presented in tables according to the limit values of pH characteristic of the PSE partly PSE and normal muscles [8]. Average values for these groups were calculated, as well as the value of standard errors, this was followed by an analysis of variance [18]. Coefficients of correlation between the relative loss of weight in the dehydrated muscle segments and a number of properties of the tissue which constitute the criteria for meat quality assesment, and which were investigated by other authors using the same material, were calculated [12]. The last experiment was carried out on muscular segments taken

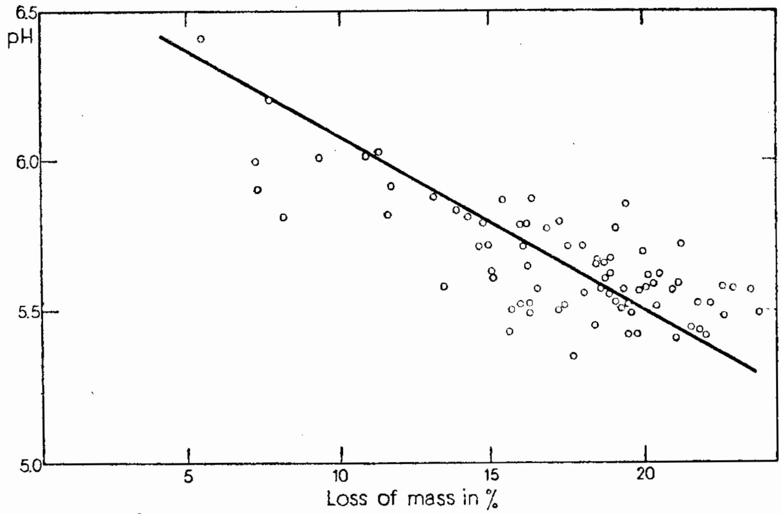

Fig. The relationship between pH and tissue susceptibility to dehydration

from pigs reared on a Large Scale Production Farm. The muscles of these animals feature a slowered acidification process rate and final pH higher than normal. In this experiment the segments were taken 48 hours after slaughter and they were dehydrated for 24 hours with 25% and 50% alcohol solutions.

A comparison of the dehydrating properties of various concentration of alcohol solutions indicated that the loss of weight in samples dehydrated with the 25% solution of alcohol is more diversified than in the remaining cases, on the other han, solutions of over 50% did concentration not differ in their effect.

RESULTS AND DISCUSSION

As it was expected, the relative loss of weight in the dehydrated muscular segments was highly diversified. The amount of water lost by the tissue mainly depended on the sample collection time i.e. on the advancement of the *post-mortem* changes and on the rate of these changes and effects resulting from them. The tissue taken from a carcass immediately after slauther of the animal, appeared to be resistant to the dehydrating effect of alcohol. This sample did not change its weight in alcohol solution or changed it only very slightly. If the samples were subjected to dehydration 45 minutes after slaughter, the loss of their weight was about 15%. The samples subjected to the same process after

3 to 5 hours showed about 20% weight loss and dehydrated after 48 hours — by as much as 26% (Table 1).

These wide differences in the loss of weight were due to the rate of the post-mortem changes resulted in the acidification of the tissue. Already 45 minutes after slaughter the muscular tissue in which the pH drop was fast (pH < 6.0) lost distinctly more water than one with a slower rate of pH decrease ($pH_1 > 6.0$), and the difference was statistically

Table 1. Relative loss of weight (%) in dehydrated segments of PSE, partly PSE and normal muscles

Experiment No	Time after slaughter		pH 45 min after slaughter 6.0	6.0-6.3	6.3	Total	%
1	3-5 hours	n	17	29	34	80	18.85
		$\bar{x}$	24.8a	21.5ab	16.4c	20.0	
		$s\bar{x}$	1.04	0.93	0.65	0.63	
2	45 min	n	25	19	41	85	
		$\bar{x}$	18.8a	14.5b	15.3b	16.1	8.31
		$s\bar{x}$	0.96	0.83	0.52	0.45	
	48 hours	$\bar{x}$	23.1a	26.2b	27.1b	25.7	16.54
		$s\bar{x}$	0.51	0.76	0.41	0.35	

Values marked with different letters are significantly different at $P<0.05$, with underlined letters at $P<0.01$.

significant at $P < 0.05$. If the sample was dehydrated 3 to 5 hours after slaughter, a similar difference could also be found between a tissue with pH lower than 6.3 and one with pH above this value. The behaviour of a muscle tissue after 48 hours was still different. In that case, unlike in the previous ones, muscular tissue samples showing a rapid acidification process ($pH_1 < 6.0$) lost less water in the same concentration of alcohol comparing with other samples (Table 1).

After dehydration of muscular samples the solution had a positive biurette reaction. This indicates that the amount of water being lost by the dehydrated tissue depends on proteins which undergo alcoholic denaturation, as well as proteins soluble in alcohol which, under these conditions, becomes extracted. Thus, one can seek the causes of these differences between the PSE and normal muscle tissue in the different properties of these proteins, although the intensified efflux from the tissue accompanying the phenomenon of PSE structure may also play some role here.

In Table 2 the results obtained are specified in narrower pH_1 intervals to show that a distinct relationship between the loss of weight in dehydrated samples and the pH_1 values characteristic of the muscles

Table 2. The effect of pH_1 value on the amount of relative weight loss in dehydrated muscular segments

Immunion of segments		pH 45 min after slaughter								
		5.2-5.4	5.4-5.6	5.6-5.8	5.8-6.0	6.0-6.2	6.2-6.4	6.4-6.6	6.6-6.8	6.8-7.0
45 min	n	2	18	11	11	14	30	30	25	13
after slaughter	$\bar{x}$	23.3	20.1	18.3	13.8	12.4	12.9	13.4	15.3	13.4
	$s\bar{x}$	2.16	1.43	1.82	0.89	1.02	0.60	0.56	0.76	0.85
48 hours	$\bar{x}$	19.5	23.7	24.3	23.1	25.6	27.3	27,4	26.1	25.4
after slaughter	$s\bar{x}$	0.25	0.56	0.83	0.83	0.87	0.44	0.33	0.69	0.67
45 min	$\bar{x}$	1.20	0.87	0.76	0.60	0.50	0.47	0.49	0.60	0.53
48 h	$s\bar{x}$	0.13	0.07	0.06	0.04	0.05	0.07	0.03	0.04	0.04

basically exists only within pH_1 rangeing from 5.2 to 6.2. At pH_1 values higher than 6.4 this relationship changes from negative into positive if the samples were dehydrated 45 minutes after slaughter, and from positive into negative if dehydration took place 48 hours after slaughter. In spite of such tendencies, the coefficient of correlation between the relative loss of weight and pH_1 was statistically significant. The relative loss of weight was also correlated with a number of other properties characterising meat quality, as water holding capacity thermal losses soluble protein content and colour indices (Table 3). Above properties deviate from the standard level in a PSE tissue.

Table 3. Coefficient of correlation between relative loss of weight in muscular segments dehydrated 45 minutes and 48 hours after slaughter, and other muscle properties in pigs from the Progeny Testing Station (Exp. 2)

	45 min	48 hours
pH 45 min	—0.451**	0.542**
pH 48 hours	—0.034	0.151
Water holding capacity	—0.251*	0.592**
Water binding ability	—0.318**	0.698**
Soluble protein content	—0.346**	0.646**
Colour lightness	0.208	—0.622**
Colour saturation	0.328**	—0.610**
% of colour stability	0.385**	—0.614**
Thermal drip	0.173	—0.517**

* — $P < 0.05$
** — $P < 0.01$

The effect of concentration of alcohol solution on the loss of weight of muscle samples is illustrated in Table 4. For the tissue weight to solution volume ratios used, the dehydrating force of the solution grew with the growth of its concentration up to 50%. Solutions of concentrations exceeding 50% practically did not differ by their effect. Also the time for which the samples were immersed after 24 hours was without any essential influence (Table 5).

Table 4. The effect of concentration of alcohol in dehydrating solution on the amount of relative weight loss in muscular segments subjected to dehydration 48 hours after slaughter (average results from 25 samples)

Alcohol concentration	15%	25%	35%	50%	75%	96%
$\bar{x}$	8.3a	15.1b	21.3c	27.6d	28.1d	28.9d
$s\bar{x}$	0.69	0.92	0.61	0.66	0.61	0.58

Values marked with different letters differ significantity

Table 5. Relative loss of weight in muscular segments immersed in alcohol solution 48 hours after slaughter for different periods of time (average results from 25 samples)

Alcohol concentration (%)		Time in hours 2	4	6	24	48
75	$\bar{x}$	22.4%	25.0%	26.0%	30.2%	31.3%
	$s\bar{x}$	0.39	0.56	0.55	0.54	0.59
50	$\bar{x}$	13.6%			30.0%	
	$s\bar{x}$	0.28			0.35	
25	$\bar{x}$	6.1%			17.8%	
	$s\bar{x}$	0.22			0.46	

Table 6. Average pH values for muscles used for experimentation

Experiment No		pH_{45min}	pH_{48h}
1	$\bar{x}$	6.26	—
	$s\bar{x}$	0.017	
2	$\bar{x}$	6.21	5.45
	$s\bar{x}$	0.045	5.008
3	$\bar{x}$	6.58	5.63
	$s\bar{x}$	0.026	0.020

Table 7. Coefficient of correlation between relative loss of weight in muscular segments dehydrated with 25% and 50% solutions of alcohol and other muscle properties in pigs from Large Scale Productions Farm (Exp. 3)

Muscle property	Alcohol concentration in dehydrating solution 25%	50%
pH 45 min	—0.201	—0.148
pH 48 h	—0.752**	—0.399**
Water holding capacity	—0.680**	—0.322**
Water binding ability	—0.771**	—0.386**
Soluble protein content	—0.529**	—0.180
Colour lightness	0.410**	0.152
Colour saturation	0.467**	0.137
Colour stability (% of colour change)	0.466**	0.199
Meat total pigments	—0.436**	—0.116

** — $P < 0.01$

The last experiment in the study was carried out on the muscles in which the pH values both after 45 minutes and 48 hours after slaughter differed considerably from those in previous experiments (Table 6). For the varions ultimate muscle pH, the relationship between tissue susceptibility to dehydration and its pH was linear and negative (Fig.), i.e. similar to that found in the previous experiment 45 minutes after slaughter (Table 3, col. 1 and Table 7). These two results together illustrate the known effect of pH on the water-holding capacity of muscular proteins and, consequently, on the amount of bound and loose water in meat. On the other hand, it is difficult to explain why at similar final pH the susceptibility of the muscular tissue to dehydration showes a reverse relationship compared with all other qualitative properties.

According to Van Logtestijn [9] and Sybesma [19], the pig muscles in which pH drop is rapid (PSE-pale and watery muscles) or very slow (DFD — dark, firm and dry muscles) feature very similar temperature and shrinkage parameters in the early postslaugter period. As it results from the present investigations when subjected to dehydration they show similar properties. Thus it may be speculated that the amount of water lost by a muscular tissue subjected to dehydration depends i.a. on the advancement of fibres shrinkage.

The *post- mortem* metabolic processes and the accompanying physicochemical and chemical conditions result in the change of may muscle tissue properties which, directly or indirectly decide about meat quality. Among others also a change in the amount of water lost by a muscle tissue when dehydrated in alcohol solution is observed and can be easily determined. The loss of weight as a result of dehydration is a property which differentiates the watery tissue from the normal one.

The use of 25% alcohol solution as the dehydrating agent has made it possible to state that a solution of such a concentration offers optimum conditions for the differentiation of the muscular tissue property being investigated. This is confirmed by the appropriately higher coefficients of correlation between this property and the remaining ones.

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WŁAŚCIWOŚCI TKANKI MIĘŚNIOWEJ ŚWIŃ ODWADNIANEJ ALKOHOLEM

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Streszczenie

Wycinki mięśnia najdłuższego grzbietu (m. *Longissimus dorsi*) świń pobierano z tusz 10 min, 45 min, 3-5 h oraz 48 h po uboju i odwadniano przez zanurzenie w stałej objętości roztworu alkoholowego. Metodą wagową określano wielkość względnego ubytku ich masy. Podatność tkanki mięśniowej na odwodnienie rosła z upływem czasu poubojowego. Tkanka zanurzona w alkoholu 10 min po uboju nie zmieniała swego ciężaru, zanurzona w nim po upływie 48 h traciła ok. 30% swej masy. Stwierdzono też, że wodnista tkanka mięśniowa różni się od tkanki normalnej wielkością masy traconej w wyniku odwodnienia.

Ilość wody przenikającej z tkanki do odwadniającego roztworu była w dużej mierze związana z szybkością procesów prowadzących do zakwaszenia tkanki. Wycinki mięśni, w których pH spadało szybko (pH_1 6,0), odwadniane 45 min lub 3-5 h po uboju, traciły znacznie więcej swego ciężaru niż pozostałe. Jeżeli natomiast odwadniano je po 48 h to ubytek ich masy był mniejszy niż w analogicznych wycinkach tych mięśni, w których pH spadało wolniej (pH 6,0).

Względny ubytek masy odwodnionej tkanki mięśniowej był w stopniu statystycznie wysoko istotnym skorelowany z wieloma cechami stanowiącymi kryteria oceny jakości mięsa, w tym między innymi z wodochłonnością, wyciekiem termicznym,

zawartością rozpuszczalnego białka oraz ze wskaźnikami barwy. W dwóch kolejnych doświadczeniach, przeprowadzonych na mięśniach o nieco odmiennych parametrach pH, współczynniki tych korelacji miały przeciwne znaki wartości. Wynika z tego, że jakkolwiek stan uwodnienia białek mięśniowych związany jest z porównywanymi cechami, to jednak może się zmieniać w sposób od nich niezależny. Przypuszcza się, że o ilości wody jaką traci odwadniana tkanka mięśniowa decydować może natężenie skurczu w jej włóknach.