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Analysis of the texture of rabbit meat subjected to different means of heat treatment*

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The aim of this study was to examine the influence of different types of heat treatment on the shear force and texture profile analysis (TPA) of rabbit meat. The research material was meat samples from 22 Blanc de Termonde rabbits. Two samples from the right loin (*m. longissimus lumborum*) were collected. The first sample was vacuum-packed in a plastic bag and frozen for 72 h at –18 °C; after thawing the samples were immersed in a water bath and boiled for 40 min at 80 °C. The second sample was placed in a plastic frozen-storage bag and frozen for 72 h at –18 °C; after thawing the samples were roasted at 180 °C to an internal temperature of 78 °C. Shear force, hardness, springiness, cohesiveness and chewiness were measured. Significant differences in hardness, cohesiveness and chewiness were found depending on the type of heat treatment. The hardness of the boiled meat was 32% higher than that of the roasted meat, cohesiveness 10% higher, and chewiness 39% higher than in the case of the roasted meat.

KEY WORDS: rabbit meat / heat treatment / shear force / texture / TPA

Rabbit meat is a product of high quality in terms of dietary value and flavour. It has high content of easily assimilated protein and B vitamins, and low content of fat, cholesterol and sodium [10]. These properties make it a valuable culinary material, particularly recommended for children and individuals at risk of cardiovascular disease [21]. Due to the varied forms of rabbit production in combination with breed diversity, rabbit meat as a final product is characterized by variation in quality [3, 7].

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The most valuable cut of the rabbit carcass is considered to be the loin (*m. longissimus lumborum*), with a mean fat content of about 1.8 g/100 g of meat [8]. Among the many parameters of meat quality one of the most important is its texture, consisting of shear force, hardness, chewiness, cohesiveness and springiness [11, 15]. These parameters are measured and assessed by subjective methods, including sensory evaluation, and objective methods, which are based on instrumental techniques. An advantage of sensory evaluation is that it is easy to perform and does not require specialized equipment for defining meat texture. It main disadvantage is the lack of objectivity of the evaluation. Another potential problem is finding an adequate number of individuals with similar sensory sensitivity to carry out the evaluation. Furthermore, the question remains of comparison of results between different research groups. Measurement of texture using appropriate apparatus is a rapid and objective method of evaluation. The use of an automated measurement method makes it possible to compare results obtained in different laboratories, provided the research conditions are consistent with the methodology. A disadvantage of this method is the need for costly equipment for measuring texture (a texturometer), as well as the attachments and software needed to analyse meat texture parameters.

The most common methods for preparing rabbit meat are boiling and roasting, and thus scientific papers deal with these types of heat treatment to prepare samples for instrumental analyses [1, 5, 6, 9, 11, 14, 17, 19]. The length and type of heat treatment are among the most important factors determining the texture properties of meat. It remains an open question whether the results of studies using different kinds of heat treatment can be compared.

Hence the aim of the study was to investigate the effect of the type of heat treatment and the effect of sex on the shear force and texture profile analysis (TPA) of a fragment of the loin (*m. longissimus lumborum*) of rabbits.

Material and methods

The research material consisted of meat samples collected from 22 Blanc de Termonde rabbits (12 females and 10 males). Two samples were collected from each animal, one for roasting and one for boiling (44 samples in total). Rabbits to be weaned stayed with their mothers in standardized conditions: wooden hutches in a building with water troughs, lighting (14L:10D), and forced ventilation. The rabbits were weaned from their mothers at 35 days of age and housed in a battery system. The rabbits were fed *ad libitum* on pelleted complete feed with min. 10.2 MJ metabolic energy, 16.5% crude protein and max. 14% crude fibre. Slaughter and post-slaughter treatment were carried out in the 12th week of life at a body weight of about 2.5 kg, according to the method described by Barabasz and Bieniek [2]. Prior to slaughter the rabbits were fasted for 24 hours. After slaughter the carcasses were chilled at 4°C for 24 h.

After this time two samples were collected from the right loin of each carcass (*m. longissimus lumborum*). The first sample was individually vacuum-packed in plastic foil for food packaging and freezing, frozen in a freezer for 72 h at –18°C, thawed at room temperature, and boiled in a water bath at 80°C for 40 minutes [4]. The second sample was individually packaged, frozen in a freezer for 72 h at −18°C, thawed at room temperature, wrapped in aluminium foil, and roasted at 180°C until reaching an internal temperature of 78°C [14].

Shear force was measured using a TA.XTplus texturometer (Stable Micro Systems) fitted with a Warner-Bratzler shear blade with a triangular hole. The shear force (kg/cm^2) of 10x10 mm samples was measured at a blade speed of 2 mm/s (mean from 3 measurements), perpendicular to the muscle fibres, until the sample was cut through.

Texture profile analysis was performed using the same device fitted with a cylindrical probe 50 mm in diameter. The hardness (kg), springiness, cohesiveness and chewiness (kg) of cubic samples with 10 mm sides were measured (mean from 3 measurements). Each sample was compressed to 70% (roasted meat) or 75% (boiled meat) of its thickness, according to the methodology described in Combes et al. [4] and Migdał et al. [14], at a probe speed of 5 mm/s, parallel to the muscle fibres. A second compression cycle was carried out following a 5 s interval.

All texture parameters of the meat and its shear force were calculated automatically using Exponent software for Windows ver. 5.1.2.0 (Stable Micro Systems). Statistical calculations were made in the SAS statistical package [23]. Two-way analysis of variance was performed. The model took into account sex and the type of heat treatment, as well as the interaction of sex × heat treatment method. Significance of differences between means was determined by an F-test at a significance level of ($P<0.05$).

Results and discussion

No significant interaction was noted between sex and the type of heat treatment. Significant differences were observed in the hardness, cohesiveness, and chewiness of the meat depending on the type of heat treatment. No significant effect of the heat treatment was found on the shear force or springiness of the meat. The hardness of the boiled meat was 32% higher than that of the roasted meat, the cohesiveness of the boiled meat was 10% higher, and the chewiness was 39% higher (Tab.).

Meat texture is influenced by many different factors, including breed, sex, the chemical composition of the meat and the structure of the muscle fibres, diet, pre-slaughter stress, carcass refrigeration conditions, and proper ageing of the meat.

Dal Bosco et al. [6] attempted to determine the effect of heat treatment and a vitamin E dietary supplement on the quality of the meat of male rabbits of a commercial hybrid line. The study showed that the type of heat treatment significantly influenced shear force. In the experimental group which did not receive vitamin E in its feed the shear

Table
Rabbit meat texture parameters according to heat treatment method and sex

Texture parameters	Heat treatment				Sex			
	boiled n=22		roasted n=22		♂ n=10 (number of samples: 2x10)		♀ n=12 (number of samples: 2x12)	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Shear force (kg/cm^2)	1.65	0.43	1.76	0.60	1.78	0.55	1.64	0.49
Hardness (kg)	9.65^a	1.69	7.30^b	1.90	9.10^a	1.77	7.95^b	2.31
Springiness	0.50	0.69	0.54	0.08	0.53	0.07	0.51	0.08
Cohesiveness	0.44^a	0.03	0.40^b	0.03	0.42	0.03	0.42	0.04
Chewiness (kg)	2.20^a	0.56	1.58^b	0.54	2.06	0.50	1.75	0.70

$\bar{x}$ – mean value; SD – standard deviation;
a, b – mean values in the same row with different letters differ significantly at P≤0.05

force of the boiled meat was 3.61 kg/cm and was statistically lower than that of the roasted meat, which had a shear force of 4.65 kg/cm. The shear force values obtained by Dal Bosco et al. [6] are higher than those obtained in the present study.

The quality of boiled rabbit meat has been the subject of many studies. Ariño et al. [1] found that its shear force was 3.57 kg/cm^2, hardness 11.7 kg, chewiness 2.7 kg, and cohesiveness 0.47. The results obtained by these authors are considerably higher than those obtained in the present study. Only the springiness value, 0.49 in the study cited, was lower than in the present study. In a study by Gil et al. [9] the shear force ranged from 34.13 N/cm^2 (3.48 kg/cm^2) to 37.61 N/cm^2 (3.84 kg/cm^2) and was higher than in the present study (1.65 kg/cm^2). The hardness of the meat ranged from 79.43 to 96.02 N (8.10-9.79 kg) and was similar to the results obtained in the present study (9.65 kg), while chewiness was 14.32-19.38 N (1.46-1.98 kg), springiness ranged from 0.40 to 0.42, and cohesiveness from 0.44 to 0.47; these results were lower than those obtained in the present study (chewiness – 2.20 kg, springiness – 0.50, cohesiveness – 0.44). Differences in the values of certain meat texture parameters may be due to the authors' [1, 9] use of rabbits of a synthetic line, housed in different conditions, receiving feed of a different composition, slaughtered at a younger age, and with lower slaughter weight.

Pascual and Pla [19], who studied the effect of selection aimed at improving the growth rate of rabbits of a synthetic line on their meat quality, obtained a shear force of 36 N/cm^2 (3.67 kg/cm^2), which was higher than in the present study. In an experiment by Kowalska et al. [11] on the relationship between the fat cover of the carcass and the content of intramuscular fat, fatty acid profile, and meat texture of White New Zealand and Popielno White rabbits, the shear force ranged from 16.1 to 16.5 N/cm. Combes et al. [5], analysing the effect of hutch size and means of housing rabbits on carcass parameters and meat quality, obtained a shear force ranging from 12.5 to 13.4 N (1.27 to 1.37 kg). The lower value for this parameter, apart from rearing conditions, may have been influenced by the earlier slaughter of the animals (71st day of life).

Migdał et al. [14], in a study on the texture of roasted rabbit meat, obtained the following values: shear force – 3.12 kg/cm^2, hardness – 65.84 N (6.71 kg), chewiness – 14.73 N (1.50 kg), springiness – 0.50, and cohesiveness – 0.41. The differences between these results and those obtained in the present study, particularly for shear force, which was higher than in our study, may be due to the use of a different breed, i.e. male New Zealand White rabbits.

The present study showed that the sex of rabbits significantly influenced only one of the texture parameters. The meat of males was characterized by significantly greater hardness (by 14.46%) than the meat of females (Tab.).

Maj et al. [13] observed no effect of sex on the texture parameters of the meat of New Zealand White rabbits slaughtered in the 12th, 21st and 32nd week of life. The shear force and TPA of the meat of the 12-week-old rabbits were as follows: shear force – 34.4 N/cm^2 (3.51 kg/cm^2); hardness – 58.69 N (5.98 kg); chewiness – 12.69 N (1.29 kg); springiness – 0.57; and cohesiveness – 0.37. The differences between these values and those obtained in the present study may be due to the use of raw meat to determine texture parameters. Ortiz Hernández and Rubio Lozano [17], who analysed the effect of breed and sex on carcass and meat characteristics of New Zealand White, Californian, Chinchilla and Rex rabbits, found no effect of sex on the shear force of roasted meat (males – 2.51 kg/cm^2; females – 2.33 kg/cm^2). The higher shear force values in comparison with the present study may have been due to the use of different breeds of rabbit.

Studies on the effect of heat treatment on meat texture have been conducted on other animal species as well. Ruiz de Huidobro et al. [22] compared the texture of raw and roasted beef. The shear force and TPA of the roasted meat were higher than for the raw meat. A study by Obuz et al. [16] on the effect of the heat treatment method and final temperature of beef samples found that the shear force of boiled meat was higher than that of roasted meat, irrespective of the final temperature of the samples. In contrast, Panea et al. [18], who studied the effect of the ageing process, heat treatment, and sample size on beef texture, found that the shear force of boiled meat was lower than that of roasted meat. A study by Prestat et al. [20] on the effect

of heat treatment of pork found no difference between the shear force of roasted and deep-fried pork loin. An experiment by Love and Goodwin [12] conducted on poultry confirmed that boiled chicken breast had a lower shear force than meat fried at 149°C or 205°C.

The most common method of culinary preparation of rabbit meat is boiling, so the use of this method of heat treatment to test meat texture seems justified. During boiling, however, it is best to use specialized equipment (e.g. a water bath), which makes it possible to maintain the water in which the samples are boiled at a constant temperature. Suitable preparation of the samples for testing is also important (individual vacuum-packing), which makes the sample preparation process more time-consuming. This means that it is a repeatable method which can be reproduced each time in similar conditions, and each sample is uniformly heated (the heat conductivity of water is much better than that of air). The same cannot be said of roasting of samples in a conventional electric oven, where uniform heating of samples is difficult and there may be problems associated with how the samples are wrapped (insufficiently sealed in aluminium foil); the samples may dry out, which can affect their texture. On the other hand, this method is simpler and less time-consuming. The cooking time itself is similar in the two methods.

The experiment revealed that the texture of Blanc de Termonde rabbit meat varied depending on the heat treatment. The effect of sex on the meat texture of this breed of rabbit was shown only for hardness. The most common method of heat treatment of rabbit meat given in the literature is boiling. Therefore the use of this method of heat treatment to test meat texture seems justified.

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