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COMPARISON OF SHEAR FORCE AND TEXTURE PROFILE ANALYSIS OF RAW, BOILED AND ROASTED RABBIT MEAT*

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The aim of the study was to compare the shear force, hardness, cohesiveness, springiness and chewiness of rabbit raw, boiled and roasted meat, as well as to determine the effect of sex on these parameters. The experimental material consisted of meat samples of 31 Termond White rabbits (19$; 12$). The rabbits were slaughtered at the age of 84 days and their carcasses were subjected to 24-hour cooling at 4°C, after which cylinder-shaped samples were collected from part of the loin (m. longissimus lumborum). The first group of samples was boiled in a water bath at 80°C for 40 minutes. The second group of samples was roasted at 180°C, to achieve an internal temperature of 78°C. The third group of samples was not subjected to thermal treatment. The shear force and texture profile analysis (PTA) were measured using a TA.XT plus texture analyser. Statistical analysis showed significant differences in the shear force between boiled (1.31 kg/cm2) and raw meat (1.69 kg/cm2) and boiled and roasted (1.83 kg/cm2) meat. The shear force of raw and roasted meat was similar. Significant differences in the hardness of raw (7.27 kg), boiled (12.32 kg) and roasted meat (15.52 kg) were found. Significant differences were also observed in the springiness of raw (0.33) and boiled meat (0.50) and raw and roasted meat (0.51). The springiness of the boiled and roasted meat was similar. Significant differences in cohesiveness between raw (0.33) and boiled (0.41) meat, raw and roasted meat (0.44), as well as boiled and roasted meat were noted. The chewiness of raw (1.27 kg) and boiled meat (2.61 kg), raw and roasted meat (3.55 kg) and boiled and roasted meat was significantly different. There were no significant differences in the shear force and texture profile analysis of male and female meat.

Key words: rabbit, shear force, texture profile analysis

A change in lifestyle of inhabitants of highly developed countries has been observed recently (Łapa et al., 2008). More and more often, they decide to choose easily digestible rabbit meat, which is characterized by a high content of easily digestible protein, abundance of B group vitamins, as well as the favourable ratio of saturated fatty acids (SFA) to polyunsaturated fatty acids (PUFA) (Gondret et al., 1998).

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In many countries of the European Union, rabbit meat is an attractive food product, however, its price is significantly higher compared to poultry, pork or beef meat. In Poland, rabbit meat is not traditionally consumed. In spite of the fact that our country is one of the leading producers of meat rabbits in Europe, almost all the obtained rabbit raw material is exported (Pomianowski et al., 2015). The average consumption of rabbit meat in Poland amounts to 0.9-1.2 kg per capita per year. However, for example Italian people consume much more rabbit meat – approximately 6 kg per person (Składanowska-Baryza, 2017).

A consumer who decides to buy meat, pays particular attention to its quality. Basic indicators of meat quality include: colour, sourness, chemical composition, tastiness, juiciness, tenderness, marbling and texture. The latter indicator is composed of such parameters as: shear force, hardness, cohesiveness, springiness and chewiness. Texture is strictly correlated with tissue structural elements and their mutual interactions (Łapa et al., 2008). Meat texture parameters may be measured and assessed with the use of subjective methods which include sensory analysis of meat quality, and objective methods based on the use of instrumental methods. The advantage of the application of automated objective method is obtaining rapid and objective assessment and the possibility of comparing the results between various research units, if the study conditions are in line with the applied methodology. A significant disadvantage of this method is the necessity to have the expensive equipment for texture measurement, i.e. texturometer, together with software and the appropriate attachments that are necessary for the analysis of meat texture parameters.

Most often, rabbit meat dishes are boiled or roasted, so these two ways of thermal treatment are used in research studies for the preparation of samples for texture analysis (Kozioł et al., 2016). Equally often, texture parameters are measured with the use of raw meat samples. The choice of the type of thermal treatment has a significant effect on the specific properties of meat texture. Therefore, a question arises whether the results of meat texture measurements should be compared with the results of studies in which a different type of thermal treatment was applied.

The aim of the study was to compare the shear force, hardness, cohesiveness, springiness and chewiness of rabbit raw, boiled and roasted meat, as well as to determine the effect of sex on these parameters.

Material and methods

The experimental material consisted of meat samples collected from Termond White rabbits (n=31; 19$, 12$). During the first 35 days of life, the rabbits stayed with their mothers in metal cages equipped with kittening houses, placed in the hall furnished with water installation (nipple drinkers) and light installation (14L:10D) as well as exhaust ventilation. Since weaning on the 35th day of life up to the 84th day of life, the animals were kept in the battery system

intended for commercial rabbit breeding. The rabbits were fed ad *libitum* with commercial pelleted all-mash feed containing 10.2 MJ of metabolic energy, 16.5% of general protein and 14% of crude fibre. Such nutrition covered the nutritional requirement of animals reported in dietary guidelines (Gugołek et al., 2011). The rabbits were slaughtered at the age of 84 days and body weight of approximately 2.6 kg, after prior 24-hour fasting with constant access to potable water. The animals were stunned, bled, pelted and then the carcasses were eviscerated and subjected to 24-hour cooling at the temperature of 4°C. After that time, three samples were collected from part of the right loin *(m. longissimus lumborum) of each carcass.* The first group of samples was vacuum-packed into the individual foil packagings intended for packing and freezing food, then they were frozen in the freezer at -18°C for 72 h, defrosted at room temperature and afterwards boiled in a water bath at 80°C for 40 minutes. The second group of samples was also vacuum-packed into the individual foil packagings, frozen in the freezer at -18°C for 72 h, defrosted at room temperature and then packed into aluminium food foil and roasted at 180°C to achieve an internal temperature of 78°C. The third group of samples was vacuum-packed into the individual foil packagings, frozen in the freezer at -18°C for 72 h, then defrosted at room temperature and not subjected to any thermal treatment (Combes et al., 2003; Kozioł et al., 2016; Migdał et al., 2013).

The shear force was measured using a TA.XT plus texture analyser (by Stable Micro Systems) equipped with Warner-Bratzler blade with triangular slot. Shear force value (kg/cm^2) of samples of section of 10 x10 mm was measured at blade velocity of 2 mm/s, transversely to the direction of muscle fibres until the complete cutting of the sample.

Texture profile analysis (TPA) was conducted with the use of the same device equipped with the attachment in the form of a cylinder of diameter of 50 mm. Hardness (kg), springiness, cohesiveness and chewiness (kg) of cube-shaped samples with edge of 10 mm were measured. Double compression tests up to 70% (roasted meat) or up to 75% (boiled and raw meat) was conducted according to the methodology described in studies by Combes et al. (2003) and Migdał et al. (2013), with cylinder velocity of 5 mm/s and interval between the compressions amounting to 5 s, along the muscle fibres. All the parameters of meat texture and shear force were calculated automatically with the use of Exponent for Windows software ver. 5.1.2.0 (Stable Micro Systems).

The obtained results were characterized using mean values and SD. In order to achieve the results concerning the effect of sex on the studied parameters, the mean was calculated from all the methods of treatment of male meat (n=57) and female meat (n=36). Statistical analysis was conducted with the use of SAS statistical package, using PROC MIXED. Constant effects, such as the method of meat preparation for texture analysis and sex, as well as the interaction between the constant effects were taken into consideration in the model. Linear regression of the studied characteristic for the age at slaughter was taken into account in the model. The significance of differences between the means was analysed with the

use of Tukey-Kramer test. The analysis was performed at the significance level of $P<0.05$.

Results

Statistical analysis showed significant differences in the shear force between boiled (1.31 kg/cm2) and raw meat (1.69 kg/cm2) and boiled and roasted (1.83 kg/cm2) meat. The shear force of raw and roasted meat was similar. Significant differences in the hardness of raw (7.27 kg), boiled (12.32 kg) and roasted meat (15.52 kg) were found. Significant differences were also observed in the springiness of raw (0.33) and boiled meat (0.50) and raw and roasted meat (0.51). The springiness of the boiled and roasted meat was similar. Significant differences in cohesiveness between raw (0.33) and boiled (0.41) meat, raw and roasted meat (0.44), as well as boiled and roasted meat were noted. The chewiness of raw (1.27 kg) and boiled meat (2.61 kg), raw and roasted meat (3.55 kg) and boiled and roasted meat was significantly different (table 1).

Table 1. Means and standard deviations (in brackets) for texture parameters depending on meat preparation method

Texture parameters	Meat preparation method		
	raw (n=31)	roasted (n=31)	boiled (n=31)
Shear force (kg/cm^2)	1.69 b (0.74)	1.83 b (0.62)	1.31 a (0.46)
Hardness (kg)	7.27 c (2.24)	15.52 b (3.46)	12.32 a (4.51)
Springiness	0.37 b (0.09)	0.51 a (0.07)	0.50 a (0.05)
Cohesiveness	0.33 c (0.06)	0.44 b (0.04)	0.41 a (0.04)
Chewiness (kg)	1.27 c (0.94)	3.55 b (1.27)	2.61 a (1.25)

a, b, c - means in rows with different letters are significantly different ($P<0.05$).

Table 2. Means and standard deviations (in brackets) for texture parameters depending on sex

Texture parameter	Sex	
	♂ (n=57)	♀ (n=36)
Shear force (kg/cm^2)	1,67 (0,65)	1,57 (0,53)
Hardness (kg)	12,30 (5,20)	10,79 (4,20)
Springiness	0,45 (0,09)	0,46 (0,10)
Cohesiviness	0,39 (0,07)	0,38 (0,06)
Chewibess (kg)	2,54 (1,65)	2,08 (1,22)

a, b – means in rows with different letters are significantly different ($P\leq0,05$).

The conducted statistical analysis did not demonstrate any significant effect of sex on texture of rabbit meat (table 2). Shear force and all the studied parameters of profile analysis of texture of male and female meat were similar.

Discussion of the results

Researchers conducting studies on meat of various species of farm animals observed the effect of the type of meat treatment on the parameters of its texture. Prestat et al. (2002), who analysed the effect of thermal treatment on the texture of pork meat, did not observe any significant differences between the shear force of roasted and deep oil-fried pork sirloin. Ruiz de Huidobro et al. (2005) compared the texture of raw and roasted beef meat and demonstrated that shear force and TPA values for roasted meat were higher than for raw meat. In turn Obuz et al. (2004), analysing the effect of the type of thermal treatment of beef meat, showed that shear force of boiled meat was higher compared to roasted meat. However, Panea et al. (2008) studied the effect of the process of maturation, thermal treatment and sample size on beef texture, and they obtained different results. Those authors demonstrated that shear force value of boiled meat was lower than of roasted meat. In turn in the studies concerning the comparison of shear force of chicken breast meat boiled and fried at the temperature of 149°C and 205°C, it was concluded that boiled meat is characterised by significantly lower values of this parameter compared to fried meat (Love and Goodwin, 2004).

The studies by Kozioł et al. (2016) on the effect of the type of thermal treatment on rabbit meat quality revealed that boiled meat had significantly higher hardness (9.65 kg), cohesiveness and chewiness (2.2 kg) in comparison with roasted meat (7.3 kg, 0.4, 1.58 kg, respectively). The values of shear force and springiness of the boiled and roasted meat were similar.

Also Dal Bosco et al. (2001) attempted to determine the effect of thermal treatment on rabbit meat texture. Their studies indicated that the type of thermal treatment significantly differentiates the shear force of rabbit meat. These authors demonstrated that the shear force value of meat of commercial hybrid line of rabbits amounted to 3.61 kg/cm^3 and was statistically lower than in case of roasted meat whose shear force value was 4.65 kg/cm^3.

Authors' own studies did not show any significant differences in texture parameters of male and female rabbit meat (table 2). These results are confirmed by the studies conducted by Maj et al. (2012); Pałka et al. (2017); Ortiz Hernandez and Lubio Lozano (2001). However, differences in hardness of male meat and female meat were demonstrated by Kozioł et al. (2016). These authors observed that male meat is characterised by higher hardness (9.1 kg) compared to female meat (7.95 kg).

As it results from the studies by Combes et al. (2000), rabbit meat should not be boiled at the temperature below 80°C, because consumer panel decided that meat boiled under 80°C was not cooked enough. Samples for shear force and

texture profile analysis should be prepared with the use of a specialised device, such as water bath, that enables to maintain constant temperature of water in which samples are boiled. Roasting meat in a traditional electric oven is an impediment in preparing samples for analysis due to the lack of a possibility of even heating of the meat as well as its excessive drying in case of improper wrapping with aluminium foil. The duration of thermal treatment in both methods is similar (Kozioł et al., 2016).

Based on the conducted studies, it was concluded that the texture of meat of Termond White rabbits differed dependent on the method of thermal treatment. It was demonstrated that the type of thermal treatment has the effect on such texture parameters as: shear force, hardness, cohesiveness, springiness and chewiness. According to the authors, sex does not differentiate the shear force and texture profile analysis of meat.

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SUMMARY

The aim of the study was to compare the shear force, hardness, cohesiveness, springiness and chewiness of rabbit raw, boiled and roasted meat, as well as determining the effect of sex on these parameters. The experimental material consisted of meat samples of 31 Termond White rabbits (19$; 12$). The rabbits were slaughtered at the age of 84 days and their carcasses were subjected to 24-hour cooling at 4°C, after which cylinder-shaped samples were collected from part of the loin *(m. longissimus lumborum).* The first group of samples was boiled in a water bath at 80°C for 40 minutes. The second group of samples was roasted at 180°C, to achieve an internal temperature of 78°C. The third group of samples was not subjected to thermal treatment. The shear force and texture profile analysis (PTA) were measured using a TA.XT plus texture analyser. Statistical analysis showed significant differences in the shear force between boiled (1.31 kg/cm^2) and raw meat (1.69 kg/cm^2) and boiled and roasted (1.83 kg/cm^2) meat. The shear force of raw and roasted meat was similar. Significant differences in the hardness of raw (7.27 kg), boiled (12.32 kg) and roasted meat (15.52 kg) were found. Significant differences were also observed in the springiness of raw (0.33) and boiled meat (0.50) and raw and roasted meat (0.51). The springiness of the boiled and roasted meat was similar. Significant differences in cohesiveness between raw (0.33) and boiled (0.41) meat, raw and roasted meat (0.44), as well as boiled and roasted meat were noted. The chewiness of raw (1.27 kg) and boiled meat (2.61 kg), raw and roasted meat (3.55 kg) and boiled and roasted meat was significantly different. There were no significant differences in the shear force and texture profile analysis of male and female meat.

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