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Relationships between meat quality traits of Popielno White rabbits

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SUMMARY

The purpose of the study was to determine the phenotypic correlations between meat quality traits in Popielno White rabbits. The experimental material consisted of 93 Popielno White rabbits (49♀; 44♂). From weaning at 35 days of age until 84 days of age, the animals were housed in a battery system and fed *ad libitum* with a complete feed containing 10,2 MJ of metabolic energy, 16,5% total protein and 14% crude fibre. The rabbits were slaughtered at 84 days of age with a body weight of about 2,6 kg. The research material was the meat of longissimus lumborum muscle. Meat quality characteristics, i.e. meat acidity, meat colour, shear force, meat texture and cooking loss, were examined. The results were analysed using the SAS package (2014). Many statistically significant relationships were found between the meat quality characteristics of Popielno White rabbits. The results indicate that potential selection towards a change in pH value may adversely affect the meat texture of Popielno White rabbits. Selection to improve the colour of the meat of this breed may have a negative effect on its shear force, hardness and cooking loss. Selection to improve shear force will improve the other texture profile parameters. An improvement in the meat texture parameters of Popielno White rabbits will lead to an improvement in the cooking loss value. Dependencies among meat quality traits in Popielno White rabbits are high enough to be useful in selecting an appropriate breeding method.

KEY WORDS: correlation, meat quality traits, rabbit

INTRODUCTION

Recent years have seen an increase in consumer interest in rabbit meat, due to growing awareness of the importance of a healthy diet (Pomianowski et al., 2015).

The quality of rabbit meat is determined by many parameters, such as its acidity, colour,

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chemical composition, and texture. Sensory perceptions are important as well; the meat should have an attractive appearance and smell. Moreover, it must have suitable processing properties, such as cooking loss.

One of the most important indicators in the assessment of meat quality is post-mortem acidification of the muscle tissue, i.e. the pH value. Post-mortem acidification of rabbit meat is relatively rapid; rabbit meat is fully acidified 12 hours after slaughter, and the pH value does not increase significantly up to 24 hours after slaughter. In rabbit meat the pH at 24 h post mortem should be 5,7-5,9; medium-quality meat has a pH of 6,0 to 6,2, and a pH above 6,2 indicates meat of poor quality (Rybarczyk and Łupkowska, 2016).

Another important determinant of meat quality is its colour. This is the first parameter assessed by the consumer purchasing meat, as an indicator of its freshness (Chwastowska et al., 2011). In addition to the acidity and colour of the meat, its texture is important as well. Texture analysis takes into account parameters such as shear force, hardness, chewiness, elasticity and cohesion. The texture of meat is linked to the structural elements of the tissue and their interactions (Łapa et al., 2008). These parameters are measured using special equipment – a texturometer – on suitably prepared samples. In rabbit carcasses, measurements are most often made on samples taken from the longissimus lumborum and biceps femoris muscles.

When assessing the quality of meat, it is also worth considering cooking loss. After weighing, the collected pieces of meat are placed in plastic bags and then cooked in a water bath at 80°C. Then the samples are cooled at room temperature, dried, and weighed to within 0,01 g (Połtowicz et al., 2003).

In breeding animals for slaughter, it should be taken into account that there are positive or negative relationships between meat quality parameters, which is of great importance when selecting animals. Strong correlations between meat quality traits can be observed in breeding rabbits of meat breeds. Determining the relationships between meat quality traits is helpful in assessing rabbit meat with regard to various expectations. These may be relationships between chemical composition, physical and dietary properties, or processing properties.

Popielno White rabbits (PB) are becoming increasingly popular, mainly on organic farms. This is due to their resistance and better adaptation to unfavourable environmental conditions, which is especially important in backyard farming. Popielno White rabbits are classified as medium-sized breeds. At the age of 90 days, they have a body weight of about 2,7-3,0 kg, with a high dressing percentage of up to 60%. Mature Popielno White rabbits can attain a body weight of up to 5,5 kg. Additionally, they produce large litters (approx. 7-8 rabbits) with good rearing outcomes – about 6,5 rabbits per litter. They are popular in home, amateur and organic farming. The breed is included in a genetic resources conservation programme. In 2010 the number of females reported for subsidies under the programme exceeded 200 (Kowalska and Bielański, 2010).

The purpose of the study was to determine the phenotypic correlations between meat quality traits in Popielno White rabbits.

MATERIAL AND METHODS

The experimental material consisted of 93 Popielno White rabbits (49 females and 44 males). During the first 35 days of life, the rabbits were housed with their mothers in metal cages with nesting boxes, located in a building equipped with a water supply (nipple drinkers), lighting (14L:10D) and forced ventilation. From weaning at 35 days of age until 84 days of age, the animals were kept in a battery system designed for commercial rearing of rabbits (two per cage, males and females separately). The rabbits were fed *ad libitum* a commercial, pelleted complete feed containing 10,2 MJ of metabolic energy, 16,5% total protein and 14% crude fibre. This diet covered the animals' needs for nutrients specified in nutritional standards (Gugołek et al. 2011). The animals were slaughtered after 24 hour fasting with constant access to water. The animals were stunned, immediately bled, skinned and eviscerated. Slaughter was conducted using methods described by Blasco et al. (1993). The carcasses were cooled for 24 hours at 4°C.

The colour of the meat was determined in the CIE L*a*b* colour space (L* - lightness, a* - red component, b* - yellow component), with illuminant D65, measurement angle 0°, observer's angle 2°and calibration against a white standard (Gozdecka, 2006), measured 45 min and 24 h after slaughter on the surface of the longissimus lumborum muscles, at the level of the first lumbar vertebra. Measurements were made with a Minolta CR-410 reflection colorimeter (three point measurements, which were then averaged).

Post-mortem acidification of muscle tissue was measured using a Consort C561 microprocessor pH-meter equipped with a SP24B reinforced glass electrode 45 min after slaughter (pH_{45}) and 24 h after slaughter (pH_{24}), with accuracy within 0,01. Measurements were made on the right side of the carcass of the same muscles and in the same places as for the colour analysis.

During dissection, meat samples were taken from the right loin (longissimus lumborum) to determine texture parameters. They were individually vacuum-packed in foil for packing and freezing food, then frozen in a freezer for 72 h at -18°C. Then they were thawed at room temperature and boiled in a water bath at 80°C for 40 minutes (Combes et al., 2003). The shear force was measured using a Stable Micro Systems TA.XT plus texturometer equipped with a Warner-Bratzler blade with a triangular hole. The shear force of samples with a cross section of 10x10 mm was measured at a blade speed of 2 mm/s across the muscle fibres until the sample was cut through. Texture profile analysis (TPA) was performed using the same device equipped with an cylindrical attachment with a diameter of 50 mm. The hardness, elasticity, cohesiveness and chewiness of cube-shaped samples with sides of 10 mm were measured. A double compression test up to 75% was carried out according to the methodology given by Combes et al. (2003), with a roller speed of 5 mm/s and a pressure interval of 5 s, along the muscle fibres. All meat texture parameters and shear forces were calculated automatically using Exponent for Windows ver. 5.1.2.0 (Stable Micro Systems).

Cooking loss was determined on samples of the longissimus lumborum muscle. Samples weighing approximately 50 grams were placed in plastic zipper storage bags and then pasteurized in a water bath at 80°C for 40 minutes. Then the samples were cooled at room temperature, dried and weighed to within 0,01 g. The cooking loss was calculated according to the following equation:

WT [%] = [weight of sample before cooking − weight of sample after cooking x 100] / weight of sample before cooking.

All calculations were performed with the SAS package (2014). Pearson's phenotypic correlation coefficients were determined using PROC CORR. There were no differences between the sexes, so the results are presented in the tables for the entire study population.

RESULTS AND DISCUSSION

Table 1 shows the means for the meat quality traits of the Popielno White rabbits.

Table 1 Meat quality traits

Traits[1)]	Mean	SD[2)]	Min.	Max
pH_{45}	6,66	0,41	5,80	7,30
pH_{24}	5,83	0,22	5,11	6,38
L^*_{45}	60,07	4,53	50,70	70,13
a^*_{45}	1,31	2,76	-3,43	8,43
b^*_{45}	-1,94	3,68	-10,10	5,40
L^*_{24}	56,26	2,73	48,40	62,02
a^*_{24}	5,07	1,67	2,21	9,96
b^*_{24}	3,29	1,58	-1,25	7,34
Shear force (kg)	1,80	0,51	0,93	3,49
Hardness (kg)	10,78	2,30	6,44	15,99
Springiness	0,47	0,04	0,35	0,58
Cohesiveness	0,43	0,03	0,38	0,52
Chewiness (kg)	2,23	0,66	0,92	3,85
Cooking loss (%)	27,19	2,69	16,82	31,81

[1)] pH - acidity, L* - lightness, a* - redness, b* - yellowness; subscript numbers refer to the time of measurement (45 min or 24 h after slaughter) [2)] SD – standard deviation

The average acidity of the rabbit meat, measured 45 minutes after slaughter, was 6,66. The pH of good quality rabbit meat measured immediately after slaughter ranges from 6,1 to 6,8 (Maj et al., 2008). The value obtained in the present study is similar to that reported by Kmiecik et al. (2017) for Popielno White rabbit meat, which was 6,73 and 6,64, depending on the season and diet. The pH value measured 24 hours after slaughter was about 5,83 (Table 1), which is also indicative of good quality (Rybarczyk and Łupkowska, 2016). The values obtained by Kmiecik et al. (2017) were 5,74 and 5,90. The mean values for the lightness of meat colour (L*) were 60,07 (45 min after slaughter) and 56,26 (24 h after slaughter) (Table 1). A higher value of this parameter indicates lighter meat colour (Łapa et al., 2008). The red component (a*) of the meat colour reached an average value of 1,31 at 45 minutes after slaughter and 5,07 at 24 hours after slaughter. These results are significantly lower than those obtained by Łapa et al. (2008); however, large differences in the value of the red component are observed in many studies. The red colour of meat depends on the relationships between the content of myoglobin, oxymyoglobin and metmyoglobin. Post mortem changes may alter the content of individual components, which translates into a change in the value of the red component after 24 hours (Łapa et al., 2008). The yellow component of the meat colour (b*) was on average -1,94 (45 min after slaughter) and 3,29 (24 h after slaughter) (Table 1). The mean shear force was about 1,8 kg (Table 1). The results are similar to those obtained by Kozioł et al. (2016; 2017), who found shear force within the range of about 1,65-1,78 kg (2016), depending on the method of heat treatment and sex, and about 1,73 (2017). The average meat hardness in the present study was 10,78 kg (Table 1), which is higher than that obtained by Kozioł et al. (2016) – about 9,65 kg, and similar to that reported by Kozioł et al. (2017) – 10,61 kg. The average springiness of the meat was 0,47 (Table 1), which is slightly lower than that obtained by the above-mentioned authors (2016; 2017) – on average 0,50. The mean value for meat cohesiveness was about 0,47 (Table 1), which is slightly higher than the result obtained by Łapa et al. (2008) – 0,45, and Kozioł et al. (2016) – 0,44. The average chewiness was about 2,23 kg (Table 1), which is similar to the results obtained by Kozioł et al. (2016; 2017) – 2,20 and 2,18 kg. In our study, cooking loss reached an average value of 27,19% (Table 1). For comparison, Rybarczyk and Łupkowska (2016) found that the cooking loss of the longissimus lumborum muscle in mongrel rabbits was on average 16,83%, while in Californian and New Zealand White rabbits it was much higher – about 21,85%. The reason for the discrepancy in the results may be the age difference and breed of animals on which the tests were carried out. Cooking loss values of 19,37% and 23,54% were found in the biceps femoris muscle of Californian and New Zealand White rabbits, respectively (Chwastowska et al., 2011).

The phenotypic correlation coefficients between the meat quality traits of the longissimus lumborum muscle are presented in Table 2.

Meat acidity at 45 minutes after slaughter was moderately positively correlated with the red component and the yellow component at 45 minutes after slaughter (a^*_{45} and b^*_{45}) and with lightness measured 24 hours after slaughter. Moreover, low, negative correlations were found between pH_{45} and shear force and between pH_{45} and meat hardness. Correlations between pH_{45} and other meat quality traits were not significant (Table 2). Contrasting results were obtained by Bieniek (1997), who found that the acidity of meat 45 minutes after slaughter was significantly correlated only with the water content in the meat (-0,403) and colour stability (-0,214) in a study on New Zealand White and Tan rabbits. In a study by Pałka (2015), low correlations were found between pH_{45} and colour lightness L^*_{45} and L^*_{24} (0,06 and 0,002, respectively) in a study on New Zealand White x Flemish Giant crossbred rabbits.

Meat acidity at 24 hours after slaughter was significantly and negatively correlated with the yellow component (b^*_{45}) of meat colour and significantly and positively correlated with the red component, measured 24 hours after slaughter (Table 2). Bieniek (1997) found moderate negative correlations between pH_{24} and meat colour and low, negative correlations for pH_{24} with colour stability and cooking loss. In our study on Popielno White rabbits, the correlation between pH_{24} and cooking loss was also negative, but non-significant. The correlation coefficients between pH_{24} and other meat quality traits were non-significant. In a study on three different lines of rabbits, Hernandez et al. (1997) showed a moderate negative correlation between the final pH (pH_{24}) of meat and the lightness of the meat colour (-0,41), while in a study on young rabbits (Hernandez et al. 2000), this correlation proved not to be significant.

Table 2 Phenotypic correlation coefficients between meat quality traits

Traits	pH_{45}	pH_{24}	L^*_{45}	a^*_{45}	b^*_{45}	L^*_{24}	a^*_{24}	b^*_{24}	Shear force	Hardness	Springin ess	Cohesive ness	Chewine ss	Cooking loss
pH_{45}	1	-0,05	-0,20	0,50*	0,49*	0,49*	-0,05	-0,02	-0,28*	-0,25*	0,01	-0,23	-0,22	0,21
pH_{24}		1	0,02	-0,15	-0,26*	0,01	0,30*	0,04	0,04	-0,14	-0,22	0,02	-0,18	-0,11
L^*_{45}			1	-0,58*	-0,35*	-0,17	-0,12	-0,14	0,40*	0,20	0,09	0,18	0,18	-0,04
a^*_{45}				1	0,83*	0,38*	0,02	0,12	-0,40*	-0,28*	0,01	-0,16	-0,21	0,09
b^*_{45}					1	0,36*	-0,17	0,01	-0,33*	-0,20	0,05	-0,18	-0,16	0,23
L^*_{24}						1	0,00	0,07	-0,25*	-0,06	0,14	0,09	0,02	0,27*
a^*_{24}							1	0,70*	-0,01	-0,29*	-0,17	-0,22	-0,30*	-0,26*
b^*_{24}								1	0,00	-0,18	0,00	-0,25*	-0,17	-0,31*
Shear force (kg)									1	0,46*	0,01	0,44*	0,42*	0,22*
Hardness (kg)										1	0,45*	0,56*	0,95*	0,33*
Springiness											1	0,31*	0,65*	0,00
Cohesiveness												1	0,68*	0,30*
Chewiness (kg)													1	0,31*
Cooking loss														1

* - significant correlation ($P < 0,05$); pH - acidity, L* - lightness, a* - redness, b* - yellowness; subscript numbers refer to the time of measurement (45 min or 24 h after slaughter)

The red component of the meat colour measured 45 minutes after slaughter was positively and significantly correlated with the yellow component of the meat colour measured 45 minutes after slaughter and with the lightness of the meat colour measured 24 hours after slaughter. The lightness of the meat colour (L^*_{45}) was moderately negatively correlated with the hardness and shear force of the meat. The remaining correlations of this feature with other meat quality traits were non-significant (Table 2). Pałka (2015) reported similar relationships between the red component (a^*_{45}) and the yellow component (b^*_{45}) (0,65). Additionally, the author showed a high, positive correlation between the red component at 45 min (a^*_{45}) and at 24 h (a^*_{24}) after slaughter (0,66) and a moderate positive correlation between a^*_{45} and b^*_{24} (0,36). Łapa (2008) showed low, positive correlations between the red component (a^*_{45}) of the loin and the red (a^*_{45}) and yellow (b^*_{45}) components of the leg (0,230 and 0,305, respectively), while the correlations for the red component (a^*_{45}) with the red and yellow components of the leg measured 24 hours after slaughter were non-significant.

There was a significant, moderate, positive correlation between the yellow component of meat colour (b^*_{45}) and its lightness (L^*_{24}) and a moderate negative correlation between b^*_{45} and shear force. No significant correlation was found between the yellow component of meat colour (b^*_{45}) and other meat quality traits (Table 2). Łapa (2008) found that the yellow component of the meat colour (b^*_{45}) was significantly correlated with its lightness (L^*_{45}) and red component (a^*_{45}) in the leg meat. In the first case, the correlation was moderate and positive (0,310), and in the second moderate but negative (-0,388).

The correlation between the lightness of the colour of meat measured 24 hours after slaughter and the cooking loss was low and positive, while the correlation between lightness and shear force was also low, but negative (Table 2). Bieniek (1997) showed a positive correlation between the lightness of meat colour and cooking loss. Similar correlations were obtained by Hernandez et al. (2000). In that study, the correlation between the lightness of meat colour measured 24 hours after slaughter and the cooking loss was low and positive (0,21). Hernandez et al. (1998) did not show a significant correlation between the lightness of meat colour and the cooking loss, while a significant, low, negative correlation was shown between lightness and shear force (-0,21). Łapa (2008) found that the lightness of the colour of the meat (L^*_{24}) of the loin was significantly and positively correlated with the yellow component (b^*_{45}) and the colour lightness (L^*_{24}) of the leg meat (0,211 and 0,332, respectively), and also significantly correlated with the red component (a^*_{24}) of the leg meat (-0,254).

The red component of the meat colour (a^*_{24}) was high and positively correlated with the yellow component of meat colour measured 24 hours after slaughter and significantly negatively correlated with hardness, chewiness and cooking loss, but these correlations were low or moderate (Table 2). Łapa (2008) found a moderate, negative correlation between the red component (a^*_{24}) of the loin and the yellow component (b^*_{45}) of the leg meat (-0,364). Moreover, that study also showed a low and positive correlation of the red component (a^*_{24}) of the loin with the red component (a^*_{24}) of the leg (0,252).

The yellow component of meat colour (b^*_{24}) was significantly and negatively correlated with meat cohesiveness as well as cooking loss (Table 2). Łapa (2008) also found a significant negative correlation between the yellow component of the meat colour (b^*_{24}) of the loin and the yellow component of the meat colour (b^*_{45}) of the leg (-0,298).

The shear force was significantly and positively correlated with the cohesiveness, chewiness and cooking loss of meat. Meat hardness was significantly and positively correlated with the springiness, cohesiveness, chewiness, and cooking loss of meat (Table 2). Hernandez et al. (2000) found a high, negative correlation between meat hardness and juiciness (-0,60) and a high positive correlation between meat hardness and chewiness (0,82).

Correlations between meat springiness and meat cohesiveness and chewiness were significant and positive. The cohesiveness of meat showed a high, positive correlation with its chewiness and a low, positive correlation with cooking loss. In addition, the cooking loss was significantly positively correlated with the chewiness of the meat (Table 2). Hernandez et al. (2000) showed a high, positive correlation between chewiness and springiness (0,69) and a moderate, negative correlation between chewiness and juiciness (-0,52).

To conclude, potential selection towards a change in pH may adversely affect the meat texture of Popielno White rabbits. Selection to improve the colour of the meat of this breed may have a negative effect on its shear strength, hardness and cooking loss. Selection to improve shear force will improve the remaining parameters of the texture profile analysis. Dependencies among meat quality traits in Popielno White rabbits are high enough that they may be useful in selecting an appropriate breeding method.

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