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Influence of transport on selected quality factors of rabbit meat

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Abstract: *Influence of transport on selected quality factors of rabbit meat.* The aim of this study was to examine the influence of transport on the quality characteristics of rabbit meat determining its technological usefulness. Meat from 20 hybrid rabbits (male crossbreds of two French hybrids: Martini and Hyla) aged 90 days was analysed in the study. The control group (10 rabbits) was transported after weaning (at the age of 50 days) and was fattened at the experimental farm until the age of 90 days. The experimental group (10 rabbits) was transported directly prior to slaughter. After 24 h and 48 h from the slaughter the pH in the experimental group was higher ($P \leq 0.01$) compared to pH of meat in the control group. The transport significantly affected L* measured 48 h post-slaughter. Rabbit meat from the experimental group was darker compared to meat from the control group ($P \leq 0.01$). The transport also caused a higher a* measured 45 min post-slaughter compared to the control ($P \leq 0.01$). The meat of rabbits fattened in the experimental farm characterised with significantly lower drip loss, free water and plasticity compared to the meat of rabbits transported directly prior to slaughter. On the basis of the research results one can conclude that the transport taking place directly before slaughter negatively affected the quality of rabbit meat, leading to abnormal quality conditions expressed with high pH and dark colour.

Key words: rabbit meat, transport, meat quality, transport, stress, DFD

INTRODUCTION

Nowadays a lot of attention is drawn to the origin of meat and meat quality. Due to increasing consumer awareness, dietary and health benefits of rabbit meat have been noticed (Petracci and Cavari 2013). The quality of rabbit meat is affected by the breed (Maj et al. 2012), nutrition (Gebler 2008), sex and age (Hernandez et al. 2004), body weight before slaughter and animal welfare (Zając et al. 1998). However, one of the major factors affecting the quality of meat is the pre-slaughter stress associated with transport and slaughter (Maj et al. 2012).

Studies on meat have shown that transport increases serum cortisol levels and has a negative effect on the quality of meat, which in turn classifies meat into PSE (pale, soft, exudative) meat quality or DFD (dark, firm, dry), as a consequence the pH value does not reach a level providing the microbiological stability of meat (Dal Bosco et al. 1997, Kowalska et al. 2016). The PSE abnormal condition is directly related to low water binding capacity. In spite of the basic effects, such as lowering the processing value, the meat is less often chosen by consumers, due to the worse organoleptic qualities (Kristensen and Purslow 2001). The DFD rabbit meat is dark, dry and highly viscous. The meat also characterizes with a reduced durability. The cause of this abnormal condition is too little glycogen in the muscle at the time of slaughter, as a consequence the

pH value does reach a level providing the microbiological stability of meat. One of the causes of this defect is the improper handling of the animal before slaughter (Rodríguez-Calleja et al. 2005).

Because the number of slaughter houses adapted to slaughter rabbits is limited, the commercial production of rabbits for meat is connected with a necessity of transport. Rabbits are known to be prone to stress, therefore all the research related to influence of transportation on rabbit meat quality provide valuable information on the proper pre-slaughter handling of this species. The aim of this study was to evaluate the effect of transport on quality characteristics of rabbit meat.

MATERIAL AND METHODS

The analysed material included 20 hybrid rabbits (crossbreds of two lines: Martini and Hyla, males) divided into two groups: the control group and the experimental group. Up to 50 days of age the animals were raised in the same rabbitry, and were fed the same diet. All rabbits were slaughtered at the age of 90 days at the experimental farm. The control group (10 rabbits aged 50 days) was transported in metal cages directly after weaning and fattened at the experimental farm until the age of 90 days. During the fattening period the animals were kept in the same groups as before weaning and during the transport. The rabbits (10 heads) from the experimental group were transported directly prior to slaughter. The time gap between the beginning of transport until the slaughter (including the loading of the rabbits and the transport time covering 120 km with an average speed of 50 km/h) was about 4 h. The rabbits were transported in metal cages, 4 rabbits per cage. The transport was carried out in the summer, early in the morning, at an environmental mean temperature of 16°C. Both groups were fasted 24 h prior to slaughter, with unlimited access to water. Prior to slaughter the animals were weighed. The slaughter included mechanical stunning (hit in the back of the head with a narrow rod) immediately followed by cutting the jugular veins (according to Council Regulation 1099/2009). The animals were hung by the hind limbs in order to allow bleeding out. After dressing, rabbit carcasses were kept at +2°C. Twenty-four hours post mortem the carcasses were weighed (cold carcass weight, kg) and the dressing percentage was calculated as a relation of the cold carcass weight to the pre-slaughter body weight of animals. Twenty-four hours after slaughter the right and left *m. longissimus thoracis et lumborum* (LTL) were cut from the carcasses in order to examine the quality of rabbit meat.

The pH was measured by inserting a calibrated combination glass calomel electrode (ERH-11X1,SCHOTT, Germany) connected to a portable pH meter (Handylab 2, SCHOTT, Germany) into the LTL. The pH was measured 45 min, 24 h and 48 h post mortem. The first measurement was made on the right LTL of carcasses, after dressing. The two following measurements were made after dissecting the LTL muscles from the carcasses.

The first colour measures were recorded 45 mins post mortem on the muscle surface, after removing the con-

nective tissues covering the lumbar part of the LTL. The colour was measured using a Minolta colour meter CR-200b (Konica Minolta, Netherlands) (illuminant D65, 2° observer with a eight-millimeter in diameter aperture size). The tristimulus CIE system which measures lightness (L*), redness (a*) and yellowness (b*) was used (CIE 1978). Colour measures were repeated 24 h and 48 h post mortem on the dissected muscles, in the previously defined point of measurement.

The drip loss, free water, cooking loss and plasticity were measured 24 h post mortem.

The drip loss (%) was measured after Honikel (1998). The three-centimeter thick, transverse slices of the LTL (25––30 g) were weighed, hung on hooks and placed in a container to reduce evaporation (+2°C). After 24 h, the samples were reweighed to calculate the change in the weight.

The free water (%) was measured using a filter-paper press method, after Grau and Hamm (1953) in modification of Pohja and Niinivaara (1957). Samples (0.3 g) of ground meat were placed on a filter paper between two glass tiles. A force of 2 kg was applied on each sample for 5 min. Then the samples were removed from the filter paper and reweighed straight after to calculate the change in the weight. The calculations were made using the following formula:

free water (%) = (*sample of ground meat* – *sample of meat after* 5 *min of* 2 *kg pressure*) · 100 / *sample of ground meat*)

Meat plasticity (cm^2) measurement was conducted according to Pohja and Niinivara (1957), simultaneously to the free water measurement and was expressed as the area of the compressed meat sample used for the measurement of free water.

The cooking loss (%) was measured after Honikel (2004). The three-centimeter thick, transverse slices of the LTL (25–30 g) were placed in thin polyethylene bags, with the bag's wall firmly adhered to the meat sample. The bags with meat were placed in a water bath at 75°C for 30 min, and then cooled to room temperature and reweighed after removing the excess of moisture with a paper towel. The change in the weight of the sample was calculated (%).

For the analysis of the chemical composition, muscle samples were minced in a food grinder. To determine dry matter content, 3 g samples of minced meat were dried in filter-paper bundles at 105°C to a constant weight (PN-ISO 1442:2000). For the protein content the Kjeldahl procedure was used (PN-A--04018:1975). The samples were boiled in concentrated H_2SO_2 for 30 min. The digest contained a catalyst (a mixture of $CuSO_4$ and K_2SO_4). The process ended with the acquisition of ammonium sulfate solution – $(NH_4)_2SO_4$. The distillation was performed by means of a B-324 Buchi distillation unit, using NaOH and H_3BO_3 solutions. The last phase was titration (Schott TitroLine, SCHOTT, Germany), which allows to quantify the amount of ammonia in the receiving solution (H_3BO_3) with the use of 1 M HCl. For the extracted fat content the Soxhlet method was used (PN-ISO 1444:2000). The samples used for determination of dry-matter content were placed in the Soxhlet extractor (MLL 147, AJL Electronics, Poland).The solvent used in the

procedure was petroleum ether. The effect of the group (control, experimental) on the body weight at slaughter, drip loss, free water, cooking loss, plasticity, dry matter, crude protein, extractable fat, water/crude protein ratio was calculated with the model given below.

$$Y_{ij} = \mu + \alpha_i + e_{ij}$$

where:
μ – the overall mean of the analysed trait;
α_i – the fixed effect of the i-group ($i = 1, 2$);
e_{ij} – the random error.

The effect of the group (control, experimental), and time post mortem on the pH (pH_{45min}, pH_{24h} and pH_{48h}) and muscle colour L* (L^*_{45min}, L^*_{24h} and L^*_{48h}), a* (a^*_{45min}, a^*_{24h} and a^*_{48h}) and b* (b^*_{45min}, b^*_{24h} and b^*_{48h}) was calculated with the model given below.

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_{j(k)} + e_{ijk}$$

where:
μ – the overall mean of the analysed trait;
α_i – the fixed effect of the i-group ($i = 1, 2$),
β_j – the random effect of the j-animal;
$\gamma_{j(k)}$ – the effects of the k-time post mortem ($k = 1, 2, 3$) nested in the j-animal;
e_{ijk} – the random error.

There was no interaction between analysed effects, therefore they were not included in the model. All the statistical analysis were made with SAS (2011). Tukey–Kramer adjustment was implemented for multiple comparisons of LS-mean differences.

RESULTS AND DISCUSSION

The presented study revealed that the examined groups of rabbits did not differ with the body weight at slaughter (Table 1). In study conducted by Mazzone et al. (2010) animals treated gently during loading characterised with smaller weight loss (2.78 vs 3.0 %) and higher dressing percentage (61.0 vs 60.8%) compared to the rabbits treated roughly.

TABLE 1. Body weight of rabbits aged 90 days

Trait	Control group	Experimental group	Group effect
	LSM ±*SE*	*LSM* ±*SE*	
N	10	10	
Body weight (kg)	3.21 ±0.12	3.08 ±0.11	Ns

Ns – non-significant.

Presented results did not show the effect of the group on the pH measured in the rabbit meat 45 min after slaughter ($P > 0.05$). However, 24 h and 48 h post mortem the pH value in the experimental group was higher than in the control group ($P \leq 0.01$) (Table 2). In the control group a gradual decrease in the pH value was observed indicating a correct course of post mortem glycolysis. Dal Bosco et al. (2004) found that long distance transport caused higher initial (pHi) and final (pHu) pH value of meat compared to short transport (pHi: 6.35 vs 5.99; $P \leq 0.01$; pHu: 6.35 vs 5.99; $P \leq 0.05$). Opposite to the results of the Dal Bosco et al. (2004), Maria et al. (2006) observed that the transport duration did not affect

TABLE 2. The pH value of rabbit meat

Time	Control group	Experimental group	Group effect
	LSM ±*SE*	*LSM* ±*SE*	
45 min	6.66 ±0.05 AB	6.68 ±0.05 AB	Ns
24 h	5.81 ±0.05 A	6.22 ±0.05 A	**
48 h	5.78 ±0.05 B	6.20 ±0.05 B	**

The effect of the measurement time is indicated in the columns. Means within the same column with the same letters (A, B) are significantly different at $P \leq 0.01$; ** $P \leq 0{,}01$, Ns – non-significant.

the pH value in rabbit meat (1 h transport, pH 5.86 and 7 h, pH 5.83; $P > 0.05$). Similarly to Maria et al. (2006), Liste et al. (2008), also did not observed effect of the transport time on the pH value of rabbit meat. Study conducted by Lambertini et al. (2006) showed the effect of transport on the pH value measured 15 min and 24 h after slaughter, with lower acidification of the muscles characteristic for rabbits subjected to longer transport ($P \leq 0.05$).

In presented study transport had a significant impact on L* measured 48 h after slaughter. The meat of the experimental group was darker compared to the control ($P \leq 0.01$). The redness of the meat was affected by the time post mortem in both groups ($P \leq 0.01$). For both rabbit groups no changes of b* have been found in the analysed time periods ($P > 0.05$) – Table 3. Trocino et al. (2003) and Liste et al. (2008) reported that rabbits submitted to transport characterize with lower L* and higher a* compared to non-transported ones. Dal Bosco et al. (1987) observed darker, redder and yellower meat from rabbits exposed to long transport compared to the rabbits exposed to short transport (L* = 44.3 vs 61.4; a* = 24.2 vs 20.1; b* = 9.6 vs 3.1; $P \leq 0.01$).

In the presented experiment, the meat of rabbits transported directly after weaning characterised with lower drip loss, lower free water content and lower plasticity compared to meat of rabbits transported 24 h prior to slaughter ($P \leq 0.01$) – Table 4. The differences between analysed groups are related to the pH of rabbit meat. High pH value leads to increase capacity of muscle tissue to hold the residual water, expresses by lower drip loss and lower free water content. There were no differences between groups in the amount of cooking loss ($P > 0.05$). Trocino et al. (2003) also reported no effect of transport on the level of cooking loss in hybrid rabbits' meat ($P = 0.99$). Opposite to Trocino et al. (2003) and to the presented study, Dal Bosco et al. (1987) showed that meat of hybrid rabbits exposed to a long transport characterizes with a lower thermal drip (28.93 vs 31.98%; $P < 0.01$) and a higher drip loss (2.34 vs 1.69%; $P < 0.01$) compared to rabbits exposed to shorter transport time. Mazzone et al.

TABLE 3. The colour of rabbit meat

Trait	Time	Control group	Experimental group	Group effect
		LSM ±*SE*	*LSM* ±*SE*	
L*	45 min	48.58 ±1.01 A	48.22 ±1.01	Ns
	24 h	50.22 ±1.01 B	47.65 ±1.01	Ns
	48 h	55.56 ±1.01 AB	46.53 ±1.01	**
a*	45 min	0.79 ±0.66 A	3.93 ±0.66 A	**
	24 h	4.21 ±0.66 AB	4.22 ±0.66 B	Ns
	48 h	0.08 ±0.66 B	–0.28 ±0.66 AB	Ns
b*	45 min	5.98 ±0.65 a	6.02 ±0.65 a	Ns
	24 h	7.92 ±0.65 ab	6.05 ±0.65 b	Ns
	48 h	5.67 ±0.65 b	4.19 ±0.65 ab	Ns

The effect of the measurement time is indicated in the columns. Means within the same column with the same letters a, b (A, B) are significantly different at $P \leq 0.05$($P \leq 0.01$); ** $P \leq 0.01$, Ns – non-significant.

TABLE 4. The water fractions and capacity to hold inner water by rabbit meat

Trait	Control group *LSM* ±*SE*	Experimental group *LSM* ±*SE*	Group effect
Drip loss (%)	1.12 ±0.14	1.74 ±0.14	**
Free water (%)	31.4 ±0.8	36.6 ±0.8	**
Cooking loss (%)	20.90 ±0.42	21.65 ±0.42	Ns
Plasticity (cm^2)	4.22 ±0.11	4.53 ±0.11	*

* $P \leq 0{,}05$, ** $P \leq 0{,}01$,Ns – non-significant.

(2010) found a higher drip loss (3.21 vs 3.10%; $P < 0.05$) and lower thermal drip (17.92 vs 19.76%; $P < 0.05$) in the group of rabbits loaded in a gentle manner compared to rabbits treated roughly during the loading process. In the study conducted by Bianchi et al. (2010) hybrids had a drip loss of 1.02–1.17%. Opposite to our results, Apata et al. (2012) and Dal Bosco et al. (2004) obtained higher value of free water in meat of hybrid rabbit (50.20–62.37% vs 62.92–66.70%, respectively). The plasticity of meat is strongly related with its capacity to hold residual water. Hogh plasticity is a results of high fluidity of meat Grau and Hamm (1957). In presented study, the meat from the control group characterised with higher plasticity compared to the experimental group ($P \leq 0.05$).

The proximate chemical composition of the LTL of hybrid rabbits was not affected by the transport ($P > 0.05$) – Table 5. Similar results were obtained by

TABLE 5. The proximate chemical composition of rabbit meat

Trait	Control group	Experimental group	Group effect
	LSM ±*SE*	*LSM* ±*SE*	
Dry matter (%)	23.88 ±0.25	23.86 ±0.25	Ns
Crude protein (%)	21.59 ±0.41	21.86 ±0.41	Ns
Fat (%)	0.67 ±0.06	0.74 ±0.06	Ns
Water/Crude protein	3.54 ±0.07	3.48 ±0.07	Ns

Ns – non-significant.

Gasperlin et al. (2010), Metzger et al. (2006) (protein – 22.8%, fat – 0.49%) and Tumova et al. (2014) (dry matter – 25.3%, protein – 23.3%, fat 0.56%). Daszkiewicz et al. (2011) obtained similar results of water/crude protein ratio between *m. longissmus* and the leg muscle ($P \leq 0.01$).

CONCLUSIONS

On the basis of the presented results one can conclude that the transport taking place directly prior to slaughter negatively affected the quality of rabbit meat, causing the development of DFD-like abnormal quality. Due to limited shelf life and darker colour DFD meat is less useful for culinary and technological purposes and less attractive for consumers.

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Streszczenie: *Wpływ transportu na wybrane cechy jakościowe mięsa króliczego*. Celem doświadczenia była ocena wpływu transportu na cechy jakościowe mięsa królików decydujące o jego przydatności technologicznej. Badaniu poddano mięso pochodzące od 20 królików hybrydowych (samce, krzyżówka dwóch linii francuskich: Martini i Hyla) ubitych w wieku 90 dni. Grupa kontrolna (10 królików) została przetransportowana po odsadzeniu (wiek 50 dni) i utrzymywana na terenie gospodarstwa doświadczalnego do wieku 90 dni. Grupa eksperymentalna (10 królików) została przetransportowana tuż przed ubojem. Analizowane króliki brojlerowe nie różniły się istotnie masą ciała. Po 24 i 48 h pH w grupie było istotnie wyższe ($P \leq 0.01$) od tego w grupie kontrolnej. Transport miał znaczący wpływ na L* mierzone po 48 h od uboju. Mięso królików z grupy eksperymentalnej było ciemniejsze w porównaniu do królików z grupy kontrolnej ($P \leq 0.01$). Transport spowodował także większą wartość a* w grupie eksperymentalnej w stosunku do grupy kontrolnej ($P \leq 0.01$) 45 min po uboju. Mięso królików przewiezionych do gospodarstwa tuż po odsadzeniu charakteryzowało się znacznie mniejszym wyciekiem naturalnym, mniejszą zawartością wody wolnej oraz mniejszą plastycznością w porównaniu do mięsa królików przetransportowanych tuż przed ubojem ($P \leq 0.01$). Na podstawie wyników wnioskuje się, że transport mający miejsce bezpośrednio przed ubojem doprowadził do obniżenia jakości mięsa, powodując zbyt małe zakwaszenie poubojowe mięśni, a co za tym idzie ciemną barwę i dużą wodochłonność charakterystyczną dla tego typu surowca mięsnego.

Słowa kluczowe: mięso królicze, jakość mięsa, transport, stres, DFD

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