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INFLUENCE OF TRANSPORT DURATION AND SEASON ON SENSORY MEAT QUALITY IN RABBITS[1]

María G.A.[*], Liste G.[*], Campo M.M.[*], Villarroel M.[‡], Sañudo C.[*], Olleta J.L.[*], Alierta S.[†]

[*]Department of Animal Production and Food Science. Faculty of Veterinary Medicine. University of Zaragoza, Miguel Servet, 177. 50013 Zaragoza, Spain.

[†]Animal Experimentation Service. Faculty of Veterinary Medicine. University of Zaragoza, Miguel Servet, 177. 50013 Zaragoza, Spain.

[‡]Department of Animal Production. High Engineering Agronomy School. Polytechnic University of Madrid, Ciudad Universitaria s/n. 28040 Madrid, Spain.

Abstract: Little is known about the effect that journey duration and position on the vehicle have on the sensory aspects of meat quality in rabbits. In this study, 156 rabbits were transported by road in a commercial truck for 1 h or 7 h in one of three replicates in summer or winter. After slaughter, slices from the left side of the *longissimus dorsi* muscle were vacuum-packaged and chilled at –18 ºC until the sensory analysis to assess odour, tenderness, juiciness, fibrousity, greasiness, and flavour intensity. Overall, the journey duration had a significant effect (P<0.05) on tenderness, fibrousity and overall liking of the meat, being better the results of the meat samples from the short transport treatment. Season had a significant effect (P<0.05) on the intensity of off-odours, being obtained the highest scores in summer transports. There was a significant interaction effect (P<0.05) of journey time and season on tenderness and meat odour. Therefore, meat from short journeys in summer was the most tender, and meat from long journeys in winter was the toughest. The position on the truck (in multi-layered cages) do not influence sensory meat quality. Therefore, rabbit sensory meat quality can be affected by transport time.

Key words: rabbit, transport, sensory meat quality, welfare.

INTRODUCTION

The consumer's perception of meat quality has been affected by changing attitudes in society (Maria, 2006). Meat quality not only includes nutritional properties such as meat texture, colour and sensory characteristics, but also perceptions about the conditions of animal production in relation to animal welfare and healthiness (Dalle Zotte, 2002; Trocino and Xiccato, 2006). In the food production chain, which involves all of the processes between the farm and the fork, transport to slaughter can have a negative impact on the animals and on the final product (Buil *et al*., 2004). In recent years, the number of abattoirs in many European countries has decreased, thereby increasing the average distance between the farm and the abattoir (Knowles, 1999) and underlining the importance of improving transport conditions for domestic animals in general.

Little is known about the effect of transport on rabbit welfare and meat quality, especially in warmer climates found in southern Europe. In Spain, journey times for commercial rabbits (to the abattoir) are relatively short, typically less than 3 h (Buil *et al*., 2004), but, as has been shown previously in other

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Correspondence: G.A. María. levrino@posta.unizar.es

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species, poor handling during even relatively short journeys can jeopardize welfare and decrease economic benefits (Agnes *et al*., 1990).

During transportation, many factors can induce stress in rabbits (Jolley, 1990) and affect meat quality (Masoero *et al.*, 1992), including texture and colour (María *et al*., 2006), but little is known about the effect of transportation on the sensory qualities of rabbit meat. Consumers assess product quality based on a series of characteristics that satisfy their needs (Warriss, 2000). One way to measure consumer preference is with a trained sensory panel, which provides quantitative data on the effects of different treatments (e.g., transport time and time of year) in terms of factors that are important for the consumer.

Instrumental and sensory meat qualities can also be linked with ethical meat quality (Villarroel *et al*., 2003), but it is unclear to what extent these three types of qualities are correlated or how to obtain optimal levels of one without compromising another. In this study, we examined whether transport time (1 h or 7 h) and season (winter and summer) had a significant effect on sensory meat quality, as reflected by odour intensity, texture, and flavour intensity. In addition, we determined whether meat quality was influenced by the rabbit's position on the truck. The results are also relevant for stakeholders since the journeys were performed under commercial conditions and represent one of the first attempts to describe stress factors that affect the sensory quality of rabbit meat.

MATERIALS AND METHODS

Materials

The experiment was performed in 2003 in June ("hot season") and January ("cold season"), in northern Spain (41ºN 40'E) using 156 commercial rabbits slaughtered at two months of age (live weight 2.3 kg). We evaluated the effects of short (1 h) and long (7 h) transport length using three replicates (i.e., journeys from the farm to the abattoir) in each season. To assess the effect of the rabbit's position on meat quality, individuals were chosen randomly from the upper, middle, and bottom sections of the truck in a multi-floor cage rolling stand (MFRS). The stocking density during transport was 360 cm^2 per animal (cage size 57×57×25 cm). The overall capacity of the truck was 2400 rabbits. On the truck, air temperature and relative humidity were recorded every 5 min using a Testo thermometer at the level of the studied animals.

Preparation of samples

At mid day, following 3 h lairage time housed in MFRS, the rabbits were slaughtered in an UE homologated abattoir. Average carcass weight (mean ±SD) was 1192.50±121 g. Carcasses were chilled under commercial conditions at 0ºC for 24 h. The pH of the meat was measured at 24 h post-mortem (pH_{24}) on the lumbar region using a Crison 52-00 electrode. The *longissimus dorsi* muscles were removed from both sides of the carcass, and the left sides were vacuum-packaged and chilled at −18ºC. On the day of the sensory assessment, the left loins were thawed in tap water for 2 h until they reached an internal temperature of 17-19ºC. The meat was wrapped in aluminium foil and cooked on a double-plate grill (SAMMIC P8D-2) at 200ºC until the internal temperature was 70ºC. Each loin was trimmed of any external connective tissue, and then cut into slices, wrapped in codified aluminium foil, and stored in a warm cabinet at 50ºC until it was presented to the sensory panel. Water holding capacity (WHC), which was measured 72 h after slaughter, is expressed in percentage of expelled juice after compression using the Grau and Ham Method (Boakye and Mittal, 2004).

The sensory analyses were performed in a tasting room that had individual booths. To conceal differences in meat colour, samples were served under red lighting. A trained, eight-member sensory panel participated

in ten tasting sessions. The panel-members were selected and trained using the method proposed by the British Standard Institution for the selection, training, and monitoring of assessors (BS7667/ISO8586-1, 1993). Each sensory analysis session was a multi-sample test that included three plates with four samples each.

On the same plate, samples were presented in a different order to each panellist. Each treatment was analyzed and compared 20 times for each panellist with 160 judges. We used a 10 point linear scale [0=lowest, 10=highest] in which panellists assessed the following parameters of the rabbit meat: rabbit odour intensity, off-odour intensity, tenderness, juiciness, fibrousity, greasiness, rabbit flavour intensity, odd-flavour intensity and overall liking.

Statistical procedures

The data were analyzed using the least squared method of the GLM procedure (SAS, 1985), with the fixed effects of journey time, season and position within the truck. To assess the relationship between meat pH and sensory traits, we used a factorial model with the fixed effect of pH class (2 levels). The general representation of the models used was: $y=Xb+e$, where b denoted the fixed effects in the model with the association matrix X and e was the vector of residual effects. Finally, we also tested the multiple regression between overall liking and the other sensorial parameters using a step-wise multiple regression methodology for the overall data and for each transport time.

RESULTS

In June and January, the average temperatures on the truck during transport were 29ºC±2 and 9ºC±3, respectively. The average relative humidity was 47.5%±6 in June and 63.5% ±7.6 in January. Average pH_{24} (5.86±0.02 for 1 h and 5.83±0.02 for 7 h) and water holding capacity (WHC: 13.77±0.45 for 1 h and 13.57±0.43 for 7 h) did not differ significantly between animals transported for 1 h compared to 7 h.

The significance of the main effects is presented in Table 1. In general, journey time affects some of the sensory measurements of meat quality. Season has a significant effect on rabbit odour. Meat sensory quality traits were not significantly affected by the rabbit's position on the multi-floor cage rolling stand (top, middle, and bottom) on the transport truck. The interactions between the fixed effects were not significant with the exception of rabbit odour and tenderness in which case a significant interaction between journey

Table 1: Summary table of the significance of the main effects and their interaction for sensory traits of the *longissimus dorsi* for commercial rabbits transported from the farm to the abattoir in Spain.

	Time (T)	Position (P)	Season (S)	T×P	T×S	P×S	T×P×S
Rabbit odour	NS	NS	NS	NS	*	NS	NS
Off-odours	NS	NS	*	NS	NS	NS	NS
Tenderness	*	NS	NS	NS	*	NS	NS
Juiciness	NS	NS	NS	NS	NS	NS	NS
Fibrousity	*	NS	NS	NS	NS	NS	NS
Greasiness	NS	NS	NS	NS	NS	NS	NS
Rabbit flavour	NS	NS	NS	NS	NS	NS	NS
Odd-flavours	NS	NS	NS	NS	NS	NS	NS
Overall Liking	*	NS	NS	NS	NS	NS	NS

NS=not significant; *=$P<0.05$. Season refers to summer or winter. Time: journey time (1 hours or 7 hours). Position: position in the multi-floor cage rolling stand (top, middle or bottom).

Table 2: Least squared means, standard error and significance of the main effects of sensory traits[1] of the *Longisimus dorsi* from commercial rabbits transported from the farm to the abattoir in Spain.

	Transport time		Season		Position on the truck		
	Short (1h)	Long (7h)	Summer	Winter	Upper	Middle	Bottom
Odour Intensity							
Rabbit odour	4.38±0.06	4.25±0.06	4.48±0.06	4.54±0.06	4.52±0.07	4.49±0.07	4.53±0.07
Off-odours	1.49±0.07	1.61±0.07	1.78±0.07^{a}	1.58±0.07^{b}	1.70±0.08	1.74±0.08	1.60±0.08
Texture							
Tenderness	6.28±0.09^{a}	5.90±0.08^{b}	6.13±0.09	6.02±0.09	6.04±0.11	6.11±0.11	6.08±0.11
Juiciness	3.81±0.07	3.80±0.07	3.84±0.07	3.80±0.07	3.78±0.08	3.87±0.08	3.82±0.08
Fibrousity	2.97±0.07^{a}	3.46±0.08^{b}	3.17±0.09	3.30±0.09	3.25±0.11	3.11±0.11	3.34±0.11
Greasiness	3.43±0.06	3.44±0.06	3.36±0.06	3.41±0.06	3.36±0.08	3.35±0.08	3.45±0.08
Flavour Intensity							
Rabbit flavour	5.46±0.05	5.39±0.05	5.22±0.05	5.15±0.05	5.09±0.07	5.19±0.07	5.28±0.07
Off-flavours	2.12±0.07	2.30±0.07	2.12±0.07	2.01±0.07	2.09±0.08	2.06±0.08	2.04±0.08
Acceptability							
Overall liking	5.46±0.07^{a}	4.50±0.07^{b}	4.81±0.07	4.89±0.07	4.80±0.08	4.86±0.08	4.90±0.08

Means within a row with different superscripts differ. (P<0.05).
[1] Using a 10 point linear scale (0=lowest, 10=highest).

time and season were observed. The least squared means (±SE) and significance of the main effects of sensory variables are presented in Table 2. Transport time significantly affected meat tenderness (P<0.05). The score assigned by the panellist was lower (less tender) in meat from animals subjected to a 7 h journey than in meat from those subjected to a 1 h journey. Fibrousity was also significantly affected by transport time (P<0.05), the meat from short journeys reflecting higher values. The judgement of the panellists regarding tenderness was negatively associated with the scores for fibrousity, which was finally reflected

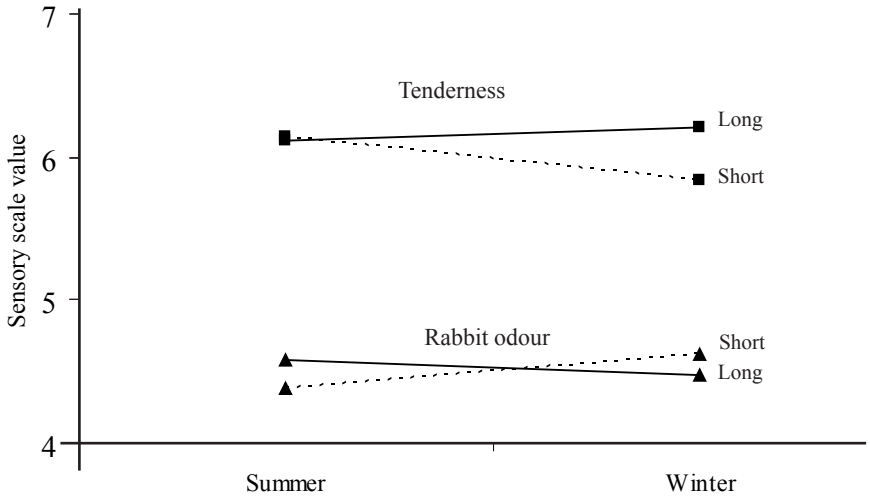

Figure 1: Interaction effect between transport time (short or long) and season (winter or summer) for tenderness and rabbit odour intensity of meat from commercial rabbits transported from the farm to the abattoir in Spain.

Table 3: Least square means and standard error for the sensorial parameters of meat from commercial rabbits transported from the farm to the abattoir in Spain in two pH classes.

	pH<5.80	pH≥5.80	*P*-value
Tenderness	5.88±0.10	6.17±0.08	0.03
Juiciness	3.75±0.08	3.86±0.06	0.27
Rabbit flavour	5.16±0.06	5.20±0.05	0.57
Off-flavours	2.19±0.07	1.99±0.05	0.03
Off-odours	1.78±0.08	1.62±0.05	0.09
Fibrousity	3.40±0.09	3.14±0.07	0.05
Greasiness	3.31±0.07	3.43±0.05	0.22
Overall liking	4.74±0.07	4.92±0.05	0.04

in the overall liking. The overall acceptability was significantly higher ($P<0.05$) in the meat samples from the short transport treatment. Off-odour scores differed significantly ($P<0.05$) between seasons and were highest in summer transports. The scores for rabbit odour and rabbit flavour were intermediate (4-5), which suggests that flavour was correlated with odour. Meat odour, rabbit odour, and off-odour did not differ significantly between transport times. Although transport time did not have a significant effect on rabbit odour intensity, there was a significant interaction between transport time and season ($P<0.05$) for this sensory trait. Meat from short journeys in summer was the most tender, and meat from long journeys in winter was the toughest (Figure 1). Transport time, season, and position on the truck did not have a significant effect on meat juiciness.

Even within normal range of pH, there is evidence that the relationship between meat pH and other meat quality traits should not be the same in meats with a pH closer to the most accepted cut off value of 6 (used to distinguish normal from the abnormal meats) than those clearly below this threshold. In our study, we tested whether meat pH values above 5.80 (5.80 to 6.00) had different sensorial attributes than meat with clearly lower (≤5.80) pH values (Table 3). Meat pH had significant effect ($P<0.05$) on tenderness, off-flavour, fibrousity and overall appreciation of the meat. Small differences in pH can affect meat tenderness. Rabbit meat with a pH above 5.80 was significantly more tender and less fibrous to the panellists (Table 3). However, off-odours were slightly higher in low pH meats.

Table 4: Step-wise multiple regression analysis between overall liking and the other sensory parameters for each journey time.

Variable order[1]	All Journeys			Short Journey			Long Journey		
	Variable	R^2	*P*	Variable	R^2	*P*	Variable	R^2	*P*
1	OF	36	0.0001	OF	39	0.0001	JUI	39	0.0001
2	JUI	62	0.0001	JUI	64	0.0001	OF	60	0.0001
3	ODO	67	0.0003	ODI	68	0.015	ODO	68	0.003
4	ODI	70	0.002	ODO	72	0.03	FLI	70	0.045
5	FLI	72	0.05	FIB	74	0.05	ODI	72	0.04
6	FIB	74	0.05				TEN	74	0.04
7	TEN	76	0.05				FIB	76	0.05

OF:off-flavour; JUI:juiciness; ODO:off-odour; FIB:fibrousity; FLI:rabbit flavour; ODI:rabbit odour; TEN: tenderness
[1]Order of variables in the stepwise analisys.

From the step-wise correlation analysis, overall liking was significantly related to all sensory parameters (Table 4). In the overall analysis, odd-flavour and juiciness were the most related to overall liking and the least was tenderness. The order of the variables in the step-wise correlation of the short journey was different from the overall and the long journey (which were also different than overall). In the meat samples from short journey treatment, off-flavour was the first variable introduced in the equation followed by the juiciness odour related parameters and fibrousity in last place. These variables explain 74% of the variation on overall liking in this treatment. In the long journey meat samples, the first variable called by the step-wise analysis was juiciness followed by the odour related variables, flavour variables and, lastly, tenderness and fibrousity. This group of variables included in the multiple regression model explains more than 76% of the variation of the overall liking.

DISCUSSION

Meat sensory properties are crucial for the consumer's choice (Dalle Zotte, 2000). Little is known about the sensorial changes in meat quality with respect to the transport time of the animals to the abattoir. This fact is even more evident in rabbit than in other farm animals. Although this time may seem negligible in comparison with the time needed for fattening, an improper treatment of the animals during transport can cause high economic losses to the breeders (Speer *et al*., 2001). Meat palatability is positively related to increased tenderness, juiciness and flavour (Love, 1994). The main cause of refusal of rabbit meat is its typical taste of wild game meat sometimes perceived by the consumers (De Carlo, 1998), partially due to the meat fat content and the fatty acid composition. In our study we found that odour and flavour related sensory parameters explain an important proportion of the variation on the overall liking of rabbit meat and this effect is not independent form the journey time. Studies of instrumental meat quality have shown that transport time can affect meat quality traits, such as colour and texture. We found differences in sensory quality with respect to transport time in terms of tenderness and fibrousity. The judgement of the panellists on tenderness was negatively associated with fibrousity, which was finally reflected in the overall liking. In our study, the pH_{24} values of meat from transported rabbits were similar to those reported by Trocino *et al*. (2003).

The relationship between initial muscle glycogen content and ultimate pH is only linear at very low levels of glycogen (Purchas and Aungsupakorn, 1993). Xiccato *et al*. (1994) found that stressed rabbits that are transported exhibit higher glycogen depletion, which results in higher pH at 24 h post-mortem, and Dal Bosco *et al*. (1997) reported that meat pH in rabbits was higher after long journeys (see also Jolley, 1990; Masoero *et al*., 1992; Ouhayoun and Lebas, 1994). Small differences in pH can affect meat tenderness (Purchas and Aungsupakorn, 1993). The reason should be the changes in sarcomere length which is affected by the pH of the meat. In our study, meat tenderness scores and overall liking were higher for rabbit meat with pH_{24} values ≥ 5.80 which is in agreement to the previous remarks.

In our study, we found that off-odour differed between seasons, and tenderness and rabbit odour were influenced by the interaction effect of transport time and season. Rødbotten *et al*. (2004) concluded that when colour was not considered, odour and flavour varied the most among species used for meat production. We found that off-odour intensity was the only trait that varied significantly between seasons. The interaction between transport time and season on rabbit odour, confirmed that the rabbit odour trait was evident in animals that travelled long distances in summer and short distances in winter. It appears that the effect of transport time on rabbit odour and tenderness was not independent of air temperature. This interaction reflects the difficulties on the understanding of transport time effect when the transport is performed in geographical areas with very marked seasons (i.e. North East of Spain). This fact should be considered when assessing the effect of transportation on rabbit meat quality to develop European regulations on rabbit welfare. In other studies of sensory meat quality, tenderness seems to improve

after short journeys (2 h in autumn) (Xiccato *et al*., 1994). Other types of stress, such as the lack of environmental control and extreme temperatures within the truck during transportation, might contribute to poor welfare during transport.

The taste satisfaction that comes from eating meat is the result of tenderness and other factors, such as juiciness and flavour (Koohmaraie, 1996). Meat texture can be assessed using sensory panels or instrumental analysis. Among the latter, Warner Bratzler shear force measurements are accepted as good predictors of the sensory measures of tenderness (Sañudo *et al*., 2003). In our study, there was a significant interaction between transport time and season on tenderness as measured by a sensory panel, which parallels the results of María *et al*. (2006) who used Warner Bratzler measurements to determine meat acceptability. Thus, it appears that there is likely a correlation between the results of a sensory panel analysis and instrumental Warner Bratzler measurements of meat texture traits. Other studies also indicate a correlation between tenderness scores measured instrumentally and sensorially (Dalle Zotte *et al*., 1995).

Therefore, even under optimum commercial conditions, rabbit sensory meat quality can be affected by transport time, which might not imply a lack of animal welfare, but emphasizes the need for increased awareness of animal welfare during the commercial process. Thus, there is a new quality concept within the meat industry that includes consideration of ethical aspects during the process, and an additional cost that consumers concerned about animal welfare may have to bear someday in the future.

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