EVALUATION OF THE SENSORY ATTRIBUTES ALONG RABBIT LOIN BY A TRAINED PANEL

MARTÍNEZ-ÁLVARO M. AND HERNÁNDEZ P.
Institute for Animal Science and Technology, Universitat Politècnica de València, 46022 València, Spain.

Abstract: The aim of this study was to evaluate and quantify variation in sensory attributes along the Longissimus dorsi (LD) muscle in rabbits. A descriptive analysis was performed by a panel of 8 assessors previously trained in the evaluation of rabbit meat. Reference standards used in training for the evaluation of rabbit meat are also described. Sensory attributes rabbit and liver odour, rabbit and liver flavour, toughness, juiciness and fibrousness were assessed in 56 rabbits from a divergent selection experiment for intramuscular fat (28 slaughtered at 9 wk and 28 slaughtered at 13 wk). Immediately after cooking, loins were cut lengthwise into 4 equidistant pieces from caudal to cranial end (LD₁, LD₂, LD₃ and LD₄). Assessors were able to detect and quantify a longitudinal sensory variation in muscle LD. Caudal extreme LD₁ was tougher and more fibrous than LD₂, LD₃ and LD₄, and less juicy than LD₃ and LD₄. The greatest variation was found between caudal and cranial ends, with LD₁ being 9% tougher (P=0.99), 11% more fibrous (P=1.00) and 12% less juicy (P=0.99) than LD₄. Assessors found few variations along LD muscle in flavour and odour attributes. Location LD₃ showed 9% greater rabbit odour (P=0.99) and flavour (P=0.97) than LD₄, and 8% greater rabbit odour than LD₂ (P=0.97). Our results highlight the importance of randomisation within muscle location in sensory studies on rabbit LD muscle, as there is considerable sensory variation along this muscle.

Key Words: loin, panel training, rabbit, sensory evaluation, within muscle variation.

INTRODUCTION

The Longissimus dorsi muscle (LD) shows a lengthwise variation in its metabolism and chemical composition in most livestock species, including rabbits (Vigneron et al., 1976 in rabbits and Faucitano et al., 2004 in pigs). These differences could influence its sensory properties.

Most sensory studies in rabbit meat are performed in LD muscle (Gondret et al., 1998; Hernández et al., 2005 and Gašperlin et al., 2006). Rabbit loin is often cut lengthwise into 4 pieces for its sensory evaluation (see for example Gondret et al., 1998 and Hernández et al., 2005), and the variation in the composition along this muscle should be taken into account when randomising sample presentation. However, to our knowledge there is no previous work in rabbits evaluating and quantifying the sensory variation along LD muscle. In pigs, Hansen et al., (2004) observed that sensory hardness gradually varied from the caudal to the cranial location in LD, being harder at the caudal location.

A quantitative descriptive analysis by a panel of trained assessors is a good way to objectively describe and compare the sensory properties of food products (Lawless and Heymann, 2010). Selection and training of assessors based on normative indications (AENOR, 2014) are necessary to obtain reproducible assessments with good discriminatory ability. There are some studies describing reference standards used in the training for meat evaluation; for example, Gasperi et al. (2005) in lambs or Gorraiz et al. (2000) in ruminants. To our knowledge, there is no information on reference standards used in the training of assessors in rabbit meat.

The aim of this study was to evaluate and quantify the sensory variation along LD muscle in rabbits. Additionally, a description of the reference standards used in the training of assessors for the evaluation of rabbit meat is included.

Correspondence: M. Martínez-Álvaro, mamaral9@upv.es. Received July 2017 - Accepted November 2017.
https://doi.org/10.4995/wrs.2018.7904
MATERIAL AND METHODS

Animals

This study was performed with 56 rabbits from the sixth generation of a divergent selection experiment for intramuscular fat (IMF). More details of this experiment can be found in Martínez-Álvaro et al. (2016a and b). Litters were homogenised at birth up to 9 kits per litter. Rabbits were reared collectively from weaning to slaughter and fed ad libitum with a commercial diet. They were under a constant photoperiod of 16:8 h and controlled ventilation.

Twenty-eight rabbits (14 from the line selected for high IMF and 14 from the line selected for low IMF) were slaughtered at 9 wk of age and another 28 (14 per line) were slaughtered at 13 wk of age. Live weights of the animals were 1647 g at 9 wk and 2596 g at 13 wk on average. Animals were slaughtered using electrical stunning and exsanguination. After slaughter, carcasses were chilled for 24 h at 4°C. From each animal, both LD muscles were excised. Right muscles were vacuum packed and stored at –20°C until sensory analysis, whereas left muscles were reserved for other analyses (Martínez-Álvaro et al., 2016b). All experimental procedures involving animals were approved by the Universitat Politècnica de València Research Ethics Committee, according to Council Directives 98/58/EC and 2010/63/EU.

Sensory analysis

Panel training. Eight people unrelated to the experiment and regular consumers of rabbit meat were trained in the sensory evaluation of rabbit meat following the recommendations in the UNE-EN-ISO 8586:2014 standard (AENOR, 2014). Sensory attributes considered in the training are described in Table 1. These sensory attributes are commonly used in the evaluation of rabbit meat (see for example Hernández et al., 2000, 2005; Gašperlin et al., 2006 and María et al., 2008) or were suggested by the assessors in a preliminary session evaluating rabbit meat. Sensory attributes were trained individually and discussed in joint evaluations during 6 sessions of approximately 1 h each, distributed in 2 wk. Training was performed to ensure the assessors agreed on the definitions of sensory attributes and were able to detect inherent variation present in rabbit meat.

Table 2 shows the composition of the reference standards for low, medium and high intensities of rabbit and liver odour and flavour. Reference samples were prepared using 9 wk rabbit meat from the hind leg as a meat matrix. They were chosen according to the studies of Gasperti et al. (2005) in lamb and Maughan et al. (2012) in beef, with some modifications to adapt them to rabbit meat. Low intensity standards were prepared soaking the meat in water 24 h to extract water-soluble odour components (firstly proposed in beef by Carmack et al., 1995). Medium and high standards were elaborated adding different amounts of rabbit perirenal fat or rabbit liver to the meat matrix, as described in Table 2. Ingredients were minced to obtain homogeneous reference samples. Reference samples of 50 g were vacuum packed and cooked at 80°C for 20 min by immersion in a water bath.

Table 1: Sensory attributes and definitions used to evaluate rabbit meat.

| Attribute      | Definition                                                                 |
|----------------|---------------------------------------------------------------------------|
| Rabbit odour   | Intensity of characteristic odour of rabbit meat.                         |
| Liver odour    | Characteristic odour of organs and blood of animals.                      |
| Rabbit flavour | The combination of taste, odour and tactile stimuli perceived retronasally during chewing – referring to the characteristic flavour of rabbit meat. |
| Liver flavour  | The combination of taste, odour and tactile stimuli perceived retronasally during chewing – referring to the characteristic flavour of organs and blood of animals. |
| Toughness      | Force required to bite the meat sample with molar teeth during the initial chewing. |
| Juiciness      | Moisture perceived during chewing, from the moisture released by the sample and from the secreted saliva. |
| Fibrousness    | Number and thickness of fibres perceived during chewing.                  |
Sensory attributes along rabbit loin

Table 2: Composition of the reference standards for different intensities of rabbit and liver odour and flavour attributes proposed in the training for evaluation of rabbit meat.

| Attribute                  | Intensity of attribute |
|----------------------------|------------------------|
| Rabbit odour and flavour   | Low: 50 g of m         |
|                            | Medium: 40 g of m + 10 g of pf |
|                            | High: 30 g of m + 20 g of pf |
| Liver odour and flavour    | Low: 50 g of m         |
|                            | Medium: 40 g of m + 10 g of l |
|                            | High: 30 g of m + 20 g of l |

m: meat matrix obtained from hind leg of 9 wk rabbits. In low intensity standards, m was soaked 24 h in water to extract water-soluble odour components; pf: rabbit perirenal fat; l: rabbit liver.

Table 3: Reference standards for different intensities of toughness, fibrousness and juiciness attributes proposed in the training for evaluation of rabbit meat.

| Attribute     | Intensity of attribute |
|---------------|------------------------|
| Toughness     | Low: 9 wk hind leg meat cooked 20 min |
|               | Medium: 9 wk loin cooked 60 min |
|               | High: adult loin cooked 60 min |
| Juiciness     | Low: adult loin cooked 60 min |
|               | Medium: 9 wk loin cooked 60 min |
|               | High: 9 wk hind leg meat cooked 20 min |
| Fibrousness   | Low: 9 wk hind leg meat cooked 20 min |
|               | Medium: 9 wk loin cooked 60 min |
|               | High: adult loin cooked 60 min |

All rabbit samples were cooked at 80°C by immersion in a water bath. Adult rabbits were 30 wk of age or longer.
Bayesian analysis was performed. Bounded flat priors were assumed for all unknowns. Marginal posterior distributions were estimated using Gibbs Sampling and convergence was tested for each chain using the Z criterion of Geweke, and Monte Carlo sampling errors were computed using time-series procedures (Sorensen and Gianola, 2002). Chains of 60 000 samples with a burn-in period of 10 000 were used and one sample in 10 was saved to avoid high correlations between consecutive samples. The rabbit program developed in the Institute for Animal Science and Technology (Valencia, Spain) was used to solve the model.

In sensory analyses, it is difficult to interpret what a relevant difference is, so instead of assessing the differences between LD locations, we analysed the ratios between levels. The features of the marginal posterior distributions calculated were: median of the ratio between LD locations, the standard deviation, and the probability (P) of the ratio >1 when the median is greater than one or <1 when the median is lower than one. More details of these features can be found in Blasco (2017).

**RESULTS AND DISCUSSION**

Table 4 shows descriptive parameters of sensory attributes in LD muscle. Rabbit odour and flavour were higher on average and more variable than liver odour and flavour. Our scores are in line with other sensory studies in rabbits in the same muscle (Gondret et al., 1998; Hernández et al., 2000; Gašperlin et al., 2006 and María et al., 2008).

Table 5 shows ratios between LD1, LD2, LD3 and LD4 locations for sensory attributes. Assessors were able to detect a variation in sensory texture properties along LD muscle. Caudal extreme LD3 was tougher and more fibrous than LD2, their palate between samples. Evaluations were carried out in a standard laboratory in accordance with the UNE 8589:2010 standard (AENOR, 2010).

**Statistical analysis**

To correct the assessor effect, sensory data were standardised subtracting the mean and dividing by the standard deviation of each assessor, as recommended by Næs et al. (2010). Then, the mean of the model was added to standardised data. Muscle location effect was evaluated with a model including the fixed effects of LD location, line, age, sex and session. Residuals were assumed to be independently normally distributed. A

---

**Table 4:** Descriptive statistics for sensory attributes of Longissimus dorsi muscle in rabbits.

| Attribute        | Mean | SD  | CV(×100) |
|------------------|------|-----|----------|
| Rabbit odour     | 4.53 | 0.98| 21.6     |
| Liver odour      | 1.67 | 0.97| 58.0     |
| Rabbit flavour   | 4.15 | 0.97| 23.4     |
| Liver flavour    | 2.17 | 1.00| 46.2     |
| Toughness        | 4.50 | 0.90| 20.0     |
| Juiciness        | 3.60 | 0.87| 24.2     |
| Fibrousness      | 4.50 | 0.90| 20.1     |

**Table 5:** Features of the marginal posterior distributions of the ratios between Longissimus dorsi (LD) muscle locations for sensory attributes in rabbits.

| Attribute        | LD1/LD2 | LD2/LD3 | LD3/LD4 | LD1/LD3 | LD2/LD3 | LD3/LD4 | LD4/LD3 | M  | SD  | P     | M  | SD  | P     | M  | SD  | P     | M  | SD  | P     | M  | SD  | P     |
|------------------|---------|---------|---------|---------|---------|---------|---------|-----|-----|-------|-----|-----|-------|-----|-----|-------|-----|-----|-------|-----|-----|-------|-----|-----|-------|-----|-----|-------|
| Rabbit odour     | 1.05    | 0.04    | 0.90    | 0.98    | 0.04    | 0.74    | 1.06    | 0.60 | 0.04 | 0.93  | 0.93 | 0.04 | 0.97  | 1.00 | 0.04 | 0.56  | 1.09 | 0.04 | 0.99  |
| Liver odour      | 0.96    | 0.11    | 0.63    | 0.91    | 0.11    | 0.81    | 0.86    | 0.60 | 0.10 | 0.92  | 0.94 | 0.11 | 0.71  | 0.89 | 0.10 | 0.85  | 0.95 | 0.10 | 0.70  |
| Rabbit flavour   | 0.99    | 0.04    | 0.56    | 0.98    | 0.04    | 0.70    | 1.06    | 0.05 | 0.90 | 0.99  | 0.04 | 0.63  | 1.07 | 0.05 | 0.93  | 1.09 | 0.05 | 0.97  |
| Liver flavour    | 0.92    | 0.09    | 0.81    | 0.89    | 0.08    | 0.91    | 0.87    | 0.08 | 0.94 | 0.96  | 0.08 | 0.68  | 0.94 | 0.08 | 0.75  | 0.98 | 0.08 | 0.59  |
| Toughness        | 1.06    | 0.04    | 0.95    | 1.07    | 0.04    | 0.97    | 1.09    | 0.04 | 0.99 | 1.01 | 0.04 | 0.61  | 1.03 | 0.04 | 0.76  | 1.02 | 0.04 | 0.64  |
| Juiciness        | 1.00    | 0.05    | 0.53    | 0.93    | 0.04    | 0.94    | 0.89    | 0.04 | 0.99 | 0.94 | 0.04 | 0.92  | 0.89 | 0.04 | 0.99  | 0.95 | 0.04 | 0.86  |
| Fibrousness      | 1.07    | 0.04    | 0.95    | 1.10    | 0.04    | 0.99    | 1.11    | 0.04 | 1.00 | 1.04 | 0.04 | 0.82  | 1.04 | 0.04 | 0.85  | 1.00 | 0.04 | 0.55  |

LD locations: Longissimus dorsi muscle cut lengthwise into four equidistant pieces from caudal to cranial end (LD1 = seventh to fifth lumbar vertebra; LD2 = fifth to third lumbar vertebra; LD3 = third to first lumbar vertebra and LD4 = first lumbar to ninth thoracic vertebra); M: median of the marginal posterior distribution of the ratio; SD: standard deviation of the marginal posterior distribution of the ratio; P: probability of the ratio >1 when the median is greater than 1 and probability of the ratio <1 when the median is lower than 1.
LD₂ and LD₄, and less juicy than LD₃ and LD₅. The greatest variation was found between caudal and cranial ends, with LD₃ being 9% tougher (P=0.99), 11% more fibrous (P=1.00) and 12% less juicy (P=0.99) than LD₁. Locations LD₂, LD₃ and LD₄ showed hardly any sensory texture variation between them, except for juiciness, which was 12% greater in LD₄ than in LD₂ (P=0.99).

Assessors found few variations along LD muscle in flavour and odour attributes (Table 5). Location LD₃ showed 9% greater rabbit odour (P=0.99) and flavour (P=0.97) than LD₄, and 8% greater rabbit odour than LD₄ (P=0.97). Location LD₃ showed 15% greater liver flavour than LD₄, and 7% lower rabbit flavour than LD₄, but in both cases, the probability of the ratio being different from 1 was moderate (P=0.94 and 0.93, respectively; Table 5).

Sensory variations observed between LD locations may be caused by morphological or metabolic differences within the muscle. Vigneron et al. (1976) described an increase in the number of fibres from cranial to caudal loin ends in rabbits. These authors also found an increase in the proportion of intermediate fast-twitch fibres αR (intermediate diameter) in comparison to slow-twitch fibres βR (small diameter) from cranial to caudal loin ends. Their results could explain the greater fibrousness that we found in caudal end in comparison to cranial. A longitudinal variation in LD texture traits has been previously reported in pigs (Hansen et al., 2004), lambs (Shackelford et al., 2004) and beef (Wheeler et al., 2007). In pigs, toughness increased from cranial to caudal end (Hansen et al., 2004), as observed in our study in rabbits. In beef, cranial and caudal ends showed lower instrumental toughness than the middle of the muscle (Wheeler et al., 2007). In lambs, there was a significant interaction between the animal genotype and the loin location, with callipyge lambs being tougher in anterior location and non-callipyge lambs tougher in posterior location (Shackelford et al., 2004).

Our results show that there is a considerable variation in sensory attributes along the LD muscle in rabbits, particularly in texture properties of toughness, juiciness and fibrousness, which varied around 10% between cranial and caudal extremes. Variations in liver and rabbit odour and flavour were also found, but they were lower. Randomisation within muscle location in sensory evaluation studies of rabbit LD muscle is necessary to correct this variability.

Acknowledgements: This work was supported by project AGL2014-55921-C2-1-P from the Spanish National Research Plan. M. Martínez-Álvaro acknowledges a FPI grant (BES-2012-052655) from the Economy Ministry of Spain. The authors thank Prof. Agustín Blasco for his useful comments.

REFERENCES

AENOR, Asociación Española de Normalización y Certificación. 2006. Norm UNE-EN ISO 4121:2006. Sensory analysis. Guidelines for the use of quantitative response scales (ISO 4121:2003). Asociación Española de Normalización y Certificación (AENOR) editors, Madrid, Spain.

AENOR, Asociación Española de Normalización y Certificación. 2010. Norm UNE-EN ISO 8589:2010. Sensory analysis. General guidance for the design of test rooms (ISO 8589:2007). Asociación Española de Normalización y Certificación (AENOR) editors, Madrid, Spain.

AENOR, Asociación Española de Normalización y Certificación. 2014. Norm UNE-EN ISO 8586:2014. Sensory analysis. General guidelines for the selection, training and monitoring of selected assessors and expert sensory assessors. Asociación Española de Normalización y Certificación (AENOR) editors, Madrid, Spain.

Arinño B., Hernández P., Plá M., Blasco A. 2007. Comparison between rabbit lines for sensory meat quality. Meat Sci., 75: 494–498. https://doi.org/10.1016/j.meatsci.2006.08.013

Blasco A. 2017. Bayesian data analysis for animal scientists. Springer, N.Y., U.S.A. https://doi.org/10.1007/978-3-319-54274-4

Braghieri A., Piazolla N., Carlucci A., Monteleone E., Girolami A., Napolitano F. 2012. Development and validation of a quantitative frame of reference for meat sensory evaluation. Food Qual. Prefer., 25: 63-68. https://doi.org/10.1016/j.foodqual.2012.01.007

Carmack C.F., Kastner C.L., DiKeman M.E., Schwenke J.R., Garcia Zepeda, C.M. 1995. Sensory evaluation of beef flavor intensity, tenderness and juiciness among major muscles. Meat Sci. 39(1), 143-147. https://doi.org/10.1016/0309-1740(95)80016-6

European Economic Community. 1998. Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals used for scientific purposes. Official Journal, 221: 8.

European Commission Directive. 2010. Council, E.P.A.E. 2010/63/EU on the protection of animals used for scientific purposes. Institute for Health and Consumer Protection, Ispra, Italy, b7.

Faucitano L., Rivest J., Daigle J.P., Lévesque J., Gariepy C. 2004. Distribution of intramuscular fat content and marbling within the Longissimus muscle of pigs. Can. J. Anim. Sci., 84: 57-61 https://doi.org/10.4141/A03-064

Gasperi F., Biasioli F., Gallerani G., Fasoli S., Piasentier E. 2005. Training of a sensory panel for quantitative descriptive analysis of lamb meat. Ital. J. Food Sci., 3: 255-268.
Gašperlin L., Polak T., Rajar A., Skvarča M., Zinder B. 2006. Effect of genotype, age at slaughter and sex on chemical composition and sensory profile of rabbit meat. World Rabbit Sci, 14: 157-166. https://doi.org/10.4995/wrs.2006.558

Gondret F., Juin H., Bonnot J., Bonneau J. 1998. Effect of age at slaughter on chemical traits and sensory quality of Longissimus lumbarum muscle in the rabbit. Meat Sci., 48: 181-187. https://doi.org/10.1016/S0309-1740(97)00088-0

Gorraiz C., Beriain M.J., Chasco J., Iraizoz, M. 2000. Descriptive analysis of meat from young ruminants in Mediterranean systems. J. Sensory Stud., 15: 137-150. https://doi.org/10.1111/j.1745-459X.2000.tb00261.x

Hansen S., Hansen T., Aaslyng M.D., Byrne D.V. 2004. Sensory and instrumental analysis of longitudinal and transverse textural variation in pork Longissimus dorsi. Meat Sci., 68: 611-629. https://doi.org/10.1016/j.meatsci.2004.05.013

Hernández P., Plá M., Oliver M.A., Blasco A. 2000. Relationships between meat quality measurements in rabbits fed with three diets of different fat type and content. Meat Sci., 55: 379-384. https://doi.org/10.1016/S0309-1740(99)00163-1

Hernández P., Guerrero L., Ramírez J., Mekkawy W., Plá M., Ariño B., Ibáñez N., Blasco A. 2005. A Bayesian approach to the effect of selection for growth rate on sensory meat quality of rabbit. Meat Sci., 69: 123-127. https://doi.org/10.1016/j.meatsci.2004.06.013

Lawless H.T., Heymann H. 2010. Sensory evaluation of food – Principles and practices. Springer Science Business Media. New York, U.S.A. https://doi.org/10.1007/978-1-4419-6488-5

Macfie H., Bratchell N., Greenhoff K., Vallis L. 1989. Designs to balance the effects of order of presentation and first-order carry-over effects in hall test. J. Sensory Stud., 4: 129-148. https://doi.org/10.1111/j.1745-459X.1989.tb00463.x

María G.A., Liste G., Campo M.M., Villarreal M., Sáfnudó C., Olleta J.L., Alierat S. 2008. Influence of transport duration and season on sensory meat quality in rabbits. World Rabbit Sci., 16: 81-88. https://doi.org/10.4995/wrs.2008.630

Martínez-Álvaro M., Hernández P., Blasco A. 2016a. Divergent selection on intramuscular fat in rabbits: Responses to selection and genetic parameters. J. Anim. Sci., 94: 4993-5003. https://doi.org/10.2527/jas.2016-0590

Martínez-Álvaro M., Penalba V., Blasco A., Hernández, P. 2016b. Effect of divergent selection for intramuscular fat on sensory traits and instrumental texture in rabbit meat. J. Anim. Sci., 94: 5137-5143. https://doi.org/10.2527/jas.2016-0850

Maughan C., Tansawat R., Cornforth D., Ward R., Martini S. 2012. Development of a beef flavor lexicon and its application to compare the flavor profile and consumer acceptance of rib steaks from grass- or grain-fed cattle. Meat Sci., 90: 116-121. https://doi.org/10.1016/j.meatsci.2011.06.006

Näs T., Brockhoff P., Tomic O. 2010. Correction methods and other remedies for improving sensory profile data. Statistics for sensory and consumer science. John Wiley and Sons Publishers. West Sussex, U.K. 39-46.

Shackelford S.D., Wheeler T.L., Koochmarie M. 2004. Evaluation of sampling, cookery, and shear force protocols for objective evaluation of lamb Longissimus tenderness. J. Anim. Sci., 82: 802-807. https://doi.org/10.2527/2004.823802x

Sorensen D., Gianola D. 2002. Likelihood, Bayesian and MCMC methods in quantitative genetics. Springer, N.Y., U.S.A. https://doi.org/10.1007/b98952

Stell R.G., Torrie J.H. 1980. Principles and procedures of statistics. McGraw-Hill, N.Y., U.S.A.

Vigneron P., Bacou F., Ashmore C.R. 1976. Distribution heterogeneity of muscle fiber types in the rabbit Longissimus muscle. J Anim. Sci., 43: 985-988. https://doi.org/10.2527/jas1976.43S988x

Wheeler T.L., Shackelford S.D., Koochmarie, M. 2007. Beef Longissimus slice shear force measurement among steak locations and institutions. J. Anim. Sci., 85: 2283-2289. https://doi.org/10.2527/jas.2006-736