Spanish Journal of Agricultural Research
17 (4), e0609, 11 pages (2019)
eISSN: 2171-9292
https://doi.org/10.5424/sjar/2019174-14774
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)

RESEARCH ARTICLE

OPEN ACCESS

Effect of slaughter age and finishing diet on sensory evaluation and consumers' preference of foal meat

Marta Ruiz (Ruiz, M)[1], Kizkitza Insausti (Insausti, K)[1], Maria J. Beriain (Beriain, MJ)[1], Santiago Crecente (Crecente, S)[2], José M. Lorenzo (Lorenzo, JM)[3] and Maria V. Sarriés (Sarriés, MV)[1]

[1]*IS-FOOD. ETSIA, Universidad Pública de Navarra, Campus de Arrosadía, 31006 Pamplona, Spain.* [2]*INGACAL. Centro de Investigaciones Agrarias de Mabegondo. Apartado 10. 15080 La Coruña, Spain.* [3]*Centro Tecnológico de la Carne de Galicia, Rúa Galicia Nº 4, Parque Tecnológico de Galicia, San Cibrao das Viñas, 32900 Ourense, Spain.*

Abstract

Aim of study: This study focused on the sensory evaluation and consumer preferences of foal meat depending on the animal slaughter age (13 and 26 months) and finishing diet (standard and linseed concentrate).

Area of study: It was developed in two localities in the north of Spain: Orense and Pamplona.

Material and methods: The sensory study was conducted by a 10-member trained and a 474-consumer panel.

Main results: The trained panel described meat from both, 13 and 26-months old foals similar between each other. On the contrary, consumers considered meat from the younger group to be juicier and tenderer, being juiciness and tenderness (p<0.05), the most important clues for their global acceptance. No differences were found in either the trained or the consumer panel due to the finishing diet. The consumers test was carried out in two Spanish cities (Pamplona and Orense. Two scenarios were considered: without and with supplementary information about the foal meat production. The additional information disclosed about foal meat had a positive effect on Pamplona consumers' assessments.

Research highlights: City and information level are essential factors to introduce foal meat in the market. The lack of knowledge about foal meat and its low presence in meat markets make it necessary to develop further sensory studies; to obtain foal meat description patterns, and to get to know consumers' likings.

Additional keywords: horse meat; linseed, trained panel; consumers; information level.

Abbreviations used: 13M (foals slaughtered at 13 months); 26M (foals slaughtered at 26 months); B (blind scenario); CL (cooking loss); DE (digestible energy); DM (dry matter); F (full information scenario); FD (finishing diet); IMF (intramuscular fat); LC (linseed concentrate); LTL (*Longissimus thoracis et lumborum*); LW (live weight); NRC (National Research Council); SA (slaughter age); SC (standard concentrate); WBSF (Warner Bratzler shear force).

Authors' contributions: MVS, MJB, JML and KI contributed to experimental design. MR took part in the responsibility for writing the manuscript. MVS, MJB and KI performed the statistical analyses. JML and SC provided support to coordinate the research project. All authors contributed critically to the interpretation of the results and to the content of the manuscript. All authors helped with data collection, reviewed and offered critical comments on the manuscript.

Citation: Ruiz, M; Insausti, K; Beriain, MJ; Crecente, S; Lorenzo, JM; Sarriés, MV (2019). Effect of slaughter age and finishing diet on sensory evaluation and consumers' preference of foal meat. Spanish Journal of Agricultural Research, Volume 17, Issue 4, e0609. https://doi.org/10.5424/sjar/2019174-14774

Supplementary material (Table S1) accompanies the paper on SJAR's website.

Received: 25 Feb 2019. **Accepted:** 15 Jan 2020.

Funding agencies/Institutions	Project/Grant
INIA, Spain	RTA 2012-00090-C03-01

Competing interests: The authors declared that they don't have competing interests.

Correspondence should be addressed to Maria V. Sarriés: vsarries@unavarra.es

Introduction

The interest in foal meat has noticeably increased due to the healthy characteristics stated by different authors (Lorenzo *et al.*, 2014). These nutritional properties are in line with recent health recommendations concerning the fatty acids and lipid consumption, and make foal meat a potential alternative in different local markets (Domínguez *et al.*, 2018). In addition, horsemeat production is based on an extensive production system which favours the maintenance of the environment and ecosystems supporting a sustainable agriculture (Belaunzaran *et al.*, 2015).

There are many studies dealing with extrinsic attributes as indicators of meat quality (Lusk & Fox, 2001). Nevertheless, slaughter conditions or the type of production system are two of the most important for consumers' decisions in different areas of Spain (Olaizola *et al*., 2005). Several production factors have been studied in foal meat, as breed/crossbreed (Franco *et al*., 2013), slaughter age and finishing diet (Sarriés & Beriain, 2006), and post-mortem factors as storage or display time (Lorenzo & Gómez, 2012) (during 14 days under modified atmosphere, vacuum or overwrapped packaging), but not from a consumer point of view.

Morales *et al*. (2013) confirmed that there are predominant intrinsic attributes for consumers to assess beef quality, namely tenderness, juiciness and flavour, which are the most important acceptance factors after colour. In foal meat, there are some studies describing this type of meat using a trained panel (Sarriés & Beriain, 2005; Franco *et al*., 2013). Nevertheless, there is a lack of researches regarding foal meat and consumer preferences or sensory acceptance. These questions are essential to know the foal meat potential market and to be able to provide the market with a well-defined product. Besides, more recent studies have attempted to explore the hedonic scores when considering different levels of product information (Realini *et al*., 2014; Beriain *et al*., 2016).

Thus, the aim of this work was to evaluate the sensory quality of foal meat from animals slaughtered at 13 and 26 months of age and supplemented with standard or linseed-enriched (5%) concentrate. On the one hand one trained panel was employed; on the other hand, a consumers' test was carried out in two Spanish cities (Pamplona and Ourense). In addition, the influence of eating habits and social factors in the acceptance of foal meat by consumers were also studied.

Material and methods

Animal management and sampling

Forty-six Galician Mountain × Burguete crossbred foals were used. The foals were kept with their mothers and allowed to suck freely on pasture from the birth to the weaning at the age of 6-7 months. Next, foals were randomly divided in two groups to be slaughtered at two different ages (SA): 22 foals were slaughtered at 13 months (403 ± 30 days) (13M) and 24 foals were slaughtered at 26 months of age (784 ± 37 days) (26M). Both groups of animals were fed on the same pasture following a rotational grazing. This period lasted 3 months (± 15 days) and 16 months (± 15 days) for 13M and 26M, respectively. Finally, foals were supplemented for 104 days (± 10 days) with a finishing diet (FD) based on concentrate. During the last period (3rd period), 11 foals from 13M group and 12 from 26M group were randomly chosen and supplemented with standard concentrate (SC). Then again, the others 11 foals from 13M and 12 from 26M group were randomly chosen and supplemented with linseed-rich concentrate (5%) (LC). Foals were supplemented with 2 kg of the mentioned concentrates to carry out an optimal animals' fattening. These supplementations were increased from 0.3 kg to 2 kg per foal/day for the first 10 days (adaptation term). The intakes were estimated according to NRC (1989). The pasture estimated intakes (dry matter, DM) were 2.18 and 2.37 % of live weight (LW) for 13M and 26M foals, respectively, whereas the estimated intake (digestible energy, DE) was 13.16 and 16.51 Mcal/foal-day for 13M and 26M foals, respectively. For the finishing period, the estimated (DM) intakes (pasture plus concentrate) were 2.80 and 2.59 % LW for 13M and 26M foals, respectively, whereas the estimated (DE) intake were 20.67 and 26.09 and Mcal/foal-day for 13M and 26M foals, respectively.

Foals were transported 50 km to the abattoir the day before slaughter in compliance with current European regulations (OJ, 2005), and were stunned with a captive bolt, slaughtered and dressed according to the specifications outlined in the European legislation (OJ, 1993). After slaughter, the carcasses were chilled for 24 h at 4 ± 1°C. Then, the *Longissimus dorsi* muscle was filleted into 15 mm thick slices, vacuum-packed and immediately frozen during 3 months until meat was analysed.

Physico-chemical analysis

The physico-chemical composition (pH, moisture, intramuscular fat (IMF), protein and cooking loss was compiled following Domínguez *et al*. (2018) publication. The pH of the samples was measured using a digital portable pH-meter (Hanna Instruments, Eibar, Spain) equipped with a penetration probe. Moisture, IMF and protein were quantified according to the ISO recommended standards 1442:1997, 1443:1973 and 937:1978, respectively. Briefly, moisture percentage was calculated by weight loss experiment by the sample maintained in the oven (Memmert UFP 600, Schwabach, Germany) at 105°C, until constant weight. For IMF content determination, samples were subjected to a liquid-solid extraction using petroleum ether in an extractor apparatus (AnkomHCI Hydrolysis System, Macedon NY, USA) at 90°C during 60 min. The fat content was obtained based on gravimetric difference. Protein content was determined according to Kjeldahl total nitrogen method, multiplying the total nitrogen content by 6.25. Sample was subjected to reaction with sulphuric acid (cuprum sulphate was employed as a catalyst) in a digester (Gerhardt Kjeldatherm KB, Bonn, Germany). Organic nitrogen was transformed to ammonium sulphate, which was distilled in alkali conditions in a distillation apparatus (Gerhardt Vapodest 50 Carrousel, Bonn, Germany). The water holding capacity (WHC) was measured as cooking loss (CL). Steaks were cooked placing vacuum package bags in a water bath with automatic temperature control (JP Selecta, Precisdg, Barcelona, Spain) until they reached an internal temperature of 70°C, controlled by thermocouples type K (Comark, PK23M, UK), connected to a data logger (Comark Dilligence EVG, N3014, UK). After cooking, samples were cooled in a circulatory water bath set at 18°C during a period of 30 min and the percentage cooking loss was recorded. All samples were cut perpendicular to the muscle fibre direction at a crosshead speed of 3.33 and 1 mm s^{-1} for Warner-Bratzler. A texture analyser (TA-XT2, Stable Micro Systems, Godalming, UK) was used. Seven pieces of meat of 1 × 1 × 2.5 cm (height × width × length) were removed parallel to the muscle fibre direction. Samples were cut using a WB shear blade. Maximum shear force to cut the sample were obtained (Sarriés & Beriain, 2006; Pateiro *et al*., 2013). These data are compiled in Table S1 [suppl]. The composition and physico-chemical characteristics of the meat used in this study was previously published by Dominguez *et al*. (2018) and is employed in the present study as complementary material.

Trained panel

Prior to the sensory evaluation, samples were thawed at 4ºC for 24 hours. Steaks were cooked in a convection oven at 180ºC to an internal temperature of 70ºC, which was measured using a handheld probe thermometer (HI-985011, Hanna Instruments, Spain). The cooked foal steaks were cut into pieces (10×10× 25 mm) and placed on white plastic trays covered with aluminium foil, and immediately served. The taste panel evaluation was conducted by ten panellists trained and selected according to ISO 8586:2012. The panellists completed 120 hours of training (training sessions were run once a week and lasted about 90-100 minutes), and all of them had a minimum of 2000 hours of sensory testing experience. Panel members were situated in a private red-lighted cabinet during sessions (ISO 8589:2007). The red light was used in order to mask appearance characteristics of products because in the present study they are not variables to evaluate in the product, as appearance or colour.

The study focuses on the variables related to odour, flavour and texture. It was used the xlstat-sensory software which allows to search the optimal design. The experimental design was a randomized block completed with 10 panellists, 6 sessions and 4 products (one by plate). In a complete block, all levels of the interest factors are present once within each block, so all products are seen once by each judge. Each sample was evaluated six times by each panellist. To avoid first sample effects, the experimental design, *i.e.* the order of sample presentation, was rotated and balanced to ensure that all samples were treated in the same way and thus, the test was fair. Carry over effects were measured by Xlstat software. The design was balanced to minimize first-order and carry-over effects (Macfie *et al*., 1989).

Water and bread rolls to clean the palates and remove residual flavours was given to them at the beginning of the performance and in between samples, which were individually labelled with three-digit aleatory numbers and were randomly served one at a time. A 10 cm unstructured scale was used, were 0 was "absence/the lowest intensity of the attribute" (left side) and 10 was "the highest intensity of the attribute" (right side). Then, each one was measured using a 10 cm ruler to score it from 0 to 10 points. Pondered variables: characteristic odour intensity (0=low intensity; 10=very intense), and characteristic flavour intensity (0=low intensity; 10=very intense), fat odour intensity (0=low intensity; 10=very intense), fat flavour intensity (0=low intensity; 10=very intense), tenderness (0=very tough; 10=very tender), juiciness (0=very dry; 10=very juicy), fibrousness (0=slightly fibrous; 10=very fibrous) and greasiness (0=slightly greasy; 10=very greasy.

Consumer panel

Screening of consumer panel and design of informatio

The study was carried out with 474 individuals from two different Spanish cities: Pamplona, Northern Spain (n = 247) and Ourense, North-West Spain (n = 227). Thus, two samples per *Longissimus thoracis et lumborum* muscle (LTL) were employed; one in each city. Taking into account the methodology followed by Beriain *et al*. (2016), the distribution of means in the random, age-stratified sample of 474 consumers resembled that of the population of the regions selected according to gender, age, education and household income level (Spanish National Institute of Statistics, 2015). The non-experienced consumers were contacted by telephone and offered a small monetary incentive in exchange for their participation in the survey as it was carried out by the aforementioned authors.

The balanced distributed sessions were of two types, differing in the experimental marketing scenario and amount of information disclosed (Beriain *et al*., 2016): Scenario 1 = blind (B) (just saying that meat samples were foal meat) (125 and 118 consumers in Pamplona and Orense, respectively); Scenario 2 = full information (F), including details on: (1) geographical breed origin (Galician Mountain × Burguete crossbred, autochthonous breeds from Galicia and Navarra, respectively); (2) the location of rearing and slaughtering: Galicia (122 and 109 consumers in Pamplona and Orense, respectively). Thus, the impact of product information absence or presence on the consumer ratings was researched. Consumers tested the product after being informed according to their assigned information scenario (B or F). It must be taken into account that 55 and 85 % of consumers from Pamplona and Orense, respectively, had never consumed foal meat. This difference is the reason why the sensory study was separately carried out in both cities.

Due to the lack of foal meat sensory references, some questions were based on beef researches related to the consumer process evaluation and the main intrinsic and extrinsic sensory attributes (Beriain *et al*., 2016).

Taste sample preparation

The methodology used for the consumer panel was described by Beriain *et al*. (2014). The frozen steaks were thawed at 1ºC for approximately 24 hours and cooked on a grill (Magefesa, Spain) according to AMSA (2015) guidelines until they reached 70ºC of internal temperature. Nine tasting sessions, each involving 25–30 consumers, were carried out in each city. For each session, three steaks of 2.5-cm-thick per treatment (from different carcasses) were cooked in each session (12 steaks [4 treatments × 3 steaks/treatment]). Whole steaks were cut into 1.5 × 2 × 1.5 cm cubes and kept in heat-retaining containers until the moment of serving. A total of four samples of meat from LTL were randomly and individually presented at each consumer. Participants were asked to evaluate the samples in the order they were served, which was previously designed to avoid the order of presentation effect and first order and carry over effects (Beriain *et al*., 2014; Macfie *et al*., 1989).

The testing panel was asked to the aroma, flavour, tenderness, juiciness, sweetness and their overall acceptance of the samples. A 9-point hedonic scale was used, being 1 = "Dislike extremely", 2 = "Dislike very much", 3 = "Dislike moderately", 4 = "Dislike slightly", 5 = "Neither like nor dislike", 6 = "Like slightly", 7 = "Like moderately", 8 = "Like very much" and 9 = "Like extremely". Before tasting each sample, consumers were asked to eat some unsalted toasted bread and then rinse their mouths out with water.

Statistical analysis

The data collected from the trained panel were analysed by the method used previously by Beriain *et al*. (2016) That is, the same model was applied for all sensory attributes. An analysis of variance (ANOVA) using the General Lineal Model (GLM) procedure was performed for all variables considered in the study (SPSS 23.0, Chicago, IL, USA).

First of all, a previous results exploration was carried out with both trained panellists and consumers. The trained panellists were considered a fixed factor whereas consumers were considered random factor. None of them showed significant effect on the sensory results. Thus, they were removed from the models developed.

Secondly, for the trained panel evaluation, the effect of slaughter age and finishing diet were included in the first model. The model used was:

$$Y_{ij} = \mu + SA_i + FD_j + SA_i \times FD_j + \varepsilon_{ijk}$$

where, Y_{ij} is the observation of dependent variables, μ is the overall mean, SA_i is the effect of slaughter age (i = 1 denotes 13 months of age; i = 2 denotes 26 months of age), FD_j is the effect of finishing diet (j = 1 denotes standard concentrate; j = 2 denotes linseed-enriched concentrate), $SA_i \times FD_j$ is the effect of the interaction between the ith slaughter age and the jth finishing diet and ε_{ijk} is the residual random error associated with the observation.

Thirdly, for the consumers' evaluation, the effect of slaughter age, finishing diet and information scenario were included in the model. The model used was:

$$Y_{ijk} = \mu + SA_i + FD_j + S_k + SA_i \times FD_j + SA_i \times S_k + + FD_j \times S_k + \varepsilon_{ijkl}$$

where, Y_{ijk} is the observation of dependent variables, μ is the overall mean, SA_i is the effect of slaughter age (i = 1 denotes 13 months of age; i = 2 denotes 26 months of age), FD_j is the effect of finishing diet (j = 1 denotes standard concentrate; j = 2 denotes linseed-enriched concentrate), S_k is the effect of information scenario (k = 1 denotes blind information; k = 2 denotes full information), $SA_i \times FD_j$ is the effect of the interaction between the ith slaughter age and the jth finishing diet, $SA_i \times S_k$ is the effect of the interaction between the ith slaughter age and the kth scenario, $FD_j \times S_k$ is the effect of the interaction between the jth finishing diet and the kth scenario and ε_{ijkl} is the residual random error associated with the observation.

In addition, Pearson's correlation test between the mean values of the meat quality attributes of the foal meat were determined. Principal component analysis

(PCA) was applied to study the relationship between the chemical composition and sensory variables of both, the trained panel and consumers' evaluation. Varimax rotation was applied to the factors to facilitate interpretation and maximize the explained variance.

Results

Sensory evaluation of the trained panel

Table 1 summarizes the effect of slaughter age and finishing diet on the sensory attributes evaluated by the trained panel. Both, SA and FD showed a small influence on them. Meat from 13M and 26M groups showed similar intensity values for flavour and tenderness attributes, reaching medium scores of 5.84 and 4.61, respectively. They also showed similar intensity values for fat odour, fat flavour and greasiness variables, which reached low scores (2.91, 2.78 and 2.44 on average, respectively). Significant interactions between the main categories (SA × FD) were found by odour (p<0.05) and fibrousness (p<0.01) attributes. On the other hand, samples from 13M group presented the highest odour scores due to linseed supplementation (5.81 *vs*. 5.26, for LC and SC groups, respectively), whereas samples from 26M groups showed an opposite behaviour (6.02 *vs*. 6.24, for LC and SC groups, respectively).

With regard to fibrousness, their scores decreased with linseed supplementation in samples from 13M group (5.40 *vs*. 4.62, for SC and LC groups, respectively), whereas they increased in samples from 26M groups (4.82 *vs*. 5.14, for SC and LC groups, respectively). According to slaughter age, scores for odour (p<0.001) and juiciness (p<0.05) attributes of samples from 13M group were lower than those obtained for older animals. Regarding finishing diet, only juiciness showed significant (p<0.01) differences, presenting higher values in LC than in SC group. Finally, the negative correlation found between the Warner-Batzler shear force (WBSF) values and the tenderness (r=-0.30; p<0.05), indicate that higher WBSF values result in low tenderness scores.

Consumers panel information and sensory evaluation

Table 2 describes the sociodemographic consumer profiles in the two cities and the information scenarios according to gender, age, education and incomes. An equalized percentage of men and women was reached in both cities, more than 65% of them between 20 and 50 years old. The majority of the tasters (> 70%) had a university degree and around 40% showed incomes from 1.500 to 3.000€. Meat consumption was relatively high, with over 70% of consumers eating chicken, pork and beef meat once per week or more, as opposed to the consumption of foal meat, as mentioned above.

No significant interactions were found among the main factors: slaughter age, finishing diet and information scenario (SA × FD × S) (p>0.05) (Table 3). Generally, in both cities, the meat from 13M foals was better evaluated than the samples from 26M, showing significant (p<0.05) differences for tenderness and juiciness attributes. Regarding linseed supplementation, no significant differences were found for the finishing

Table 1. Trained panelists' scores[a] for sensory attributes (mean and SEM). Effect of slaughter age (SA) (13 *vs.* 26 months) and finishing diet (FD) (standard *vs.* linseed-rich concentrate).

	Slaughter age		Finishing diet			*p*-value		
	13M	26M	Standard	Linseed	SEM	SA	FD	SA × FD
Characteristic odor	5.54±0.47	6.13±0.23	5.76±0.53	5.92±0.37	0.12	0.001	0.348	0.027
Characteristic flavor	5.85±0.32	5.83±0.44	5.81±0.37	5.87±0.39	0.12	0.915	0.727	0.300
Fat odor	3.03±0.55	2.79±0.37	2.89±0.51	2.93±0.45	0.12	0.159	0.789	0.249
Fat flavor	2.69±0.42	2.87±0.55	2.74±0.52	2.81±0.46	0.12	0.320	0.687	0.725
Tenderness	4.56±0.71	4.45±0.63	4.31±0.94	4.70±0.65	0.15	0.600	0.077	0.907
Juiciness	3.74±0.59	4.11±0.66	3.67±0.63	4.19±0.65	0.13	0.041	0.004	0.190
Fibrousness	5.01±0.74	4.98±0.65	5.11±0.40	4.88±0.51	0.14	0.869	0.259	0.007
Greasiness	2.47±0.44	2.40±0.46	2.43±0.54	2.44±0.34	0.11	0.645	0.957	0.054

	13M		26M	
	Standard	Linseed	Standard	Linseed
Characteristic odor[b]	5.26	5.81	6.24	6.02
Fibrousness[b]	5.40	4.62	4.82	5.14

[a] Scale: 0 to 10 (low intense perception to high intense perception). [b] Supplementary data due to effects interaction.

Table 2. Market experiment design. General description of the consumer sample by information scenario in two Spanish cities (mean percentages).

	Pamplona		Ourense	
	Blind (n=125)	Full (n=122)	Blind (n=118)	Full (n=109)
Gender				
Male	56.67	43.97	50.43	43.93
Female	43.33	56.03	49.57	56.07
Age (years)				
20-30	24.59	49.14	47.46	55.05
35-50	39.34	31.03	33.05	28.44
51-65	22.13	17.24	15.25	13.76
>65	13.93	2.59	4.24	2.75
Education				
High	70.25	76.07	75.42	71.96
Secondary	23.97	17.09	16.10	19.63
Elementary	5.76	6.84	8.47	8.41
Income				
Low	2.65	3.66	5.54	5.05
Modest	16.81	7.32	27.69	38.39
Medium	44.25	45.76	46.16	45.46
High	36.28	35.69	20.31	14.14

diet effect neither in Pamplona nor in Ourense. The given information described a high and positive effect on almost all attributes (except for sweetness) and general acceptance (p<0.01) in Pamplona, but not in Ourense.

Figures 1 and 2 represent the consumers' evaluation in Pamplona and in Ourense. All the scenario showed a positive correlation with the values assigned for every attribute and in both cities were in the range of 5-6 ("Neither like nor dislike"-"Like slightly").

Table 4 displays the Pearson's (r) coefficients of correlation between the mean scores of sensory attributes. There were positive correlations in both information scenarios. The attributes with higher effect on the overall acceptability of foal meat were juiciness (0.91<r<0.73), tenderness (0.97<r<0.84), and flavour (0.97<r<0.65) (p<0.01), for samples from 13M and 26M groups, respectively with or without complementary information. The highest correlations between overall acceptability and juiciness, tenderness and flavour scores were obtained in samples from 26M group. It should be mentioned that negative correlations were found between WBSF and tenderness (r=-0.78; p<0.01), juiciness (r=-0.66; p<0.05) and overall acceptability (r=-0.73; p<0.05). Nevertheless, only the full information scenario described lower sensory scores with higher WBSF values. The tenderness and juiciness of 26M samples in the full information scenario showed a positive correlation with the IMF content (r=0.68, r=0.67; p<0.05, for tenderness and juiciness, respectively).

The relationship between the trained and consumer panel and the physico-chemical characteristics is shown in Figure 3. The PC1, related to consumers' evaluation, explained 35% of the variability, whereas the PC2, related to trained panel evaluation, explained 21% of the variability. Finally, the PC3 (15% of the variability) was related to physico-chemical parameters (WBSF, CL, moisture and IMF content).

Discussion

Sensory evaluation of the trained panel

The lack of sensory studies regarding foal meat makes difficult to stablish comparisons with other works. In addition, it could be remarked that there are not numerous differences according to slaughter age or finishing diet. Regarding the differences found by slaughter age for odour and juiciness scores, lower in meat from 13M group than in those from older animals, Sarriés & Beriain (2005) are in disagreement as they described that meat from 16M foals was juicer than meat from 26M foals, whereas the odour attribute was similar in both age groups. The higher scores for odour and juiciness attributes found in samples from 26M group compared to those obtained in 13M group could be due to the higher IMF content of older animals (Domínguez *et al*., 2018). Regarding finishing diet, only juiciness showed significant differences, presenting higher values in LC than in SC group. This fact could be related to lower cooking loss values of samples from foals supplemented with linseed, as also stated by Domínguez *et al*. (2018).

The negative correlation found between the WBSF values and the tenderness has been also reported by Franco *et al*. (2011) in foals slaughtered at 9 and 12 months of age. Nevertheless, despite WBSF values were different between 13M and 26M samples (Table 1 [suppl]), the trained panel was not able to appreciate any difference according to tenderness.

Consumer panel information and sensory evaluation

Regarding the interactions found among the main factors, Ruiz *et al*. (2018) did not find any significant differences either between slaughter age and finishing diet.

Table 3. Consumer scores[a] for aroma, flavor, tenderness, juiciness, sweetness and acceptance of foal meat in two Spanish cities (Pamplona and Orense). Effect of slaughter age (SA) (13 *vs.* 26 months), finishing diet (FD) (standard *vs.* linseed-rich concentrate) and information scenario (S) (blind *vs.* full) (mean and SEM).

	Aroma	**Flavor**	**Tenderness**	**Juiciness**	**Sweetness**	**Acceptance**
			Pamplona			
Slaughter age						
13M	5.51±0.42	5.57±0.38	5.76±0.55	5.61±0.50	5.76±0.60	5.65±0.29
26M	5.66±0.32	5.51±0.66	5.03±0.87	5.14±0.64	5.70±0.74	5.36±0.60
SEM	0.09	0.10	0.14	0.13	0.13	0.10
Finishing diet						
Standard	5.59±0.35	5.65±0.33	5.44±0.54	5.45±0.49	5.77±0.59	5.60±0.32
Linseed	5.57±0.38	5.44±0.51	5.35±0.65	5.31±0.80	5.69±0.76	5.41±0.51
SEM	0.10	0.10	0.15	0.14	0.14	0.10
Scenario						
Blind	5.40±0.39	5.38±0.26	5.14±0.61	5.13±0.51	5.64±0.60	5.30±0.32
Full	5.82±0.36	5.76±0.69	5.73±0.52	5.71±0.80	5.85±0.74	5.78±0.63
SEM	0.09	0.10	0.15	0.13	0.13	0.10
p-value						
SA	0.285	0.675	0.001	0.018	0.056	0.753
FD	0.877	0.154	0.692	0.477	0.221	0.685
S	0.002	0.009	0.007	0.003	0.298	0.001
			Orense			
Slaughter age						
13M	5.51±0.34	5.45±0.52	5.80±0.54	5.53±0.36	4.94±1.79	5.59±0.47
26M	5.28±0.48	5.25±0.72	4.98±0.74	4.77±0.64	4.96±0.69	5.18±0.59
SEM	0.08	0.12	0.16	0.15	0.25	0.12
Finishing diet						
Standard	5.50±0.35	5.45±0.52	5.26±0.48	5.11±0.38	5.01±0.89	5.41±0.60
Linseed	5.29±0.49	5.26±0.72	5.52±0.71	5.18±0.89	4.89±1.69	5.36±0.74
SEM	0.08	0.12	0.17	0.16	0.25	0.13
Scenario						
Blind	5.48±0.35	5.24±0.59	5.42±0.73	5.12±0.74	4.79±0.86	5.31±0.69
Full	5.30±0.36	5.48±0.61	5.35±0.72	5.17±0.75	5.14±1.67	5.47±0.73
SEM	0.08	0.12	0.18	0.17	0.22	0.13
p-value						
SA	0.047	0.254	0.001	0.001	0.025	0.952
FD	0.064	0.282	0.302	0.796	0.785	0.748
S	0.135	0.167	0.803	0.840	0.406	0.328

In both cities, tenderness and juiciness were key attributes better valued in 13M foals than 26M. The higher juiciness described in the younger group could be related to the higher moisture and lower cooking loss values found in samples from 13M group compared to the other one, as it was shown in Dominguez *et al.* (2018) (Table S1 [suppl.]).

The absence of significant differences for the finishing diet neither in Pamplona nor in Ourense could be due to the low linseed percentage included in the finishing diet (5%) and the short time of the fattening period (Domínguez *et al.*, 2018), that did not lead to a sensory noticeable difference between groups.

Regarding the information scenarios, the provided information described a high and positive effect on almost all attributes in Pamplona, but not in Ourense. These results showed differences regarding consumption habits and the information level importance among different

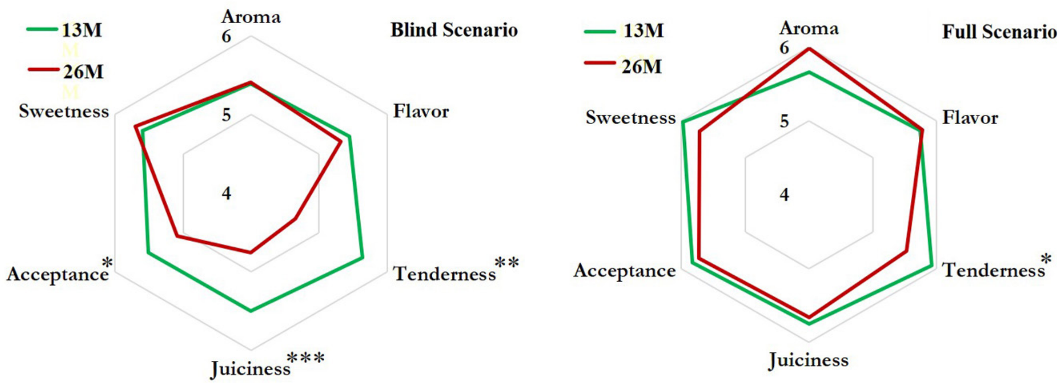

Figure 1. Consumers' scores for aroma, flavor, tenderness, juiciness, sweetness and acceptance of foal meat in Pamplona. Effect of the slaughter age (13 *vs.* 26-month old foals) (13M *vs.* 26M) under the blind (a) and full (b) scenario. Scale range: 4-6. *p<0.05, **p<0.01, ***p<0.001.

cities or regions (Realini *et al*., 2013; Kallas *et al*., 2014). In this regard, Resano & Sanjuán (2017) stated that differences between regions should be taken into account when marketing strategies are being developed for the meat market. Besides, Lusk & Fox (2001) highlighted the importance of defining the relevance of the different types of information (origin, diet, age, safety, animal welfare, etc.) to identify the major aspects impacting consumer behaviour when developing marketing or branding strategies.

The outcomes provided by Figures 1 and 2 agree with results previously reported in beef meat (Beriain *et al*., 2014, 2016). Despite the greater familiarity of consumers in Pamplona with foal meat, similar scores were obtained in both cities (range between 4 and 6). Taking into account the lack of consumption habit of foal meat, noticeably marked in Ourense, these average assessment values could be a positive result from a future marketing perspective.

Table 4 displays the Pearson's (r) coefficients of correlation between the mean scores of sensory attributes. It reveals that there were positive correlations in both information scenarios. Thus, a higher score of one attribute had a positive impact on the scores of the other ones (Beriain *et al*., 2016). The importance of juiciness, tenderness and flavour on the overall acceptability was previously described by Beriain *et al*. (2016) in beef meat. The high correlations found between overall acceptability and juiciness, tenderness and flavour scores could be useful to explain the lower scores obtained for samples from 26M foals with respect to the youngest group, as consumers assessed samples from 26M group as lower tenderness (p<0.001) and juiciness (p<0.01). In spite of the negative correlations found between WBSF and tenderness, juiciness and overall acceptability, just the full information scenario described lower sensory scores with higher WBSF values.

Consumers were able to slightly perceive higher IMF content in 26M samples compared to 13M samples, even when the percentage (1.72 *vs*. 0.56, for 26M and 13M, respectively) was lower than 3%, which is the threshold stated by Savell & Cross (1988) to observe palatability differences in red meat. Thus, in spite of the correlations obtained, consumers did not give higher assessments to 26M than to 13M groups regarding tenderness or juiciness attributes. The results found in this study showed that tenderness and juiciness attributes were determining for consumers to accept foal meat. These results agree with those reported by Sánchez *et al*. (2012) and Beriain *et al*. (2016) in beef.

The results obtained in Figure 3 revealed not only the low relationship between the trained panel and consumers' attributes, but also the low relationship between the physico-chemical properties and the sensory attributes. Such a clear difference between the response

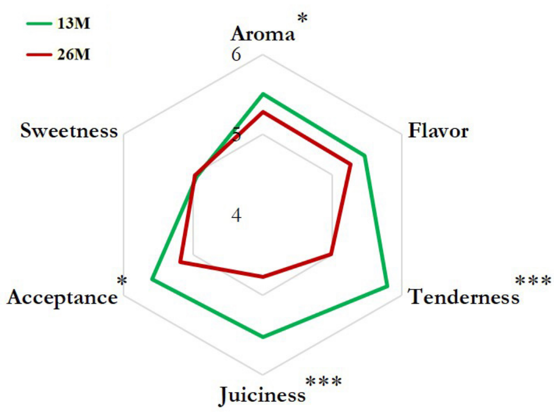

Figure 2. Consumers' scores for aroma, flavor, tenderness, juiciness, sweetness and acceptance of foal meat in Ourense. Effect of the slaughter age (13 *vs.* 26-month old foals) (13M *vs.* 26M). Scale range: 4-6. *p<0.05, **p<0.01, ***p<0.001.

Table 4. Correlation mean scores for hedonic attribute given by the panel of consumers, of the two types of meat (from 13 and 26-month old foals) in the two information scenarios (blind and full) and in the two Spanish cities (Pamplona and Ourense).

	Slaughter at 13 months				Slaughter at 26 months			
	Flavor	**Tenderness**	**Juiciness**	**Acceptance**	**Flavor**	**Tenderness**	**Juiciness**	**Acceptance**
Pamplona				**Blind Scenario (n=125)**				
Aroma	0.344	0.557*	0.460	0.552*	0.591*	0.506*	0.717**	0.611*
Flavor		0.361	0.173	0.650**		0.775**	0.641**	0.848**
Tenderness			0.856**	0.836**			0.793**	0.910**
Juiciness				0.808**				0.826**
				Full Scenario (n=122)				
Aroma	0.628*	-0.420	-0.105	0.163	0,655*	0.514	0.437	0.659*
Flavor		-0.015	0.203	0.679*		0.900**	0.816**	0.945**
Tenderness			0.850**	0.688*			0.871**	0.969**
Juiciness				0.800**				0.894**
Orense				**Blind Scenario (n=118)**				
Aroma	0.628*	0.390	0.511	0.769**	0,840**	0.749**	0.771**	0.781**
Flavor		0.311	0.591*	0.881**		0.966**	0.888**	0.966**
Tenderness			0.865**	0.632*			0.908**	0.958**
Juiciness				0.805**				0.903**
				Full Scenario (n=109)				
Aroma	0.335	-0.398	-0.445	0.098	0.684*	0.445	0.325	0.614*
Flavor		0.260	0.405	0.878**		0.733**	0.564	0.916**
Tenderness			0.895**	0.604*			0.944**	0.919**
Juiciness				0.730**				0.820**

* $p<0.05$, ** $p<0.01$, ns = non-significant ($p>0.05$).

of the expert panel and the consumer panel was not actually expected. These results evidence the lack of knowledge about foal meat and the need to further the sensory study of this type of meat. Deepening the results, the WBSF seemed to be positively related to fibrousness and negatively to the juiciness and tenderness evaluated by both, the trained panel and consumers. On the other hand, IMF content seemed to be slightly related to the greasiness and the fat flavour evaluated by the trained panel, but it was not related to the consumers' evaluation. Therefore, the trained panel was able to perceive the greasiness and the fat flavour and relate it positively to juiciness and tenderness, whereas consumers were not able to perceive the higher IMF content of the older foals (26M). This fact could help to explain the higher scores given by the trained panel to samples from 26M group in contrast to scores given by consumers. These results suggest that this type of meat obtains different results for a panel of experts who are qualified to evaluate meat objectively and for consumers. Consumers are affected, consciously and unconsciously, by multiple factors that make them value meat not only for its own characteristics but also for its perception, environment, culture, etc., which, in this sensory analysis, is not being taken into account.

Figure 3 confirms the results showed in Tables 1 and 3 according to sensory attributes. In general, the WBSF seemed to be positively related to fibrousness and negatively to the juiciness and tenderness evaluated by both, the trained panel and consumers. On the other hand, IMF content had not a significant influence on trained panel and the consumers' evaluation. While, the trained panel described little variation between the intrinsic attributes of meat from 13M and 26M foals, consumers clearly differentiated meat from 13M foals, giving an important role to tenderness and juiciness attributes. In contrast to the results of Beriain *et al*. (2014) in beef, this study showed barely any interesting correlation between the attributes defined by the panel of experts and the untrained consumers. Thus, beef is not fully comparable to foal meat. In addition, beef together with lamb and pork, has been widely studied and is very important in the meat sector (Belaunzaran *et al*., 2015). Therefore, further studies are necessary to obtain a deeper knowledge about the foal meat characteristics and consumers liking and perception.

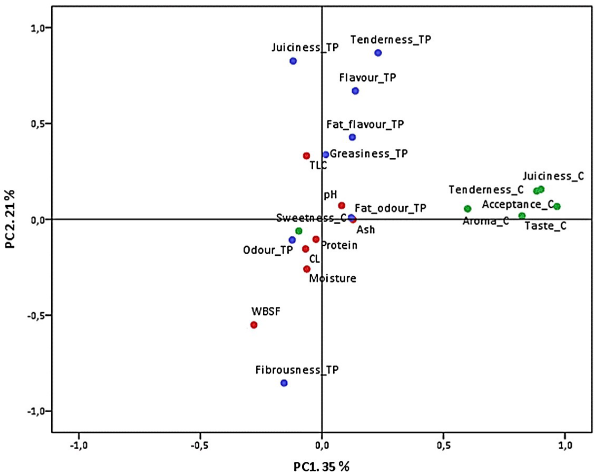

Figure 3. Biplot representation of principal components PC1 and PC2 studied on foal meat samples for the chemical parameters and the sensory attributes evaluated by the trained panel (TP) and consumers (C). TLC: total lipid content; CL: cooking loss; WBSF: Warner Bratzler shear force.

It can be concluded that slaughter age seemed to be slightly important factor for the trained panel, whereas consumers noticeably preferred meat from younger foals due to their higher juiciness and tenderness, which were the most important attributes correlated with the overall acceptability of foal meat. According to finishing diet, the linseed percentage in the finishing concentrate should be increased (above 5%) or the fattening period should be longer in order to perceive differences between the two groups studied. Finally, the lack of knowledge about foal meat and its low presence in meat markets make it necessary to develop further sensory studies to obtain better description patterns to get to understand consumers' likings.

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