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ABSTRACT

Most suckling kids are raised on farms oriented toward cheese production, and many goat farmers' rear kids with milk replacers. The aim of the current study was to investigate the consumer preferences for the visual appearance of meat from suckling kids reared with milk replacers or natural milk. Meat colour was the major criterion used to select meat. The meat of Cabra del Guadarrama reared with milk replacers was preferred by 72% of consumers and had a preferred lightness and hue angle. The rearing system did not influence preference through the time of display. Web-based surveys provided similar information to information recorded with live surveys using actual products instead of pictures. Meat colour appears to be a recurring intrinsic cue to assess consumer preference. In general, consumers preferred meat of light suckling kids reared on milk replacers because this meat had a high lightness and hue angle as well as a low chroma.

HIGHLIGHTS

- Meat colour was the major criterion used to choose meat.
- Rearing system did not influence consumer's preference through time of display.
- Consumers preferred meat with high lightness and hue angle, and low chroma.

Introduction

Consumer behaviour is complex and is determined by psychological, marketing and sensory factors, and visual appearance is one type of sensory factor (Font-i-Furnols and Guerrero 2014). The choice of meat at the point of purchase is determined by visual appearance characteristics, such as colour and marbling, because these intrinsic quality cues are highly related to expectations of meat quality (Banović et al. 2012). From these cues, the appearance of freshness and colour has been reported to be the most important (Bernués et al. 2012; Gracia and de Magistris 2013; Ripoll et al. 2018b). Meat colour is defined by the concentration and chemical state of the muscle pigment, which can be measured using the hue angle (h_{ab}) and chroma (C^*_{ab}) parameters of CIE L*a*b* (Renerre 1982). There are some studies relating CIE L*a*b* colour to consumer preferences, but most are focussed on beef

or heavy lambs (Khliji et al. 2010; Holman et al. 2016). However, consumer colour preferences are different when assessing red meat and light meat and consequently use different colour cues. Thus, consumers of heavy lambs preferred the reddest meat (Khliji et al. 2010), while consumers of light lambs preferred pale meat (Bernués et al. 2012; Ripoll et al. 2018b). In beef, a* provides the best prediction of the consumer acceptance of colour (Holman et al. 2016), while C^*_{ab} is an important indication of colour (Ripoll et al. 2012). Albertí et al. (2002) used an artificial intelligence algorithm to find a function yield a score beef from 1 (light pink meat) to 5 (dark red meat). The function found selected L* and h_{ab} as the most explanatory variables. Also, Liu et al. (1996) recommend the use of h_{ab} because it is precise and easily understandable. The relationship between consumers visual appraisal and instrumental colour remains unclear. However, in

order to gain greater knowledge on the subject, a study should be carried out with a greater variety of types of meat. Hence, L* is the most important CIE L*a*b parameter used for the consumer judgement of light suckling kid meat (Ripoll et al. 2018a). This meat is characterised by high L* and h_{ab} and low C^*_{ab} (Morales-De la Nuez et al. 2011; De Palo et al. 2015).

Spain is a great producer of kid meat, and 80% of this kid meat originates from the light suckling kid category (MAPAMA 2016). Most of the suckling kids are raised on milk farms oriented toward cheese production. When goats are suckling their kids, the milk protein and fat quantity and quality decrease (Caravaca et al. 2004). As a result, some goat farmers remove the kids from their dams at a very young age and rear them with milk replacers. However, some farmers still rear kids with their dams because they believe that the meat from suckled kids is more tender than the meat from kids reared on artificial suckling systems (Argüello et al. 2005). The proximate composition of milk could modify kid meat colour, and, consequently, this could affect the consumer preference (Ripoll et al. 2018a). Some studies have shown that the leg chops of kids reared with milk replacers were preferred by consumers because the meat was paler and dull, with a greater hue angle and a lower redness and chroma (Ripoll et al. 2018a).

Most of the studies examining consumer visual appraisal are carried out with real product; nevertheless, this technique is expensive and time-consuming, and, because of this, other techniques have been developed in recent years. Web-based surveys using pictures have been demonstrated as a valid method to relate the instrumental colour of meat to consumer visual appraisal (Holman et al. 2016). At the same time, the lack of representativeness of the studied population, which was the principal weakness of web surveys, is quickly disappearing each year as more people around the world gain internet access (Evans and Mathur 2005, 2018).

Consequently, the aim of the current study was to study consumer preference for the visual appearance of meat from suckling kids reared with milk replacers or natural milk as well as to determine the choice criteria used during the process.

Materials and methods

Carcase sampling

All procedures were conducted according to the guidelines of Directive 2010/63/EU on the protection of animals used for experimental and other scientific purposes (E.U. 2010).

Suckling male kids of the Cabra del Guadarrama, Majorera, Palmera, and Tinerfeña breeds reared with milk replacers (MR) or natural milk from their dams (NM) were selected from two farms for each breed. Sixteen kids per breed were fed NM; and 15 kids were fed MR for Guadarrama and Palmera while, and 16 kids were fed MR for Majorera and Tinerfeña. The kids were slaughtered following standard commercial procedures according to the European norms for the protection of animals at the time of killing (E.U. 2009). The kids had a live weight of 8.2 ± 0.1 kg and an age of 40–45 days old. A head-only electrical stunning (1.00 A) was applied to the kids, and they were then exsanguinated and dressed. The kids had an average hot carcase weight of 4.5 ± 0.1 kg. The carcases were hung by the Achilles tendon and chilled for 24 h at 4 °C in total darkness. The right hind leg was separated from the carcase, vacuum packed and stored at –20 °C until sampling.

Instrumental colour measurement of the chops

The shelf life of the meat of suckling lambs and kids is approximately one week (Alcalde et al. 2017). Because of the very small size of the kid legs, only four of the leg chops were sufficiently large enough to measure the colour of the different muscles. With these boundaries, we used a reversed storage design (Giménez et al. 2012). Hence, the 126 frozen legs were sliced into four 2-cm thick chops and assigned to 8, 6, 3, and 1 days before taking a picture (day 0). On the assigned day, the chops were thawed and placed in expanded polystyrene trays covered with retractile oxygen-permeable plastic film (water vapour permeability: 10 g m$^{-2}\cdot$24^{-1} h, oxygen transmission rate: 200 cm^3 m$^{-2}\cdot$24^{-1} h, CO$_2$ transmission rate: 650 cm^3 m$^{-2}\cdot$24^{-1} h; LINPAC Packaging Limited, Featherstone, UK). Then, the chops were stored for 24 h at 4 °C in total darkness until the day of picture capture.

Muscle colours were measured at 0% UV with an observer angle of 10° and zero and white calibration using a Minolta CM-2006d spectrophotometer (Konica Minolta Holdings, Inc., Osaka, Japan) in CIE L*a*b* 1986 space with the specular component included. The measurement area (diameter of 8 mm) was covered with a CM-A149 dust cover (Konica Minolta Holdings, Inc., Osaka, Japan). The illuminant used was D65. The lightness (L*), redness (a*) and yellowness (b*) indexes were recorded using the software

SpectraMagic NX (Minolta Co. Ltd., Osaka, Japan), and the hue angle $\left[h_{ab} = \tan^{-1}\left(\frac{b*}{a*}\right)\cdot\frac{180}{\pi}\right]$ and chroma $\left[C_{ab}^* = \sqrt{(a*)^2 + (b*)^2}\right]$ were calculated. The colour of the *semimembranosus*, *semitendinosus* and *biceps femoris* leg muscles were measured because they represent most of the chop area. Colour measurements were repeated three times, and the spectrophotometer was rotated on the horizontal plane before each measurement. The mean of the three readings was used for statistical analysis.

Capture of the images of the chops

Following each measurement, the chops were individually positioned in a Cubelite Lastolite portable studio (Vitec Imaging Distribution UK, Leicestershire, UK) above a black background. The studio was placed beneath two lightbulbs with five Cromalite bulbs (Cromalite S.L, Barcelona, Spain). Each lightbulb contained 28 W, 5.200 K, and 1.600 lm, delivering 1.200 average lx to the sample surface. An Olympus Pen E-PL1 12.3 Mpx camera with a M. Zuiko digital 14–42 mm 1:3.5–5.6 L lens (Olympus Imaging Corp., Shinjuku-ku, Tokyo) was placed overhead the sample with a tripod. The camera's exposure settings were manually adjusted to an ISO of 400, a lens aperture of F5.6 and a shutter speed of 1:125. All images were downloaded in raw format, and no flash, filters or other lenses were applied. Additionally, no other image editing or processing of manipulation was applied other than the cropping of the image.

When the chop colour was measured and all chops were photographed, an assortment of pictures was selected for the surveys. The chops with L*, h_{ab} and C_{ab}^* values representative of their breed and rearing systems were selected for visual appraisal by consumers. L*, h_{ab} and C_{ab}^* were chosen because these parameters are similar to the colour perception of human beings (Ripoll et al. 2012).

Survey design and dissemination

Two surveys were designed for this study. The geographical scope of the surveys was restricted to Spain, ruling out the responses of consumers from other countries. This study was conducted using an online survey service (www.encuestafacil.com), and the survey data were converted to an MS Excel sheet. The questionnaires were tested by researchers who may or may not have been involved in the study and adapted until the final version was approved. Moreover, a

compromise had to be reached between thoroughness, simplicity, and shortness.

The questionnaires were distributed using social media websites, university mailing lists and survey mailing lists. A divulgation message was included that asked receivers to further broadcast the web link to other persons in their respective electronic mailing lists. For those receivers willing to participate in the survey, the survey welcome page was immediately accessible after they clicked on the web link. The questionnaire was anonymous to guarantee a higher level of participation and honesty. Personal data, such as identification or electronic mail address, were not required, and there was no financial compensation. Participants were clearly informed of the aim of the study and gave implicit consent for the use of their supplied information in the research according to European regulations (U.E. 2010). This study was conducted according to the Declaration of Helsinki for studies on human subjects.

The surveys comprised several sets of pictures of chops from different rearing systems and times of display but of similar breeds, and the respondent had to choose the picture with their preferred chop. The effects of the rearing system and time of display were tested with the first survey (Survey RS + TD). This survey only used pictures of Cabra del Guadarrama, and eight sets of four pictures each were shown to respondents. The time of display was compared in four sets of pictures, and the rearing system within each time of display was compared in the other four sets of pictures. A second survey (Survey RS) was conducted to study the effect of the rearing system involving the four breeds at 1 days of display. Therefore, four sets of two pictures were shown, and consumers were asked to choose between the rearing systems within each breed. The chop shape and size were balanced within and between the picture sets. Questionnaire and pictures are shown in Supplementary Apppendix A. Both surveys had a common sociodemographic section. The information gathered in this section included gender (woman, man), age (<25 years, between 26 and 40 years, between 41 and 55 years, and >55 years), living environment, 'Have you ever tasted meat from light suckling kids?' (yes/no), and 'If the response is yes, do you like it?' (yes/no). A last question common for both surveys asked about the choice criteria used to select the picture of the preferred chop. The options were (a) meat colour, (b) fat colour, (c) meat brightness, (d) chop size, and (e) chop shape.

Statistical analysis

For both surveys, the χ^2 test was used to analyse the frequencies of consumer answers (gender, age, the criteria used to choose the pictures, the frequency of consumers who had previously tasted meat from light suckling kids, and the frequency of people who liked the meat from light suckling kids). Picture selection according the rearing system, time of display and breed were also tested using the χ^2 test, as were the criterion used for picture selection according to breed. The level of significance was 0.05. When one of the cells had a frequency of less than five, which makes the use of the χ^2 statistic unadvisable, the likelihood ratio statistic was used at the same probability level. To interpret the patterns of association between the studied variables, the corrected standardised residual between the observed and expected cases within each cell greater than $|1.96|$ was considered.

Instrumental colour variables were analysed with an analysis of variance with rearing system, muscle and breed as fixed effects. The Duncan test was used to compare means, and the level of significance was $p < .05$.

Results

Sample characterisation and the choice criteria used by consumers

The survey RS + TD, which investigated the effects of the rearing system and time of display, was completed by 186 consumers, and the survey RS, which investigated the effects of the rearing system, was completed by 399 consumers. The gender distributions in the RS + TD and RS surveys were similar ($\chi^2 = 0.02$; $p < .9$), with 59% and 60% women, respectively. Similarly, both surveys had the same distribution of ages ($\chi^2 = 3.2$; $p = .3$). There were 14% and 19% of people between 18 and 25 years, 30% and 29% of people between 26 and 40 years, 40% and 34% of people between 41 and 55 years and 17% and 18% of people older than 55 years in the RS + TD and RS surveys, respectively. Population of Spain were 51% woman, and there were 10% of people between 18 and 25 years, 27% of people between 26 and 40 years, 30% of people between 41 and 55 years and 25% of people older than 55 years (INE 2016). Therefore, younger people and older people were under- and over represented although both intermediate segments were well represented. Eighty-eight percent of the respondents had tasted meat from light suckling kids, and there was no difference in this number
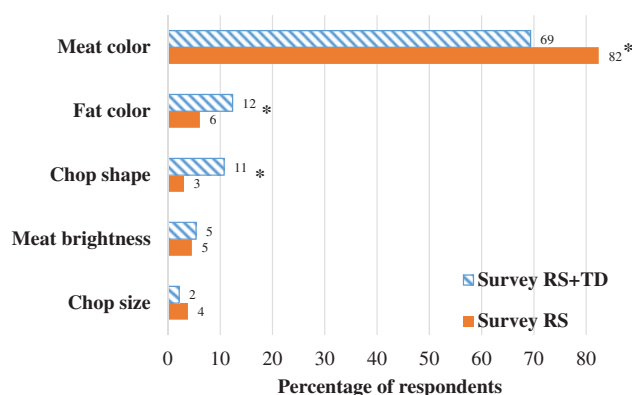

Figure 1. Choice criteria used by the respondents within each survey. Survey RS + TD compared the rearing systems and time of display, and survey RS compared the rearing systems. The distribution of frequencies of each survey was independent ($\chi^2 = 23.5$; $p < .001$). The observed frequencies with asterisks are significantly different ($p < .05$) between surveys.

between the surveys ($\chi^2 = 1.26$; $p = .3$). From these respondents, 94% confirmed that they liked this meat, also without differences between the surveys ($\chi^2 = 1.9$; $p = .2$).

The criteria used by the respondents to choose their preferred chops are shown in Figure 1. The choice criteria were different for each survey ($\chi^2 = 23.5$; $p < .001$), but meat colour was the major criterion for both surveys. A significantly higher percentage of respondents in survey RS (82%) used meat colour as a criterion than that in survey RS + TD (60%). However, more respondents of survey RS + TD used fat colour (12%) and chop shape (11%) as criterion than did the respondents of survey RS (6% and 3%, respectively). Meat brightness and chop size were less frequently used and did not show differences ($p > .05$) between the surveys, with 5% and 3% of respondents, respectively. The choice criterion was not conditioned by gender, age or the living environment of the consumer on both surveys ($p > .2$).

Consumer preference and the instrumental colour of the chops displayed for 8 days

The percentage of the chops preferred by the survey RS + TD respondents according to the rearing system and time of display are shown in Figure 2. The respondents similarly chose both rearing systems through the time of display ($p > .05$), but the rearing system and the time of display affected the percentage of preferred chops ($p < .0001$). The chops at 7 days of display were significantly less preferred ($p < .05$) than the chops at other display times. The chops displayed for 3 days were the most preferred, although this preference was not statistically relevant
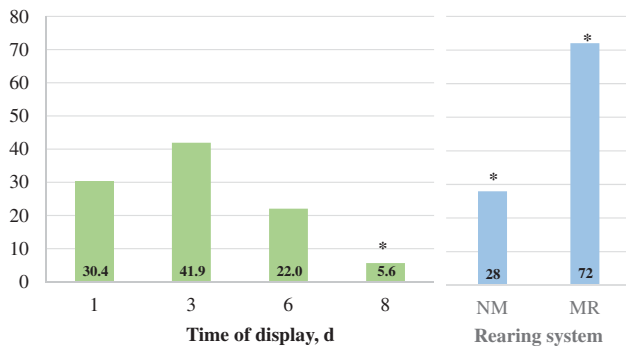
Figure 2. Percentage of the Cabra del Guadarrama chops preferred by consumers according to the time of display ($\chi^2 = 208.4$; $p < .0001$) and rearing system ($\chi^2 = 144.6$; $p < .0001$). NM, natural milk; MR, milk replacer. The observed frequencies with asterisks are significantly different ($p<.05$) from the expected frequencies.

($p > .05$). The chops from the kids fed MR were preferred in 72% of consumers, while 28% preferred the chops from the kids fed NM ($p < .0001$). The rearing system preference was not affected ($p > .4$) by age, gender, or the living environment of consumers at any time of display.

The instrumental colour of the chops shown to the consumers in survey RS + TD is shown in Table 1. There were no significant interactions between the studied effects ($p > .05$) for any variable. The rearing system affected all variables ($p < .05$). The meat from the kids fed MR had a greater L*, b* h_{ab} and a lower a* and C_{ab}^*. Therefore, the difference in colour between MR and NM was $\Delta E_{ab}^* = 4$. The time of display also affected all colour variables ($p < .05$). Lightness increased slightly from 1 to 8 days ($p < .05$). Conversely, redness decreased steadily over the time of display, with significant differences from 1 to 8 days ($p < .05$). Yellowness and hue angle showed similar patterns, with a slight decrease from 1 to 6 days ($p > .05$) and an increase from 6 to 8 days ($p < .05$). The chroma decreased from 3 to 6 days ($p < .05$) and increased from 6 to 8 days ($p < .05$). The three muscles had similar L* and a* ($p > .05$). The BF and SM muscles had similar b*, h_{ab} and C_{ab}^* ($p > .05$), while the ST muscle was different from both the BF and SM muscles ($p < .05$).

Consumer preference and the instrumental colour of the chops from the four breeds

The percentage of the chops preferred by the survey RS respondents according the rearing system and choice criteria are shown in Table 2. The total percentage of the selection of NM was higher (52.3%) than that of MR ($\chi^2 = 6.7$; $p = .009$). However, the

Table 1. Instrumental colour of the leg chops from the Cabra del Guadarrama kids reared with milk replacer (MR) or natural milk from their dams (NM).

	L*	a*	b*	h_{ab}	C_{ab}^*
Rearing system					
MR	42.70	7.34	6.77	40.85	10.80
NM	39.54	9.98	5.84	29.74	11.60
SE	0.395	0.254	0.254	1.291	0.260
Time of display					
1 day	40.30[b]	9.91[a]	6.71[ab]	34.31[ab]	12.14[a]
3 days	40.96[b]	8.86[ab]	6.11[ab]	34.39[ab]	10.95[a]
6 days	41.12[ab]	8.17[b]	5.43[b]	32.99[b]	9.95[b]
8 days	42.20[a]	8.49[b]	6.90[a]	39.35[a]	11.17[a]
SE	0.586	0.375	0.376	1.910	0.351
Muscle					
Biceps femoris	41.18	8.60	5.65[b]	32.86[y]	10.40[y]
Semimembranosus	40.59	8.74	5.94[b]	34.55[y]	10.66[y]
Semitendinosus	41.59	9.23	7.32[x]	38.48[x]	11.92[x]
SE	0.472	0.301	0.302	1.537	0.310
Significance[†]					
Rearing system	<0.001	<0.001	0.006	<0.001	0.001
Time of display	0.041	0.025	0.018	0.019	0.009
Muscle	0.283	0.265	<0.001	0.023	0.001

Pictures of these leg chops were used on survey RS + TD (rearing system and time of display).
a*: redness; b*: yellowness; C_{ab}^* : chroma; h_{ab} : hue angle; L*: lightness; SE: standard error.
[†]Interactions were not significant ($p > .05$).
Different superscripts (a and b) indicate significant differences between times of display ($p < .05$).
Different superscripts (x, y) indicate significant differences between muscles ($p < .05$).

$$h_{ab} = \tan^{-1}\left(\frac{b*}{a*}\right) \cdot \frac{180°}{\pi}; \quad C_{ab}^* = \sqrt{(a*)^2 + (b*)^2}$$

Table 2. Percentages of the preference for the rearing systems in the general sample ($\chi^2 = 84.1$; $p < .0001$) and the consumers that used meat colour ($\chi^2 = 80.4$; $p < .0001$) and fat colour ($\chi^2 = 13.0$; $p = .005$) as decision criteria.

	Choice criteria					
	General sample		Meat colour		Fat colour	
Breed	MR	NM	MR	NM	MR	NM
Cabra del Guadarrama	29.3	70.7*	26.5	73.5*	44.0	56.0
Majorera	48.1	51.9	48.5	51.5	32.0	68.0*
Palmera	60.4*	39.6	58.5*	41.5	80.0*	20.0
Tinerfeña	52.9*	47.1	53.0*	47.0	60.0*	40.0
Total	47.7	52.3	46.6	53.4	54.0	46.0

MR: milk replacer; NM: natural milk.
*Percentages higher from the expected ($p < .05$).

preference for the rearing system was not the same for each breed ($\chi^2 = 84.1$; $p < .0001$). As a result, consumers preferred the chops from the Cabra del Guadarrama fed NM and the chops from the Palmera and Tinerfeña fed MR ($p < .05$). There was no preference for the rearing system of Majorera ($p > .05$). The preference for the rearing system was not affected ($p > .5$) by age, gender, or the living environment of consumers at any time of display. However, the choice criteria also affected the percentage of preferred chops. Therefore, the consumer preference, using

meat colour as a criterion, was different according to the breed ($\chi^2 = 80.4$; $p < .0001$). Consumers also preferred the chops from the Cabra del Guadarrama fed NM and the chops from the Palmera and Tinerfeña fed MR ($p < .05$), but with different proportions than the total consumer sample. However, when considering fat colour ($\chi^2 = 13.0$; $p = .005$), consumers also preferred the Palmera and Tinerfeña fed MR ($p < .05$) but preferred the Majorera fed NM ($p < .05$). Additionally, the consumers did not show a preference for any rearing systems when choosing the chops of Cabra del Guadarrama ($p > .05$). Finally, when considering meat brightness ($\chi^2 = 4.2$; $p = .2$), chop shape ($\chi^2 = 1.7$; $p = .6$) and chop size ($\chi^2 = 1.1$; $p = .8$), consumers did not prefer one rearing system more than another.

The instrumental colour at 1 day of display of the chops shown to the consumers in survey RS is shown in Table 3. There were no significant interactions between the studied effects ($p > .05$) for any variable. The rearing system affected all variables ($p < .05$) except b* ($p = .4$). The meat from the kids fed MR had a greater L*, b*, h_{ab}, and a lower a* and C_{ab}^*. Therefore, the difference in the colour between MR and NM was $\Delta E_{ab}^* = 2.4$. In general, these results are consistent with those of survey RS + TD. The breed affected all variables ($p < .05$). Cabra del Guadarrama was clearly different compared with the other breeds because they had a lower L, b*, and h_{ab}, and a higher a and C_{ab}^* ($P < 0.05$). Majorera, Tinerfeña and Palmera had similar b* and h_{ab} ($P > 0.05$). Majorera and Palmera had different L*, a*, and C_{ab}^* ($p < .05$), while Tinerfeña had intermediate values among the breeds ($p > .05$). There were differences in L*, b*, and C_{ab}^* ($p < .05$) between the muscles. As in the results noted when chops were shown to consumers in survey RS + TD, the differences between the SM and BF muscles were higher than the differences between the BF and SM. Hence, ST had a higher L*, a*, and C_{ab}^* ($p < .05$) than SM, while BF had intermediate values of C_{ab}^* ($p > .05$) and similar values of L* and b* to SM ($p > .05$).

Discussion

There is a well-founded consensus in the literature that the principal criterion used in meat choice is colour due to its relationship with freshness (Kubberød et al. 2002; Bernués et al. 2012; Gracia and de Magistris 2013; Ripoll et al. 2018b). However, visible fat content is also a main cue used to assess meat quality (Kubberød et al. 2002; Banović et al. 2016). Nevertheless, meat from light suckling kids has no

Table 3. Instrumental colour of the leg chops from the kids of the four breeds reared with milk replacer (MR) or natural milk from their dams (NM) at 1 days of display.

	L*	a*	b*	h_{ab}	C_{ab}^*
Rearing system					
MR	45.48	6.03	8.22	54.89	10.45
NM	43.59	7.54	8.00	47.44	11.32
SE	0.462	0.337	0.225	1.770	0.240
Breed					
Cabra del Guadarrama	40.27[c]	9.88[a]	6.68[b]	34.34[b]	12.04[a]
Majorera	45.07[b]	6.53[b]	8.74[a]	53.52[a]	11.02[b]
Palmera	46.87[a]	4.95[c]	8.31[a]	59.98[a]	9.87[c]
Tinerfeña	45.93[ab]	5.78[bc]	8.60[a]	56.82[a]	10.59[bc]
SE	0.618	0.466	0.307	2.494	1.5630
Muscle					
Biceps femoris	44.15[y]	7.05	8.09[y]	50.04	11.01[xy]
Semimembranosus	43.53[y]	6.77	7.17[z]	48.23	10.24[y]
Semitendinosus	45.92[x]	6.54	9.01[x]	55.22	11.41[x]
SE	0.350	0.397	0.174	2.122	0.288
Significance†					
Rearing system	0.003	0.002	0.400	0.040	0.014
Breed	<0.001	<0.001	<0.001	<0.001	<0.001
Muscle	0.006	0.664	<0.001	0.060	0.017

Pictures of these leg chops were used on survey RS (rearing system).
a*: redness; b*: yellowness; C_{ab}^*: chroma; h_{ab}: hue angle; L*: lightness; SE: standard error.
[†]Interactions were not significant ($p > .05$).
Different superscripts (a, b, and c) indicate significant differences between times of display ($p < .05$).
Different superscripts (x, y, and z) indicate significant differences between muscles ($p < .05$).

$$h_{ab} = \tan^{-1}\left(\frac{b*}{a*}\right) \cdot \frac{180°}{\pi}; \quad C_{ab}^* = \sqrt{(a*)^2 + (b*)^2}$$

apparent fat. Consequently, in both surveys, colour was the most important cue. Meat from light suckling kids has high L* and low a* and b* values. Therefore, this meat is lighter, paler and duller (Morales-De la Nuez et al. 2011; De Palo et al. 2015) than the meat of heavy suckling kids (Ozcan et al. 2014; Yakan et al. 2016) and of concentrate-fed kids (Emami et al. 2015). Because of this paleness, it could be expected that 'meat brightness' was used as a criterion by more consumers, as L* (lightness) has been reported as the main colour variable used by consumers to assess suckling kid meat (Ripoll et al. 2018a). In addition to L*, consumers assessed the appearance of the whole chop rather than the individual muscles and focussed on h_{ab} (Ripoll et al. 2018a). The relationship between the visual appraisal of meat colour and L* has been reported previously (Eikelenboom et al. 1992; Denoyelle and Berny 1999; Hulsegge et al. 2001). In contrast, b* is not naturally associated with meat colour (Mancini et al. 2005; Ripoll et al. 2012), and its use by human beings is unclear (O'Sullivan et al. 2003). Khliji et al. (2010) only used L* and a* to score lamb meat. Holman et al. (2017) reported a* as the best predictor of consumer acceptance of beef, but h_{ab} and C_{ab}^* increased the prediction precision.

The results of survey RS + TD showed a clear preference of consumers for MR meat, demonstrating that the kid meat with greater L^* and h_{ab} and low C_{ab}^* is preferred. However, survey RS was not so clear because the difference in colour (Δ_{ab}^*) between the rearing systems was considerably higher for survey RS + TD ($\Delta_{ab}^*=4.0$) than that for survey RS ($\Delta_{ab}^*=2.4$). This latter colour difference is close to the concept of the 'just noticeable difference' between two stimuli reported by some authors (Stokes et al. 1992; ISO 2004). However, defining a visually detectable threshold is difficult because it depends largely on where the two compared colours are located in the colour space (Lee 2005). Abril et al. (2001) reported that Δ_{ab}^* for beef >0.9 were visually detectible. However, theoretically, when Δ_{ab}^* is below 2.2, the stimuli are not discriminable different from each other (Stokes et al. 1992). Other authors reported that Δ_{ab}^* below 1 is imperceptible and differences between 1 and 4 may or may not be perceptible (Ebner 2007). Also is important the physical and temporal distance between the stimuli (Wyszecki and Stiles 1982). In fact, Babiker et al. (1990) reported that goat and lamb meat with $\Delta_{ab}^*=1.97$ was not detected by consumers when not are showed together. Carrasco et al. (2009) reported that trained evaluators were not able to differentiate fat colours with $\Delta_{ab}^*=5.2$ because colour stimuli were not evaluated next to each other. In addition, the rearing systems compared on survey RS had values of L^* above 40.77, which has been reported as the first threshold to assess suckling kid meat (Ripoll et al. 2018a). Therefore, according to these latter authors, both rearing systems would achieve similar visual appraisal.

Diet strongly affects the meat colour of preruminants, such as suckling lambs and kids (Joy et al. 2012; Ozcan et al. 2014). Meat lightness is influenced by pH and protein structures (MacDougall 1982) more than diet (Renerre 1982). Hence, some authors reported that milk replacers do not affect the L^* of fresh kid meat, independent of the measured muscle (Bañón et al. 2006; Zurita-Herrera et al. 2013; De Palo et al. 2015). However, in agreement with Ripoll et al. (2018a), frozen/thawed meat could show a different behaviour due to the denaturalisation of sarcoplasmic proteins. In agreement with our results, De Palo et al. (2015) found that the meat of kids fed with natural milk had lower b^* and h_{ab} than that of those fed with milk replacers. Additionally, the authors also did not find differences in C_{ab}^*. Compared with the use of natural goat milk, the use of milk replacers affects the

colour of the *semimembranosus* muscle by decreasing b^* (Zurita-Herrera et al. 2013). However, the composition of goat milk is dependent on the feeding/management system of the goats (Raynal-Ljutovac et al. 2008), and this influences the colour of meat, especially a^*. Some authors explained that the meat from kids reared with natural milk has lower a^* and greater h_{ab} because natural goat milk of is poor in Fe (Sañudo et al. 2012). However, a higher level of Fe was found in the kids fed with milk replacer (Wittek 2002). In contrast with the Fe insufficiency, Bañón et al. (2006) and Argüello et al. (2005) reported that the meat from kids reared with MR had greater h_{ab} and the same L^* as those reared with NM, but the results disagree concerning C_{ab}^*. Zurita-Herrera et al. (2013) reported the same L^*, a^*, and b^* in both rearing systems.

To our current knowledge, there are no studies in the literature examining the visual appraisal or purchase intentions of kid meat through times of display. However, some authors have reported that consumers significantly reject the meat of light (Panea et al. 2005; Joy et al. 2012) or heavy lambs after 5 days (Kennedy et al. 2004). Meat discolouration is important because discoloured meat cannot be easily sold (Liu et al. 1995). Meat discolouration is produced during storage as deoxymyoglobin is converted to metmyoglobin. A stronger relationship between visual assessment and h_{ab}, C_{ab}^* and the a^* to b^* ratio has been reported, rather than with the standalone trichromatic coordinates (Lee et al. 2005; Morrissey et al. 2008; Ripoll et al. 2012). Therefore, increases in h_{ab} and decreases in C_{ab}^* have been used as indicators of red meat discolouration (MacDougall 1982; Albertí et al. 2005; Lee et al. 2005; Ripoll et al. 2011, 2012; De Palo et al. 2015; Holman et al. 2017). The browning of beef has been related to the decrease of chroma (Renerre and Mazuel 1985). This finding is in agreement with the results of our study, as the discolouration of the kid meat and the rejection from consumers were related to a decrease of C_{ab}^* rather than h_{ab} due to the paleness of this type of meat. However, Ozcan et al. (2014) studied the meat colour of Gokceada suckling kids and concluded that while a^* and b^* seemed to not change from 1 to 5 days, L^* decreased slightly. Morales-De la Nuez et al. (2011) did not report changes in L^* and a^* of the meat from Majorera kids stored for 7 days; however, b^* and h_{ab} increased while C_{ab}^* decreased. The changes in h_{ab} and C_{ab}^* observed with storage time can be a result of myoglobin oxidation to metmyoglobin and the loss of heminic pigments due to the freeze/thaw process.

Conclusions

The just noticeable difference in the consumer colour detection was similar when the consumer assessed pictures of meat instead of actual meat samples. Consequently, web-based surveys provided similar information compared with surveys using actual product instead of pictures. Meat colour appears as a recurring cue to assess consumer preference, and this cue is used consistently across the sociodemographic characteristics of the consumer. However, a minority of consumers choose other kinds of meat because they use other cues, such as fat colour and chop shape/size.

In general, consumers preferred the meat of light suckling kids reared on milk replacers because this meat has an increased lightness, hue angle and low chroma. However, when the meat of both rearing systems has lightness levels above 40.77 and small differences in colour, the consumer preference for a rearing system is dependent on the breed. Finally, the relationship between instrumental colour of meat and consumer visual appraisal remains unclear, especially in suckling light goat kids because the literature focussed on this topic is scarce.

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