Escuela Técnica Superior de Ingeniería Agronómica

Departamento de Ciencias Agroforestales

Escuela Técnica Superior de Ingeniería

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TESIS DOCTORAL

CALIDAD DE LA CANAL Y DE LA CARNE DE CABRITOS DE LAS RAZAS AUTÓCTONAS PAYOYA Y BLANCA ANDALUZA EN SISTEMAS DE PASTOREO

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Sevilla, Febrero de 2016

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CALIDAD DE LA CANAL Y DE LA CARNE DE CABRITOS DE LAS RAZAS AUTÓCTONAS PAYOYA Y BLANCA ANDALUZA EN SISTEMAS DE PASTOREO

MEMORIA DE TESIS DOCTORAL

Para aspirar al grado de doctor por la Universidad de Sevilla, presentada por el Licenciado en Veterinaria D. Francisco De la Vega Galán.

El Doctorando

Fdo: Francisco De la Vega Galán

Escuela Técnica Superior de Ingeniería Agronómica

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Que la Tesis Doctoral titulada: "CALIDAD DE LA CANAL Y DE LA CARNE DE CABRITOS DE LAS RAZAS AUTÓCTONAS PAYOYA Y BLANCA ANDALUZA EN SISTEMAS DE PASTOREO", que se recoge en la siguiente memoria y de la que es autor D. FRANCISCO DE LA VEGA GALÁN, licenciado en veterinaria, ha sido realizada bajo nuestra dirección, cumpliendo las condiciones exigidas para que la misma pueda optar al Grado de Doctor.

Lo que suscribimos como Directores de dicho trabajo y a los efectos oportunos en Sevilla a 13 de octubre de 2015.

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Programa de doctorado:
Zootecnia y Gestión Sostenible, Ovino y Caprino

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TÍTULO DE LA TESIS: CALIDAD DE LA CANAL Y DE LA CARNE DE CABRITOS DE LAS RAZAS AUTÓCTONAS PAYOYA Y BLANCA ANDALUZA EN SISTEMAS DE PASTOREO.

AUTOR: FRANCISCO DE LA VEGA GALÁN D.N.I.: 28.576.057 Y

INFORME RAZONADO DE LOS DIRECTORES DE LA TESIS.

Esta tesis se ha desarrollado correctamente en tiempo y en forma y ha dado lugar a dos artículos ya publicados y otros tres pendientes de publicación. El primer artículo ha sido publicado en 2013 en la revista Spanish Journal Agricultural Research, 11(3): 770-779. 2014 JCR (Thomson Reuters Web of Science): El factor de impacto es 0,703; 5-yr es 0,821. El segundo también ha sido publicado en 2013 en la misma revista Spanish Journal of Agricultural Research, 11(3): 759-769. No hay que destacar ninguna circunstancia desfavorable.

Por todo ello, se autoriza la presentación de la tesis doctoral.

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TÍTULO DE LA TESIS: **CALIDAD DE LA CANAL Y DE LA CARNE DE CABRITOS DE LAS RAZAS AUTÓCTONAS PAYOYA Y BLANCA ANDALUZA EN SISTEMAS DE PASTOREO**

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INFORME SOBRE LA IDONEIDAD DE LA PRESENTACIÓN DE LA TESIS POR COMPENDIO DE PUBLICACIONES

La Tesis Doctoral realizada es fruto de un trabajo de investigación que aborda y desarrolla distintos aspectos de la calidad de la canal y de la carne de cabritos de las razas Payoya y Blanca. La Tesis Doctoral se ha elaborado a modo de "**compendio de publicaciones**", estructurándose en los siguientes apartados:

- Resumen
- Abstract
- Introducción
- Objetivos: Se ha planteado un objetivo general y cinco objetivos específicos.
- Resultados: Los resultados son dos artículos que abordan los distintos estudios que han sido realizados para alcanzar cada uno de los objetivos específicos.

  - Artículo 1: "**Fatty acid composition of muscle and internal fat depots of organic and conventional Payoya goat kids**". El primer artículo ha sido publicado en 2013 en la revista Spanish Journal Agriculture Research, 11(3): 770-779.2014 JCR (Thomson Reuters Web of Science): Impact factor is 0.703; 5-yr IF is 0.821. Este artículo recoge los resultados del Estudio 3, que analiza la composición de ácidos grasos en el músculo y los depósitos grasos de cabritos de la raza Payoya.

  - Artículo 2: "**Fatty acid composition of muscle and adipose tissues of organic and conventional Blanca Andaluza suckling kids**". El segundo artículo también ha sido publicado en 2013 en la misma revista Spanish

Journal of Agricultural Research, 11(3): 759-769. Este artículo recoge los resultados del Estudio 3, que analiza la composición de ácidos grasos en el músculo y los depósitos grasos de cabritos de la raza Blanca Andaluza.

- Discusión global de los resultados obtenidos en las diferentes publicaciones que integran la Tesis Doctoral.
- Conclusiones.
- Bibliografía.

Así pues, además de los dos artículos que conforman esta Tesis Doctoral, hay otros tres artículos pendientes de publicación.

En resumen, consideramos que la originalidad, grado de innovación y calidad científica de la Tesis Doctoral que se presenta es indudable, y por todo ello, autorizamos la Presentación y Defensa de esta Tesis Doctoral bajo la modalidad de “**compendio de publicaciones**”, para obtener el grado de **Doctor.**

Sevilla, a 13 de Octubre de 2015

Firma de los directores:

Dr. José Luis Guzman Guerrero   Dr. Manuel Delgado Pertíñez   Dr. Luis Ángel Zarazaga Garcés

VºBº de la Directora del Departamento responsable del Programa de Doctorado:

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Los trabajos experimentales que conforman la presente Tesis Doctoral han sido financiados por el Proyecto titulado:

Conversión de los sistemas de producción caprina de sierra a ganadería ecológica: potencialidad, viabilidad y estrategias de cambio (Proyecto nº 75).

Subproyecto nº 3: Caracterización de la calidad de la canal y de la carne de cabritos procedentes de ganaderías de razas autóctonas con sistema de producción ecológica.

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Proyecto nº 75, la Dra. Yolanda Mena Guerrero

Subproyecto nº 3, el Dr. José Luis Guzmán Guerrero

COPIA COMPLETA DE LOS TRABAJOS PENDIENTES DE PUBLICACIÓN

Trabajo nº1 (pendiente de publicación).

Carcass characteristics and instrumental meat quality of conventional and organic Payoya suckling kids.

Carcass characteristics and meat quality of conventional and organic Payoya suckling kids

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Topic: Animal production

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Received:

Abstract:

Initiatives exist in several countries in the Mediterranean area, allowing us to affirm that organic goat production, using sustainable production and management techniques, is viable. To determine the possibility of transformation to organic production system, a study is necessary analyzing the differences on quality of their products. The aim of this study was to evaluate the comparative carcass and meat quality of Payoya goat kids under organic and conventional grazing–based livestock production system. Twenty-four twin kids (12 males, 12 females) were selected from each system. Carcass quality and instrumental meat quality were studied.

Small significant differences were found only in a few parameters: slaughter live weight, hot carcass weight, cold carcass weight, empty body weight and farm dressing percentage were greater in conventional than in organic kids. However, shoulder, leg,

and first category were lower in conventional than in organic kids. Hot carcass weight, cool carcass weight and dressings percentages were greater in male than in female. The values of external carcass length ($P < 0.01$), chest depth and leg compactness index ($P < 0.05$) were higher in males than in females. Only there were differences for the production system and gender in three of the ten non-carcass components analyzed. Therefore it can be concluded thatconventional grazing–based management farms could easily be transformed into organic production.

Introduction

Spain belongs to the group of EU countries where goat production is remarkable. This livestock plays a key role in many rural areas, despite its reduced economic importance compared to other livestock species. The fastening of the population, maintenance of typical products such as cheese or meat, and its contribution to the environment are positive qualities that should promote strategies for their maintenance.

The goat farming in Andalusia is presented as a real alternative to mainstream productions, such as beef or pork, with an ecological function as they consume pastures in marginal areas, and a social function, because they serve employment for people living in rural areas where they could hardly make other productive activity.

In Spain there are 5,808 organic farms and Andalusia (in Southern Spain) contains the majority of these with 3,309 farms (MAGRAMA, 2013). Also, among countries in the European Union, Spain has the second highest goat head number (2.6 million) and Andalusia is the region with major census (35.7 % of the national total) (MAGRAMA, 2012) and also with the highest number (363) of goat herd organic farms (60 % of the national total); 276 of which are meat production farms and 87 are dairy farms (MAGRAMA, 2013). Also, initiatives exist in several countries in the Mediterranean Basin (Kyriazakis and Zervas. 2002), allowing us to affirm that organic goat production, using sustainable production and management techniques, is viable.

Organic production has grown rapidly in the European Union in the past few years, with Spain in first place in terms of ecologically cultivated surface. It is expected that both area and markets will continue to grow increasing demand, continued policy support and increasing research activities (Willer and Lernoud, 2014).

Moreover, interest in the preservation of autochthonous breeds, raised using extensive or semi-extensive grazing, has also recently increased among Spanish farmers and many of these breeds, such as the Payoya, are considered as endangered according to the Official Catalogue of Spanish Livestock Breeds (BOE, 2008). The main objective of these farms is the milk production. Converting these breeds to organic production should be straightforward owing to the adaptive capacity and disease resistance of autochthonous breeds and to the rustic environment and nutritional resources available in Andalusia's mountain zones.

According to organic production system requirements (Regulation CEE. 834/2007), mountain goat systems, in which feeding is largely based on grazing (Ruiz *et al*., 2008), could easily be transformed into organic production (Mena *et al*., 2009a, b). A study of the possibilities of transformation to organic production needs to analyze, not only the technical and economical viability of the organic production systems, but also the quality of their products, specially the suckling kids carcass and meat.

Therefore, the aim of this study was to evaluate the comparative carcass and meat quality of Payoya goat kids of both sexes, under organic and conventional grazing–based livestock production system.

Materials and methods

Study area, experimental farm goats and kids

All goats used in this study were of the Payoya breed and located in the Sierra Norte of Cádiz (Andalucía, Spain). There are four organic and twenty seven conventional farms currently working with this breed (Association of Payoya Breeders, unpublished data). To evaluate the technical and economical viability of organic and conventional dairy goat farms of the Andalusian mountains and analyze the transition from conventional to organic production, 18 farms (14 conventional; 4 organic) were selected in collaboration with the Association of Payoya Breeders (Mena *et al*., 2009a, b). Within those farms and for the present study, one farm from each management system (certified organic under EC 834/2007 [EC, 2007] and conventional) were selected. All procedures were performed by trained personnel in strict accordance with Spanish guidelines for the protection of experimental animals (BOE 2007). Twenty-four twin goat kids (12 males and 12 females) were selected from each farm during the same season. Kids had free access to dams but not to feedstuff.

The dams in both experimental farms were raised with similar semi-extensive system based on the grazing of natural pastures (Ríos-Castaño, 2008; Mena *et al.,* 2009a). The systems are characterized by a large land surface per animal, few sanitary problems, and grazing as an integral part of animal feeding, and the main difference is the major consumption of concentrates per animal and head in the conventional farm. In this sense and according to the previous technical characterization of the farms (Ríos-Castaño, 2008), a supplementary feed concentrate was added at a flat rate of 1.0 kg head^{-1} d^{-1} for the conventional farm and at 0.5 kg head^{-1} d^{-1} (organic constituents) for the organic farm (De La Vega *et al.,* 2013). On the rangeland, the diet was composed of herbaceous plant species and leaves and stems from Mediterranean shrubs and trees (mainly *Mirtus communis*, *Pistacia lentiscus*, *Quercus ilex, Cistus salvifolius* and *Arbutus unedo*).

Slaughter and post slaughter conditions

All goat kids were slaughtered at a body commercial weight of 8.40 ± 0.06 kg at the San Juan del Puerto (Huelva, Spain) municipality slaughterhouse, according to current EU regulations (Regulation (EC) No 1099/2009) after 16.33 ± 0.12 hours of fasting with free water access. After slaughtering, carcasses were kept in a chilling room at 4°C for 24 h and after chilling the carcasses were split down the dorsal midline and then the left half of each carcass was removed according to the procedure of Colomer-Rocher *et al*. (1987) and transported under refrigeration to Huelva's University.

Carcass quality

Farm live weight, slaughter live weight, carcass weight and subcutaneous fatness grade scores were measured and empty body weight, chilling losses and dressing percentage were calculated. Farm live weight (FLW) was recorded on the farms. Slaughter live weight (SLW) was recorded immediately prior to slaughter. Hot carcass weight (HCW) and weight of non carcass components (blood, skin, head, feet, heart, lungs and trachea, liver, spleen, thymus, full and empty gastro-intestinal tract gastro-intestinal tract) were recorded after slaughter. Gastrointestinal content was determined as the difference between full and empty gastrointestinal tract. Tail, kidneys, perirrenal and pelvic fats, and testes were retained in carcass. After chilling (24 h at 4ºC), cold carcass weights (CCW) and empty body weights (EBW) were recorded. Empty body weight was calculated by subtracting the weight of the gastrointestinal contents from SLW. Then, each carcass was evaluated for subcutaneous fatness (scale from 1= low to 5= very high) using the scoring system suggested by Colomer-Rocher *et al.* (1987).

Dressing carcass percentages and chilling losses were calculated as follows: farm dressing percentage (FDP)= 100 x (HCW/FLW); slaughter dressing percentage (SDP)= 100 x (HCW/SLW); commercial dressing percentage (CDP)= 100 x (CCW/SLW); real dressing percentage (RDP)= 100 x (HCW/EBW); biological dressing percentage (BDP)= 100 x (CCW/EBW); chilling losses (CH)= (HCW-CCW)x100/HCW.

Carcass linear measurements were measured based on standard protocols (Palsson & Verges, 1952; Boccard *et al*., 1958), including internal carcass length (L), external carcass length (K), leg length (F), buttock width (G), buttock perimeter (BG), chest depth (Th), thorax width (Wr), thoracic perimeter (PT). The indices from these carcass conformation measurements: relation carcass length/width L/G, relation depth/width, Th/G, relation carcass depth/length (Th/K), carcass compactness (CCW/L), leg compactness index (leg weight /F), chest roundness index (Wr/Th) and buttock/leg index (G/F), and osseo index (Os1+Os2/2).

After chilling, the left half of each carcass was weighed and physically dissected into five prime cuts (shoulder, flank, neck, ribs and long leg) according to Colomer-Rocher *et al.* (1987). Prime cuts were weighed and grouped into three categories: extra (long leg and ribs), first (shoulder) and second (neck and flank). Minor cuts (tail, testes, kidney, kidney fat and pelvic fat) were removed before jointing and weighed. All cuts were vacuum packed and frozen at -20ºC until analysis, except the ribs.

The shoulder, after thawing under chilling (4°C) for 24 h, was weighed and separated into dissectible fat (subcutaneous + intermuscular), muscle, bone and the remainder (major blood vessels, ligaments, tendons and thick connective tissue sheets associated with some muscles) in a dissection room under controlled environment. The muscle/ bone and muscle/ fat index were calculated. Freezing and dissection losses were calculated. Freezing (by weight difference before and after freezing) and dissection (by weight difference before dissection and the sum of the weights of its entire constituent after dissection) losses were calculated.

Meat sampling and analysis

The color, pH were evaluated at 0h, 45 minutes, 24 and 72h after slaughtering. The color was measured in *longissimus* muscle (4/5th lumbar vertebra) of the carcass left side, directly on muscle surface after removing, with a scalpel, connective tissue. All meat color variables: Lightness (L*), redness (a*), yellowness (b*) and the colorimetric indices of Chromaticity (C*) and Hue angle (Hº) was assessed according to the CIELAB color system (CIE, 1986) using a portable chromo-meter (Minolta CM-2002), which gives the average of three measurements. The pH was measured using a penetrating combined glass electrode with a pH-meter (Crison 25) at the same site as color.

After the rib joint was obtained and after chilling (24 h), the *longissimus* muscle was dissected. One sub-samples of *longissimus* muscle were taken (4/5th lumbar vertebra), and chilling (5ºC) for 48 h more, for determining color at 72 h after slaughter. The rest of the loin was vacuum packed and frozen at –20°C until analysis.

Once thawed *longissimus* muscle, under chilling (4°C) for 24 hours, cooking loss, shear force, water holding capacity (WHC) and haem pigments were analyzed. Cooking loss was evaluated in meat samples of similar geometry, individually weighed and packed vacuum in plastic bag in water bath at 75 °C for 30 min. Cooked samples were cooled at room temperature, were taken from the bags, dried with filter paper and reweighed. Cooking loss was expressed as the percentage of loss related to the initial weight.

After measurement of cooking loss, samples were used for objective tenderness determinations. The Warner–Bratzler shear force (WBSF) was measured in sub-samples (at least 3) of 1 cm^2 cross section with fibers perpendicular to the direction of the blade attached to a Stevens QTS 25 apparatus. Results were expressed in kg/cm^2.

Water holding capacity were determined according to Grau and Hamm (1953) as modified by Sierra (1973) and expressed as expelled juice percentage. Two repetitions were performed for each sample.

Haem pigments were measured according to Hornsey (1956) and expressed as mg myoglobin/ g fresh muscle. Two repetitions were performed for each sample.

Once thawed the shoulder and dissected was obtained *Triceps brachii* muscle, without intermuscular fat and tendons. After, were analyzed the amount of moisture, ash, crude protein and fat (AOAC, 2000).

Statistical analyzes

Differences in all studied parameters, except for pH and colorimetric parameters, were assessed by analysis of variance using the general linear model (GLM) of the IBM SPSS Statistics for Windows (version 22.0; IBM Corp., Armonk Nueva York, USA), including the fixed effects of production system and gender. The linear model used for each parameter was as follows:

$$Y_{ijk} = \mu + PS_i + G_j + (PS \times G)_{ij} + \varepsilon_{ijk}$$

Where Y_{ijk} = observations for dependent variables; μ = overall mean; PS_i = fixed effect of production system (i = organic system or conventional system); G_j = fixed effect of gender; PS × G = interactions between production system and gender, and ε_{ijk} = random effect of residual.

Colorimetric parameters and pH were analysed with the repeated measures procedure, including the fixed effects of production system and gender (within-subjects factors), time (intra-subject factor) and interactions among these factors. Pairwise comparisons of means were carried out, where appropriate, using Tukey's honest significant difference or least significant difference tests, considering a level of significance of 5 %.

Results

Carcass quality

Some of the conformation variables, dressing percentage and carcass morphology differed significantly among productions systems and gender (Table 1 and 2). The values of SLW, HCW, CCW ($P < 0.05$) and EBW, FDP ($P < 0.01$) were higher in conventional than in organic kids. Fast losses were higher in organic kids ($P < 0.001$). The values of HCW, CCW and all dressing percentages were higher in male than in female ($P < 0.05$). Regarding the linear measurement of the carcass and index (Table 2), the values of K ($P < 0.01$), Wr and Wr/Th ($P < 0.001$) were higher in carcass conventional kids. Instead, the values of Th ($P < 0.05$), Th/K ($P < 0.001$) and Th/G ($P <$

0.01) were greater in organic kids. In relation to gender, the values of K ($P < 0.01$), Th and Leg Weight/F ($P < 0.05$) were higher in male than in female. Non interaction was observed between both factors ($P > 0.05$) for either of the previous parameters.

There were significant differences among systems and gender for few offal components tested (Table 3). For conventional kids, percentage contributions to empty body weight of skin ($P < 0.05$) and thymus ($P < 0.01$) were significantly higher than for organic kids. Instead, percentage contributions to empty body weight of head ($P < 0.01$) were significantly lower for conventional kids than organic kids. Also, percentage contributions to empty body weight of feet ($P < 0.001$) were significantly higher for male, whereas that this percentage of blood ($P < 0.05$) and gastro intestinal tract ($P < 0.01$) were significantly lower. No interaction was observed between both factors ($P > 0.05$).

Percentages contributions of prime and minor cuts of carcasses in relation to half-carcass left side weight were affected by productions systems and gender (Table 4). Left half carcass weight and percentage contributions of flank and kidney were greater in conventional kids ($P < 0.01$). However, shoulder, leg, and first category were lower in conventional than in organic kids. Also, left half carcass ($P < 0.05$) were significantly greater in male, while percentage contributions of flank ($P < 0.01$) and perirenal fat ($P < 0.05$) were lower in male than in female (Table 4). No interaction was observed between both factors ($P > 0.05$).

Management system and gender of Payoya suckling kids differed significantly in their shoulder tissue compositions (Table 5). Intermuscular fat ($P < 0.01$), subcutaneous fat ($P < 0.05$) and other tissues ($P < 0.05$) were significantly greater in conventional kids. While muscle and bone ($P < 0.01$) and muscle/fat relation ($P < 0.001$) were significantly lower in conventional kids than organic kids. Also, other tissues and freezing loss ($P < 0.05$) were greater in male and nevertheless muscle and muscle/bone relation ($P < 0.01$) were lower. No interaction was observed between both factors ($P > 0.05$).

Meat quality

Regarding the chemical composition of the *Triceps brachii* muscle, management system did not affect any of the variables studied ($P > 0.05$) and gender only influences the intramuscular fat content ($P < 0.01$), showing a higher value in females (Table 6).

The management system and gender factors did not influence the rheological parameters studied ($P > 0.05$), except for WHC, showing interaction between both factors ($P < 0.001$) (Table 6). The meat of female kids of organic system show a higher value (17.00 ± 0.93%) than meat of conventional female kids (13.56 ± 0.95%), whereas there was no difference between the two production systems for the meat of male kids (Figure 1). As for pH, were not affected by production system and gender ($P > 0.05$), but were affected by the time of measures post slaughter ($P < 0.001$) (Table 7). Interaction was observed among gender and time for pH (Figure 2). A clear reduction of the pH of the meat goat is observed when post slaughter time progresses, but at 0 and 45' post slaughter the pH value was higher in males kids, while at 24h and 72h post slaughter there were not significant differences in the pH found between both sexes.

As regards the color measurements were observed individual effects of the factors gender and post slaughter time and joint effects (double interactions) production system with gender and post slaughter time (Table 7). There were significant differences by gender for color variables: L* showed higher values in male that female ($P < 0.05$), while a* value was higher in female ($P < 0.01$). The color variables a*, b* and Chroma were affected by the time ($P < 0.001$), experiencing a significant increase in their values when the post slaughter time increased from 0h to 24 h, and also when the post slaughter time increased from 24h to 72h, except for a*. The observed increase from 0h to 72 h post slaughter was 1.64, 5.72 and 5.4 units for a *, b * and Chroma, respectively.

Interaction was observed among production system and gender for b* ($P < 0.001$), Chroma ($P < 0.05$) and Hue ($P < 0.01$). In b*, there were significant differences among gender in conventional kids (9.68 ± 0.27 and 7.16 ± 0.27 for male and female kids, respectively) but not in organic kids, where both sexes showed lower values. In Chroma, there were significant differences among gender in organic kids (10.16 ± 0.33 and 11.37 ± 0.33 for male and female kids, respectively), but not in conventional kids. And, in Hue, there were not significant differences among gender in organic production system, although there were significant differences on conventional production system (55.6 ± 2.44 and 40.46 ± 2.44 for male and females, respectively).

Interaction was observed among production system and time post slaughter for L* (*P* < 0.001) and Hue (*P* < 0.001). In relation to L * (Figure 3), it was observed a higher mean value for the kids from conventional system at all times post-sacrifice, except for 24h, that was higher in organic kids. For the Hue (Figure 4) there were significant differences at 0h, 45´, y 24h between the two systems, with the higher values for kids from conventional system, and yet they there were no significant differences at 72h.

Discussion

Management system did have effect on some of the quality parameters of the carcass studied in this work (weights, dressing percentages, carcass linear measures and index, non-carcass components, percentage contribution of primal cuts of carcass and tissue composition) in Payoya kids slaughtered at a body weight of 8.40 ± 0.06 kg. In the current study, the kids were fed exclusively with milk by suckling their dams, and even though the suckled milk is the only factor that could influence these parameters, since neither the quantity nor the milk composition was monitored, this will have to be tested in future studies. However, it is important to indicate that feeding of the dams the main difference is the major consumption of concentrates per animal in the conventional farm (0.5 kg head^{-1} d^{-1} additional).

In the current study, although there was no difference in farm live weight between both studied livestock production system (conventional *vs*. organic), However the SLW, HCW, CCW, EBW and FDP were significantly higher in conventional kids that in the organic. Also in others works (Johnson y McGowan, 1998; Ryan et al., 2007; Safari et al., 2009; Mushi et al., 2009; Germano Costa et al., 2010; Liméa et al., 2012) the live weight, carcass weight and dressing were significantly higher with increasing the level of concentrate in the diet of the animals. However, in our study, the diet of the mothers was similar in both systems. As consequence the differences between production systems in the live weight could be due to greater losses caused by fasting before slaughter on the organic kids, that could be induced by a longer fast on these kids; moreover. One result that support this hypothesis it was that the gastrointestinal tract weight was the same in both systems kids.

The HCW and CCW were higher in the male kids, which in turn explain the higher dressing percentages also found in this gender. These differences could be explained by a greater contribution of the gastrointestinal tract weight, in the case of females, to the empty body weight (10.1% of females compared to 9.1% of males). In contrast, Peña et al. (2007) found no differences between the sexes for any of those parameters in Florida kids with similar slaughter live weight. Zurita Herrera et al. (2011) found no differences between sexes for HCW, CCW, CDP and RDP in Murciano-Granadina breed kids, with slaughter live weight slightly lower. The values of these parameters, found in this work are similar. These discrepancies could be due to the different used breeds used in each study.

Most linear measurements taken on the carcass have not been affected by the production system. Only K and Wr were lower and Th slightly higher in organic system carcass kids and, therefore, the Th/K and Th/G ratios were higher and the Wr/Th ratios lower in these same kids. Borghese et al. (1990) observed that animals raised in small pens have a shorter long leg length and Zurita Herrera et al. (2007, 2011) found lower values F, L and G in kids raised in the intensive system compared to other systems where kids accompanied their mothers during grazing. The values of these measures are similar to those found in our study.

The small differences observed in our study between both systems have a hard explanation, since all the kids were confined in a pen without accompany mothers during grazing and therefore the physical activity was similar and also all kids were slaughtered with similar ages/weights. In a similar study, Cutrignelli et al. (2007), with the aim of studying the influence of goat livestock systems (conventional vs. organic) on the performance of Cilentana kids they found that the measurements effected on living animals and carcasses on livestock were unaffected by the production system.

Genders not affect the most carcass linear Measures, only K, Th and leg compactness index were higher in male kids. These results are agreed with those found by Peña et al. (2007) in Florida kids with the same slaughter weight (7-8 kg). In this work only significant gender differences in HCW/L and leg compactness index (higher values in males) were found. In addition, the values found for most of the measures taken, in both studies were very similar.

Determination of the weight of the offal and non-carcass components is of interest because of their large contribution (> 50%) to maintenance energy expenditure (Ortigues, 1991). In our study, the percentage of non-constituent carcass components for suckling Payoya kids showed little variation for the different systems studied. According to our study, Germano Costa et al. (2010) they also found no significant differences in most of these components, between animals raised in intensive and extensive systems in Blanca Serrana Andaluza breed or Zurita et al. (2011), when comparing kids whit similar weight of Murciano-Granadina breed reared in intensive systems, semi-intensive or extensive. Cutrinelli et al. (2007), comparing the same livestock methods, found differences in the slaughter measurements (empty digestive tract, skin, liver + spleen, kidney + bladder). The values found by previous authors were very similar to those found in the present study.

Although the sex is the main factor that influence the non carcass weight (Warmington and Kirton, 1990), in our study only feet and lighter blood and gastrointestinal tract were heavier on the males. Also, others authors (Johnson *et al*., 1995) found than female goats (slaughter weight for goats in this study was 20 + 3.4 kg) had lower percentages of feet. In a similar study, Peña *et al*. (2007), in kid of Florida Breed, with 7-8 kg of slaughter weight (group 1), no found effect of gender on any percentages of non-carcass components.

As for percentage contribution of primal and minor cuts of carcasses in relation to half-carcass left side weight for suckling Payoya kids, there has been few statistically significant differences between the two systems (the shoulder and leg percentage has been higher and the flank percentage lower in organic kids). Nevertheless, these small differences found in our study are not biologically relevant. Germano Costa et al. (2010) also found significant differences between systems for the shoulder, flank and leg. Moreover, these values were higher than those found by other authors (Zurita et al., 2011) in kid's whit similar weight but different breed (Murciano-Granadina), which could explain this discrepancy.

The gender did not modify the percentages of different cuts, only the percentage of flank was higher in female's kid. Similarly, Peña et al. (2007) whit Florida kids with 7-8 kg at slaughter, they found no significant differences between genders for primal cut percentages.

The shoulder tissue composition was affected by the production system. The organic kids showed a higher percentage of muscle and bone and a lower percentage of fat (intermuscular and subcutaneous) and others tissues than conventional kids. These differences could be explained by lower energy/protein intake in the diet of the mothers of these kids, because they consumed 0.5 kg less concentrate, which could become a smaller amount of milk taken by kids or of different quality. Atti et al. (2004) concluded that the kids growing on medium CP diet (130 g CP/kg DM) deposited relatively more muscle and less adipose tissue than those receiving the high protein level diet. Moreover, the effects of a concentrated diet on carcass fat of Creole goats were evaluated by Liméa et al. (2012), the goats were slaughtered at 22 to 24 kg of body weight; goats fed the concentrated diets had greater cold carcass weight and omental, perirrenal and intermuscular adipose tissues weights. However, others authors (Cutrignelli et al., 2007) observed that the body composition was not influenced by the livestock method (conventional vs. organic).

As for sex, only perirenal fat was higher in females but no differences in the subcutaneous fatness, pelvic, and subcutaneus intermuscular fat between both the sexes. In Florida kids, slaughtered a similar weight were also differences only in the pelvic-renal fat (Peña et al., 2007). Zurita et al. (2011) also found no differences in the shoulder intermuscular and subcutaneous fat, although their values were lower than those obtained in our study. This fat may explained by differences among breeds. Other authors agreed that carcass female goat, have a greater fat percentage than males (Zurita Herrera, 2007). Also, in our study, females showed a higher percentage of muscle in the shoulder than females and a higher percentage of other tissues in the male. Todaro et al. (2004) observed similar results, although in the pelvic limb and being the weight at slaughter slightly higher. Nevertheless, other authors (Peña et al, 2007), did not observed differences between gender; but their values (58-59%) were very similar to the observed in the present experiment in spite of the different used breed. Those authors also found a higher percentage of other tissues in the female, which was opposed to the results observed in the present experiment.

There was no effect of the production system on the chemical composition and rheological parameters, except for WHC *Longissimus* muscle, for which there was interaction between the production system and gender. In a previous study (Cutrignelli et al., 2007), the meat WHC was unaffected by the livestock method. Gender only affected the percentage of intramuscular fat *Triceps brachii* muscle, higher for females. However, Todaro et al. (2004) found no differences between gender for meat chemical composition of the pelvic limb. In our study we found no effect on the pH of the production system. Nevertheless, Caputi *et al*. (2007) found differences among production systems in pH values, so that pH value of the *Longissimus lumborum* muscle 45´ after slaughter was higher in intensive production system. In the current study, the pH gradually decreases along the time (from 0h at 72h post sacrifice), but their development was different between males and females only at 0h and 45´ post slaughter (higher values in the males). This decrease may due to lactic acid production by anaerobic glycolysis muscle.

Meat color is an important parameter influencing consumer purchasing choice (Zervas and Tsiplakou, 2011), and it is well known that animal diet could strongly affect meat color (Priolo *et al*., 2001). In the current study, color was affected by production system, except for a*, but in all cases the significant effect was dependent on the sampling time (L* and Hue) or the sex (b*, Chroma and Hue). The L* and Hº paramenters were higher at 0h and 45´ time after slaughter on kids from conventional system but on the other sampling times the way of behaving was different. The b*, Chroma and Hue parameters were higher on the male kids from conventional system. In this case, lightness (L*) and yellowness (b*) seem to be affected by diet of dams. The L* and b* parameters were closely linked to quantity and quality aspects of intramuscular fat (De Palo *et al*., 2012; Mancini and Hunt, 2005; Tateo *et al*., 2013) consequently by different FA composition and oxidation, that is strictly correlated to meat color (Emami *et al*., 2015; Luciano *et al*., 2009). Regarding the differences found in FA composition in muscle kid of our study (De la Vega *et al*., 2013), among production systems, may explain the differences among meat color. However, Emami *et al*., (2015) affirmed that Hue angle (H*), being a function of a* and b*, gives a more realistic perspective of meat browning than single color. In our case, the higher Hue values of meat of conventional's kids showed that this meat is characterized by lighter color. Every color parameter increases along the time (from 0h at 72 h post slaughter). The pH is the more important factor in meat quality. Decreases in pH values along the time may be the fact of color change. The increases in Hue values over storage time, resulting from decreases in a* relative to b*, have often been used to describe meat discoloration (Lee *et al*., 2005; Luciano *et al*., 2009; Renerre, 2000; Young *et al*., 1999).

In the current study, color parameters were affected by gender. The L* value was higher in males and the value of a* lower. The gender differences on meat color agreed with Bonvillani *et al*. (2010), and which could be partly due to female carcasses cooled slowly than those of intact males.

The results of the present work suggest that the conventional grazing–based management farms could easily be transformed into organic production because in the most part of the studied variables, the meat and carcass quality of Payoya suckling kids, was not modified or even it was improved in the organic vs conventional system. On the other hand, the gender did not modified the most part of the studied parameters except the dressing percentages and color parameters.

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Table 1. Farm live weight, slaughter live weight, empty body weight, carcass weight, chilling losses, dressing percentage and subcutaneous fatness grade scores (means and S.E.M.) for suckling Payoya kids according to production system and gender. There was no interaction between these factors ($P > 0.05$).

Item [a]	Production system (PS)		Gender (G)			Significance [c]	
	Conventional (n=24)	Organic (n=24)	Male (n=24)	Female (n=24)	S.E.M. [b]	PS	G
Farm Live Weight (FLW) (Kg)	8.87	8.82	8.90	8.79	0.049	ns	ns
Slaughter Live Weight (SLW) (Kg)	8.52	8.28	8.47	8.32	0.057	*	ns
Empty Body Weight (EBW) (Kg)	8.25	7.92	8.15	8.02	0.055	**	ns
Hot Carcass Weight (HCW) (Kg)	4.58	4.42	4.58	4.41	0.041	*	*
Cold Carcass Weight (CCW) (Kg)	4.44	4.29	4.45	4.29	0.039	*	*
Pérdidas por Ayuno (Kg)	0.35	0.54	0.43	0.47	0.022	***	ns
Chilling Losses (%)	3.15	2.74	3.00	2.88	0.270	ns	ns
Farm dressing percentage (%)	51.70	50.01	51.54	50.16	0.312	**	*
Slaughter dressing percentage (%)	53.87	53.29	54.16	53.02	0.259	ns	*
Commercial dressing percentage (%)	52.16	51.83	52.52	51.49	0.268	ns	*
Real dressing percentage (%))	55.62	55.73	56.39	55.00	0.278	ns	*
Biological dressing percentage (%)	53.86	54.21	54.69	53.41	0.292	ns	*
Subcutaneous Fatness 1-5	1.21	1.04	1.13	1.13	0.048	ns	ns

[a] Farm dressing percentage (HCW/FLW); slaughter dressing percentage (HCW/SLW); commercial dressing percentage (CCW/SLW); real dressing percentage (HCW/EBW); biological dressing percentage (CCW/EBW).
[b] Standard error of mean.
[c] ns= no significant ($P > 0.05$); *$P < 0.05$; **$P < 0.01$.

Table 2. Carcass linear measures and index (means and S.E.M.) for suckling Payoya kids according to production system and gender. There was no interaction between these factors ($P > 0.05$).

	Production system (PS)		Gender (G)			Significance [b]	
Item	Conventional (n=24)	Organic (n=24)	Male (n=24)	Female (n=24)	S.E.M.[a]	PS	G
Internal Carcass Length (L) (cm)	42.20	41.90	42.19	41.91	0.228	ns	ns
External Carcass Length (K) (cm)	38.75	37.65	38.69	37.71	0.184	**	**
Leg Length (F) (cm)	24.44	24.51	24.66	24.28	0.107	ns	ns
Buttock Width (G) (cm)	9.06	8.83	8.98	8.91	0.065	ns	ns
Buttock Perimeter (BG) (cm)	30.41	38.84	29.49	39.76	5.378	ns	ns
Chest Depth (Th) (cm)	16.99	17.37	17.38	16.98	0.092	*	*
Thorax Width (Wr) (cm)	10.55	9.49	10.06	9.99	0.108	***	ns
Thoracic Perimeter (PT) (cm)	43.55	43.24	43.72	43.07	0.187	ns	ns
Th/K	0.44	0.46	0.45	0.45	0.003	***	ns
Th/G	1.88	1.97	1.94	1.91	0.017	**	ns
L/G	4.67	4.76	4.71	4.71	0.046	ns	ns
G/F	0.37	0.36	0.36	0.37	0.003	ns	ns
Wr/Th	0.62	0.56	0.58	0.59	0.007	***	ns
Osseo Index	2.83	2.79	2.86	2.77	0.027	ns	ns
Carcass Compactness index	100.37	102.03	100.48	101.92	2.34	ns	ns
Hot Carcass Weight/ L	104.41	105.41	104.22	105.61	2.50	ns	ns
Leg compactness index	29.58	28.74	29.80	28.53	0.319	ns	*

[a] Relation carcass depth/ length (Th/K); relation depth/width (Th/G); relation carcass length/width (L/G); buttock/leg index (G/F); chest roundness index (Wr/ Th; Carcass Compactness index (Cold Carcass Weight/L); leg compactness index (Leg Weight/F).
[b] Standard error of mean.
[c] ns= no significant ($P > 0.05$); *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

Table 3. Non-carcass components (means and S.E.M.) for suckling Payoya kids according to production system and gender. There was no interaction between these factors ($P > 0.05$).

Item[a]	Production system (PS)		Gender (G)			Significance [c]	
	Conventional (n=24)	Organic (n=24)	Male (n=24)	Female (n=24)	S.E.M.[b]	PS	G
Blood	4.81	4.74	4.61	4.95	0.072	ns	*
Skin	9.95	9.48	9.83	9.60	0.086	*	ns
Head	6.29	6.59	6.46	6.42	0.052	**	ns
Feet	4.77	4.73	4.90	4.60	0.040	ns	***
Heart	0.63	0.59	0.60	0.62	0.011	ns	ns
Lungs+Trachea.	1.70	1.61	1.71	1.60	0.031	ns	ns
Liver	2.29	2.40	2.35	2.34	0.029	ns	ns
Spleen	0.27	0.27	0.26	0.28	0.009	ns	ns
Thymus	0.30	0.24	0.28	0.25	0.012	**	ns
Gastro intestinal tract	9.61	9.57	9.04	10.14	0.167	ns	**

[a] Percentage on empty body weight.
[b] Standard error of mean.
[c] ns= no significant ($P > 0.05$); *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Table 4. Percentage contribution of primal and minor cuts of carcasses in relation to half-carcass left side weight (means and S.E.M) for suckling Payoya kids according to production system and gender. There was no interaction between these factors ($P > 0.05$).

Item [a]	Production system (PS)		Gender (G)		S.E.M. [b]	Significance [c]	
	Conventional (n=24)	Organic (n=24)	Male (n=24)	Female (n=24)		PS	G
Left Half carcass (Kg)	2.26	2.14	2.25	2.14	0.022	**	*
Shoulder (First category) (%)	21.69	22.29	21.92	22.06	0.131	*	ns
Leg (%)	32.01	32.92	32.62	32.31	0.194	*	ns
Neck (%)	9.77	9.78	9.79	9.76	0.177	ns	ns
Ribs (%)	21.61	21.15	21.45	21.31	0.212	ns	ns
Flank (%)	9.13	8.57	8.47	9.23	0.142	**	**
Tail (%)	0.61	0.62	0.60	0.63	0.011	ns	ns
Kidney (%)	1.02	0.91	0.97	0.95	0.020	**	ns
Perirenal fat	2.53	2.50	2.17	2.86	0.140	ns	*
Pelvic fat	0.32	0.40	0.38	0.34	0.021	ns	ns
Extra category (%)	53.62	54.07	54.07	53.62	0.236	ns	ns
Second category (%)	18.90	17.99	17.90	18.99	0.268	ns	ns

[a] Half-carcass left side (with Testis, Kidney and Tail). Extra category (leg and ribs), First (shoulder) and Second (neck and flank).
[b] Standard error of mean.
[c] ns= no significant ($P > 0.05$); *$P < 0.05$; **$P < 0.01$.

Table 5. Tissue composition (means and S.E.M.) of the shoulder for suckling Payoya kids according to production system and gender. There was no interaction between these factors ($P > 0.05$).

Item[a]	Production system (PS)		Gender (G)		S.E.M.[b]	Significance [c]	
	Conventional (n=24)	Organic (n=24)	Male (n=24)	Female (n=24)		PS	G
Muscle (%)	57.24	59.75	57.18	59.81	0.433	**	**
Bone (%)	22.80	24.72	24.19	23.33	0.328	**	ns
Intermuscular fat (%)	10.66	8.11	9.60	9.17	0.418	**	ns
Subcutaneous fat (%)	3.75	2.81	3.36	3.21	0.227	*	ns
Other tissues (%)	5.53	4.61	5.66	4.48	0.255	*	*
Muscle/ Bone	2.53	2.43	2.39	2.57	0.034	ns	**
Muscle/ Fat	4.22	5.85	4.78	5.30	0.237	***	ns
Freezing loss (%)	2.41	1.99	2.78	1.64	0.228	ns	*
Dissection loss (%)	1.50	1.18	1.45	1.23	0.171	ns	ns

[a] Percentage on shoulder weight.
[b] Standard error of mean.
[c] ns= no significant ($P > 0.05$); *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Table 6. Chemical composition and rheological parameters (means and S.E.M.) of the *Triceps brachii* and the *Longissimus* muscle, respectively, for suckling Payoya kids, according to production system and gender.

Item [a]	Production system (PS)		Gender (G)		S.E.M.[b]	Significance [c]		
	Conventional (n=24)	Organic (n=24)	Male (n=24)	Female (n=24)		PS	G	PS*G
Moisture	84.58	73.74	73.17	73.48	0.420	ns	ns	ns
Ashes	4.88	5.16	4.94	5.10	0.127	ns	ns	ns
Fat	7.57	7.06	6.64	7.99	0.292	ns	**	ns
Protein	88.46	89.10	88.75	88.81	0.755	ns	ns	ns
Chilling loss (%)	2.76	3.03	2.15	3.63	0.587	ns	ns	ns
Cooking loss (%)	38.62	38.46	38.74	38.34	0.292	ns	ns	ns
WBSF[d] on cooked meat (kg/cm^2)	7.17	7.36	6.97	7.55	0.310	ns	ns	ns
Water holding capacity (% of water expelled)	15.80	17.39	18.00	15.28	0.552	*	***	***
Myoglobin (mg/g)	0.56	0.61	0.55	0.62	0.077	ns	ns	ns

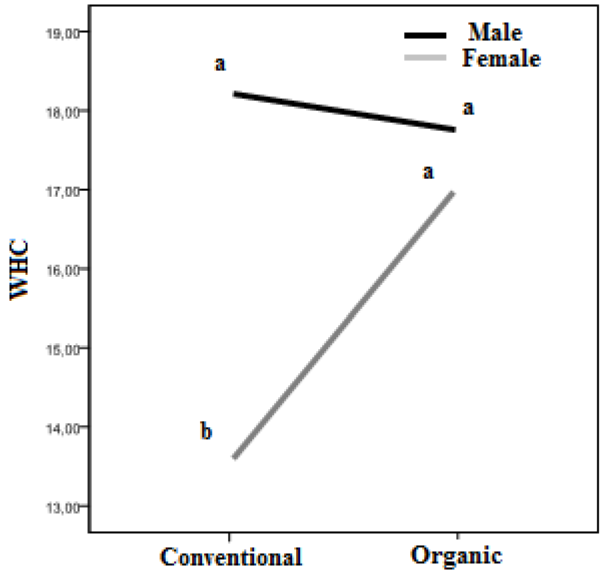
[a] Percentage on dry matter.
[b] Standard error of mean.
[c] ns= no significant ($P > 0.05$); *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.
[d]WBSF: Warner–Bratzler Shear Force.

Table 7. pH and colorimetric parameters (means and S.E.M.) of the *Longissimus* muscle for suckling Payoya kids, according to production system and gender and time of measures post slaughter .

Item [d]	Production system (PS)		Gender (G)		Time (T)[a, b]				S.E.M.[e]	Significance[c]					
	Conventional (n=24)	Organic (n=24)	Male	Female	0h	45´	24h	72h		PS	G	T	PS*G	PS*T	G*T
pH	6.36	6.36	6.39	6.33	6.90a	6.71b	6.05c	5.78d	0.026	ns	ns	***	ns	ns	***
L*	44.25	41.35	43.64	41.99	39.70c	40.54b	45.59a	45.38a	0.485	***	*	***	ns	***	ns
a*	7.37	8.31	7.03	8.65	7.00c	7.49b	8.22a	8.64a	0.342	ns	**	***	ns	ns	ns
b*	8.42	6.37	7.93	6.86	5.37c	5.34c	7.78b	11.09a	0.192	***	***	***	***	ns	ns
Chroma	11.65	10.76	10.99	11.42	9.07c	9.45c	11.83b	14.47a	0.233	**	ns	***	*	ns	ns
Hue (º)	48.04	36.08	46.55	37.57	38.58c	36.50b	40.65c	52.50a	1.528	***	***	***	**	***	ns

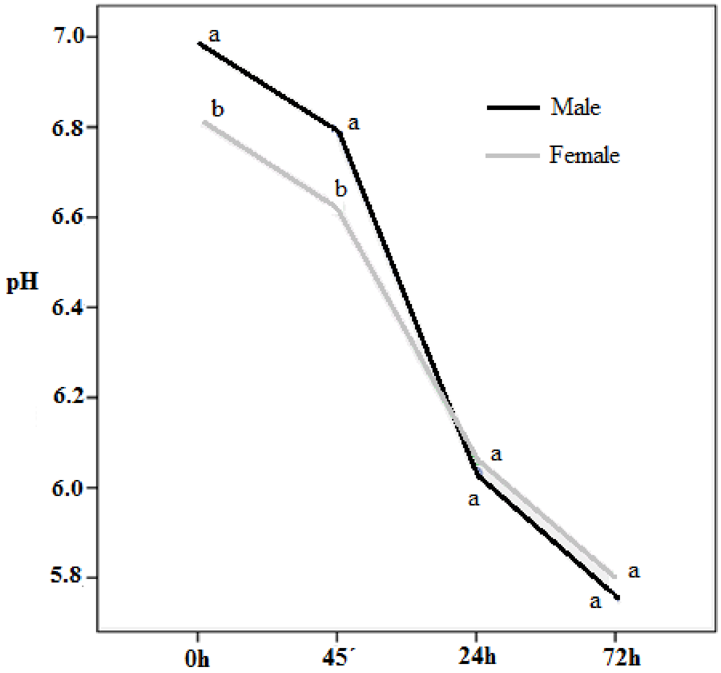
[a] 0h, 45´, 24h and 72h: measures taken at the time of slaughter and at 45´, 24h and 72h respectively.
[b] Different letters in the same line shown statistical differences.
[c] ns= no significant ($P > 0.05$); *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.
[d] L*: luminosity; a*: red index; b*: yellowness index); saturation Chroma = $(a^{*2} + b^{*2})^{0.5}$; tone Hue (°) = $Tan^{-1}(b^*/a^*)$ expressed in degrees (CIE, 1986).
[e] Standard error of mean.

Figure 1. Interaction was observed among production system and gender for WHC.



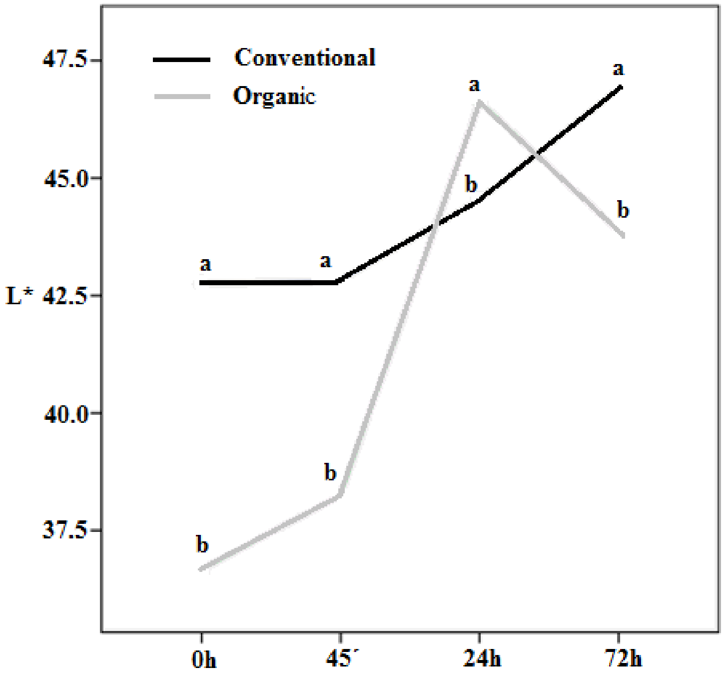
The mean values of each production system for each gender were compared and those with the same letter do not differ (p > 0.05).

Figure 2. Interaction was observed among gender and time post slaughter for pH.



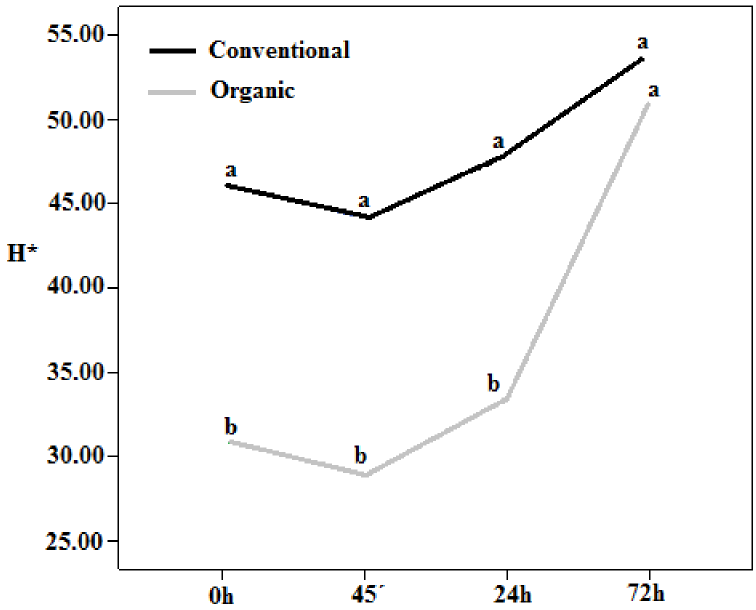
The mean values of each gender for each time were compared, and those with the same letter do not differ (p > 0.05).

Figure 3. Interaction was observed among production system and time post slaughter for L*.



The mean values of each production system for each time were compared, and those with the same letter do not differ ($p > 0.05$).

Figure 4. Interaction was observed among production system and time post slaughter for Hue.



The mean values of each production system for each time were compared, and those with the same letter do not differ (p > 0.05).

Trabajo nº2 (pendiente de publicación).

Carcass characteristics and instrumental meat quality of conventional and organic Blanca Andaluza suckling kids.

Carcass characteristics and meat quality of conventional and organic Blanca Andaluza suckling kids

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Tables: 7

Topic: Animal production

Short title: Carcass and meat quality of Blanca Andaluza suckling kids

Abstract:

Interest in the preservation of autochthonous breeds such as the Blanca Andaluza goat (meat breed), raised under grazing-based management, has recently increased among Spanish farmers. A study of the possibilities of transformation to organic production needs analyze the quality of their products. The aim of this study was to evaluate the comparative carcass and meat quality of Blanca Andaluza goat suckling kids under organic and conventional grazing–based livestock production system. Twenty-four twin kids (12 males, 12 females) were selected from each system. Weight, chilling losses, dressing percentage subcutaneous fatness grade scores, carcass linear measurements and index, non-carcass components, primal and minor cuts of carcasses, tissue composition, chemical composition and rheological parameters, pH and colorimetric parameters were studied. There were no significant differences (P > 0.05) among productions systems and gender in most of the parameters studied, except for some non-carcass components and colorimetric parameters that were affected by the

production system, highlighting a lower L* (40.44), b* (7.43) and Hue (39.16) in the organic kid. Due to this reason, we can conclude that conventional grazing–based management farms could easily be transformed into organic production system without carcass quality and meat parameters of this breed being affected.

Additional key words: production system, gender, goat

Introduction

An organic production system should comply with the following requirements: contribute to the equilibrium of agricultural systems integrated with the natural environment, contribute to sustainable agriculture development, minimize all types of contamination, respect animal well-being, avoid systematic use of chemically synthesized substances, and renounce to the use of genetically modified organisms (European Union Directives, EC nº 834/2007). Organic production has grown rapidly in the European Union in the past few years, with Spain in first place in terms of ecologically cultivated surface. It is expected that both area and markets will continue to grow increasing demand, continued policy support and increasing research activities (Willer and Lernoud, 2014).

Organic farming is of particular interest in the Mediterranean area, where it may play a role in safeguarding agricultural functions and preserving rural villages, with positive effects on the quality of life in these communities. In Spain there are 5,808 organic farms and Andalusia (in Southern Spain) contains the majority of these with 3,309 farms (MAGRAMA, 2013). Also, among countries in the European Union, Spain has the second highest goat head number (2.6 million) and Andalusia is the region with major census (35.7 % of the national total) (MAGRAMA, 2012) and also with the highest number (363) of goat herd organic farms (60 % of the national total); 276 of which are meat production farms and 87 are dairy farms (MAGRAMA, 2013). Also, initiatives exist in several countries in the Mediterranean Basin (Kyriazakis and Zervas, 2002), allowing us to affirm that organic goat production, using sustainable production and management techniques, is viable.

Moreover, interest in the preservation of autochthonous breeds, raised using extensive or semi-extensive grazing, has also recently increased among Spanish farmers and many of these breeds, such as the Blanca Andaluza goat (meat breed), are considered as endangered according to the Official Catalogue of Spanish Livestock Breeds (BOE, 2008). The main objective of these farms is the meat where kids must weigh 7-9 kg at slaughter. Converting these breeds to organic production should be straightforward owing to the adaptive capacity and disease resistance of autochthonous breeds and to the rustic environment and nutritional resources available in Andalusía's mountain zones. According to organic production system requirements, mountain goat systems, in which feeding is largely based on grazing (Ruiz *et al*., 2008), could easily be transformed into organic production (Mena *et al*., 2009a, b). A study of the possibilities of transformation to organic production needs to analyze, not only the technical and economical viability of the organic production systems, but also the quality of their products, specially the suckling kids carcass and meat.

Therefore, the aim of this study was to evaluate the comparative carcass and meat quality in both sexes of Blanca Andaluza goat kids, under organic and conventional grazing–based livestock production system.

Materials and methods

Study area, experimental farm goats and kids

The study was carried out in the Sierra of Huelva (Hinojales, Andalusia, Spain) and all goats included in this study were of the Blanca Andaluza breed. Currently, with this breed there are 16 organic and 33 conventional farms (Blanca Andaluza Breeders' Association, unpublished data). Within those farms, one farm from each management system (certified organic under EC 834/2007 [EC, 2007] and conventional) was selected. All procedures were performed by trained personnel in strict accordance with Spanish guidelines for the protection of experimental animals (RD 32/2007). Twenty-four twin goat kids (12 males and 12 females) were selected from each farm born during the same season. Kids had free access to dams but not to feedstuff.

The dams, in both experimental farms, were raised with similar semi-extensive system based on the grazing of natural pastures. The systems are characterized by a large land surface per animal, abrupt and difficult topography, hard climatology, grazing during all year and supplemented with concentrates only during the suckling phase. The average size of the farms is small (less than 100 breeding females) and, frequently, are mixed flocks/herd (sheep-goats) (Blanca Andaluza Breeders' Association, unpublished data).

In this study, a supplementary feed concentrate was added at a flat rate of 0.6 kg head^{-1} day^{-1} (composed of beans and peas) for the conventional farm and at 0.35 kg head^{-1} day^{-1} (commercial concentrate, organic constituents) for the organic farm (De La Vega *et al*., 2013). On the rangeland, the diet was composed of herbaceous plant species and leaves and stems from Mediterranean shrubs and trees (mainly *Mirtus communis*, *Pistacia lentiscus*, *Quercus ilex, Cistus salvifolius* and *Arbutus unedo*).

Slaughter and post slaughter conditions

All goat kids were slaughtered at a body weight of 7.75 ± 0.11 Kg at the San Juan del Puerto (Huelva, Spain) municipality slaughterhouse, according to current EU regulations (Council Regulation (EC) No 1099/2009). After slaughtering, carcasses were kept in a chilling room at 4°C for 24 h and after chilling the carcasses were split down the dorsal midline and then the left half of each carcass was removed according to the procedure of Colomer-Rocher *et al*. (1987) and transported under temperature for refrigeration to Huelva University.

Carcass quality

Farm live weight, slaughter live weight, carcass weight and subcutaneous fatness grade scores were measured and empty body weight, chilling losses and dressing percentage were calculated. Farm live weight (FLW) was recorded on the farms. Slaughter live weight (SLW) was recorded immediately prior to slaughter. Hot carcass weight (HCW) and weight of non carcass components (blood, skin, head, feet, heart, lungs and trachea, liver, spleen, thymus, full and empty gastro-intestinal tract) were recorded after slaughter. Gastrointestinal content was determined as the difference between full and empty gastrointestinal tract. Tail, kidneys and pelvic fats, and testes were retained in carcass. After chilling (24 h at 4ºC), cold carcass weight (CCW) and empty body weight (EBW) were recorded. Empty body weight was calculated by subtracting the weight of the gastrointestinal contents from SLW. Then, each carcass was evaluated for subcutaneous fatness (scale from 1= low to 5= very high) using the scoring system suggested by Colomer-Rocher *et al.* (1987).

Dressing carcass percentages and chilling losses were calculated as follows: farm dressing percentage (LDP)= 100 x (HCW/FLW); slaughter dressing percentage (SDP)= 100 x (HCW/SLW); commercial dressing percentage (CDP)= 100 x

(CCW/SLW); real dressing percentage (RDP)= 100 x (HCW/EBW); biological dressing percentage (BDP)= 100 x (CCW/EBW); chilling losses (CH)= (HCW-CCW)x100/HCW.

Carcass linear measurements were measured based on standard protocols (Palsson & Verges, 1952; Boccard *et al*., 1958), including internal carcass length (L), external carcass length (K), leg length (F), buttock width (G), buttock perimeter (BG), chest depth (Th), thorax width (Wr), thoracic perimeter (PT). The indices from these carcass conformation measurements: relation carcass length/width (L/G), relation depth/width (Th/G), relation carcass depth/length (Th/ K), carcass compactness (CCW/L), leg compactness (LW/ F), chest roundness index (Wr/ Th) and buttock/leg index (G/F).

After chilling, the left half of each carcass was weighed and physically dissected into five prime cuts (shoulder, flank, neck, ribs and long leg) according to Colomer-Rocher *et al.* (1987). Prime cuts were weighed and grouped into three categories: extra (long leg and ribs), first (shoulder) and second (neck and flank). Minor cut (tail, testes, kidney, kidney fat and pelvic fat) were removed before jointing and weighed. All cuts were vacuum packed and frozen at -20ºC until analysis, except the ribs.

The shoulder, after thawing under chilling (4°C) for 24 h, was weighed and separated into dissectible fat (subcutaneous + inter-muscular), muscle, bone and the remainder (major blood vessels, ligaments, tendons and thick connective tissue sheets associated with some muscles) in a dissection room under controlled environment. The muscle/ bone and muscle/ fat index were calculated. Freezing (by weight difference before and after freezing) and dissection (by weight difference before dissection and the sum of the weights of its entire constituent after dissection) losses were calculated.

Meat sampling and analysis

The color and pH were evaluated at 0 minutes, 45 minutes, 24 and 72 h after slaughtering. The color was measured in *Longissimus* muscle (4/5th lumbar vertebra) of the carcass left side, directly on muscle surface after removing, with a scalpel, connective tissue.

All meat color variables: lightness (L*), redness (a*), yellowness (b*) and the colorimetric indices of chromaticity (C*) and hue angle (Hº) was assessed according to the CIELAB color system (CIE, 1986), using a portable chromo-meter (Minolta CM-2002), which gives the average of three measurements. The pH was measured using a penetrating combined glass electrode with a pH-meter (Crison 25) at the same site as color.

After the rib joint was obtained and after chilling (24 h), the *Longissimus* muscle was dissected. One sub-samples of *Longissimus* muscle were taken (4/5th lumbar vertebra), and chilling (5ºC) for 48 h more, for determining color at 72 h after slaughter. The rest of the loin was vacuum packed and frozen at –20°C until analysis. Once thawed *Longissimus* muscle, under chilling (4°C) for 24 hours, freezing and cooking losses were calculated and shear force, water holding capacity (WHC) and haem pigments were analyzed.

Cooking loss was evaluated in meat samples of similar geometry, individually weighed and packed vacuum in plastic bag in water bath at 75 °C for 30 min. Cooked samples were cooled at room temperature, were taken from the bags, dried with filter paper and reweighed. Cooking loss was expressed as the percentage of loss related to the initial weight.

After measurement of cooking loss, samples were used for objective tenderness determinations. The Warner–Bratzler shear force (WBSF) was measured in sub-samples (at least 3) of 1 cm^2 cross section with fibers perpendicular to the direction of the blade attached to a Stevens QTS 25 apparatus. Results were expressed in kg/cm^2.

Water holding capacity were determined according to Grau and Hamm (1953) as modified by Sierra (1973) and expressed as expelled juice percentage. Two repetitions were performed for each sample.

Haem pigments were measured according to Hornsey (1956) and expressed as mg myoglobin/ g fresh muscle. Two repetitions were performed for each sample.

Once thawed the shoulder and dissected was obtained *Triceps brachii* muscle, without inter-muscular fat and tendons. After, were analyzed the amount of moisture, ash, crude protein and fat (AOAC, 2000).

Statistical analyzes

Differences in all studied parameters, except for pH and colorimetric parameters, were assessed by analysis of variance using the general linear model (GLM) of the IBM SPSS Statistics for Windows (version 22.0; IBM Corp., Armonk Nueva York, USA), including the fixed effects of production system and gender. The linear model used for each parameter was as follows:

$$Y_{ijk} = \mu + PS_i + G_j + (PS \times G)_{ij} + \varepsilon_{ijk}$$

Where Y_{ijk} = observations for dependent variables; μ = overall mean; PS_i = fixed effect of production system (i = organic system or conventional system); G_j = fixed effect of gender; PS × G = interactions between production system and gender, and ε_{ijk} = random effect of residual.

pH and colorimetric parameters were analysed with the repeated measures procedure, including the fixed effects of production system and gender (within-subjects factors), time (intra-subject factor) and interactions among these factors. Pairwise comparisons of means were carried out, where appropriate, using Tukey's honest significant difference or least significant difference tests, considering a level of significance of 5 %.

Results

Carcass quality

All weights performed on living animal and on carcasses, chilling losses, dressing percentage, subcutaneous fatness grade scores and carcass linear measurements and index not differed significantly ($P > 0.05$) among productions systems and gender. The Table 1 and 2 shows the overall averages for each of these parameters. Non interaction was observed between both factors ($P > 0.05$).

There were significant differences among productions systems for some offal component tested (Table 3). For conventional kids, percentage contributions to empty body weight of feet and spleen ($P < 0.05$), blood and liver ($P < 0.01$) and heart ($P < 0.001$) were significantly higher than for organic kids. Also, percentage contributions to empty body weight of head were significantly lowers ($P < 0.05$) for conventional kids than organic kids. Non interaction was observed between both factors ($P > 0.05$).

There were no significant differences (*P* > 0.05) among productions systems and gender in percentage contributions of primal and minor cuts of carcasses in relation to half-carcass left side weight. The Table 4 shows the overall averages for each of these parameters. Interaction was observed between both factors for extra category (*P* < 0.05). In organic production system, females showed a higher value (55.03 ± 0.44 %) than male (52.56 ± 0.47 %), while conventional system were not different among gender with average values.

Management system and gender not differed significantly in their shoulder tissue composition (*P* > 0.05). The Table 5 shows the overall averages for each of these parameters.

Meat quality

The Table 6 shows the overall averages for chemical composition and rheological parameters of the *Triceps brachii* and the *Longissimus* muscle, respectively, for suckling Blanca Andaluza. Management system and gender did not affect the content of moisture, protein, intramuscular fat and ash (*P* > 0.05 for all variables). Non interaction was observed between both factors (*P* > 0.05).

The rheological parameters (freezing and cooking loss, shear force, WHC and myoglobin) were not affected by production system and gender (*P* > 0.05). Non interaction was observed between both factors (*P* > 0.05).

As for pH, were not affected by production system and gender (*P* > 0.05), but were affected by the time (P < 0.001). A clear reduction of the pH's meat goat is observed when post slaughter time progresses from 0h-45´ to 72 h (Table 7). Not interaction was observed between these factors (*P* > 0.05).

Color variables (Table 7), were affected by production system (P < 0.001), except Chroma (*P* > 0.05). L*, b* and Hue showed higher values in the conventional kid goat meat that ecological kid goat meat while a* value was higher in organic kid goat meat. All color variables were affected by the time (P < 0.001), experiencing a significant increase in their values when the post slaughter time increased from 0h to 24 h, except for Hue, and also when the post slaughter time increased from 24h to 72h. The observed increase from 0h to 72 h post slaughter was 5.03, 1.92, 3.94, 3.79 and 3.16

units for L*, a *, b * , Chroma and Hue, respectively. There were no significant differences by gender ($P > 0.05$) or by the interaction between these factors ($P > 0.05$).

Discussion

We observed that the majority of carcass quality parameters were unaffected by the livestock method (conventional *vs.* organic) and gender in Blanca Andaluza kids slaughtered at a body weight of 7.75 ± 0.11 Kg. These small differences found are probably due to both systems, the dams were raised with similar semi-extensive system based on the grazing of natural pastures whit similar amounts of feed concentrate.

There were any effect of both studied factors, on weights, chilling loss, dressing percentages, subcutaneous fatness grade, carcass linear measurements and index, percentage contribution of primal and minor cuts of carcass, tissue composition of the shoulder and chemical composition of the *Triceps brachii* and rheological parameters of the *Longissimus* muscle. In the literature there are few studies that study the effect of these two production systems on carcass quality or kids meat. In a similar study (Cutrignelli *et al.* (2007), with greater differences in management system, comparing kids from dams of Cilentana breed housed in a stall that were led to pasture and raised following EU Regulation 1804/99 on organic farming, and slaughter weight higher (12 kg), they no found effect of the livestock system on hot carcass, dressing percentages, carcass measurements and tissue composition of the right hind leg. Nevertheless, Morbidini *et al.* (2001), in Italian Merino breed and slaughtered at 75 days, observed differences between "organic" and "traditional" meat lambs; slaughtering characteristics (high dressing percentages, good carcass quality) and more positive physical and chemical characteristics (tenderness on cooked meat, drip and cooking loss and ash) of organically grown lambs. These authors attribute lower warm dressing percentage in conventionally carcasses to the early weaning and transporting stress, especially associated with changes in diet and environment.

The sex of the animal had not influence on weights, dressing percentages, subcutaneous fatness, carcass linear measurements and index. Similar effect and means parameters values were found by Peña *et al*. (2007), comparing kids from dams of Florida breed at similar slaughter weight (7-8 kg).

There were significant differences among productions systems for some offal component tested. Determination of the weight of the non-carcass components is of interest due to their large contribution (> 50%) to maintenance energy expenditure (Ortigues, 1991). In relation to these organs, conventional kids had heavier feet, spleen, blood, liver and heart weights. The lighter organs weight in organic kids would be in accordance with a decreasing plane of nutrition, eliciting a reduced metabolic rate and mass of metabolically active tissue (Wester *et al*., 1995). In this study, a supplementary feed concentrate was added to dams in organic farm, was lower than in conventional farm (De la Vega *et al.*, 2013). Although the kids were fed exclusively with milk by suckling their dams, and as the suckled milk is the only factor that influence the offal components, this could explain the differences among systems on this parameter but milk composition was not monitored, this will have to be tested in future studies. However, Cutrignelli *et al.* (2007) found no effect of livestock system in slaughtered kids on the weight of some of these organs (skin, liver + spleen, kidney + bladder and empty digestive tract) even using very similar nutrition levels. Furthermore, and although the sex is one of the main factors that influence the non carcass weight (Warmington and Kirton, 1990), in the current study, there were no significant effect ($P > 0.05$) among gender. Peña *et al.* (2007) found no effect on the weight of blood, skin, head, feet and this organs (lung + trachea, heart, liver, spleen and thymus) of suckling kids of the Florida breed slaughtered at 7–8 kg and raised on milk replacer and housed indoors in group boxes at 20–25 °C with automatic feeders.

In the current study the pH was not affected by production system and gender, but was affected by time factor. The pH gradually decreases along the time (from 45' at 72h post sacrifice), due to lactic acid production by anaerobic glycolysis muscle.The pH value was similar to those observed by other authors in suckling kids whit the similar slaughter weight (Argüello *et al.*, 2005; Caputi *et al.*, 2007; Bonvillani *et al.*, 2010).

Meat color is an important parameter influencing consumer purchasing choice (Zervas and Tsiplakou, 2011), and it is well known that animal diet could strongly affect meat color (Priolo *et al.*, 2001). In the current study, color was affected by production system. In this case, lightness (L*), redness (a*) and yellowness (b*) seem to be affected by diet of dams. In fact, in kids coming from conventional system, they appear higher L* and b* and lower a* values. L* and b* parameters are closely linked to quantity and quality aspects of intramuscular fat (De Palo *et al.*, 2012; Mancini and Hunt, 2005; Tateo *et al.*, 2013) consequently by different FA composition and oxidation, that is strictly correlated to meat color (Emami *et al.*, 2015; Luciano *et al.*, 2009). Regarding the differences found in FA composition in muscle kid of our study (De la Vega *et al.*, 2013), among production systems, may explain the differences among meat color. However, Emami *et al.* (2015) affirmed that Hue angle (H*), being a function of a* and b*, gives a more realistic perspective of meat browning than single color. In our case, the higher Hue values of meat of kids from conventional system showed that this meat is characterized by lighter color. All colors parameters increases along the time (from 0h at 72 h post slaughter). The pH is the most important factor in meat quality. Decreases in pH values along the time may be the fact of color change. The increases in Hue values over storage time, resulting from decreases in a* relative to b*, have often been used to describe meat discoloration (Lee *et al.*, 2005; Luciano *et al.*, 2009; Renerre, 2000; Young *et al.*, 1999). The gender had not significant influence on meat color. Nevertheless, Bonvillani *et al.* (2010) observed significant different and which could be partly due to female carcasses cooled slowly than those of intact males.

In conclusion, all attributes studied regarding the carcass and meat quality of conventional and organic Blanca Andaluza suckling kids, significant differences were found only in a few offal components and colorimetric parameters. Due to this reason conventional grazing–based management farms could easily be transformed into organic production without parameters carcass quality and meat of this breed they are affected.

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Table 1. Farm live weight, slaughter live weight, empty body weight, carcass weight, chilling losses, dressing percentage and subcutaneous fatness grade scores for suckling Blanca Andaluza kids. There were no significant (*P* > 0.05) among productions systems and gender.

Item	Means	Standard error of mean
Farm Live Weight (FLW) (Kg)	8.26	0.11
Slaughter Live Weight (SLW) (Kg)	7.75	0.11
Empty Body Weight (EBW) (Kg)	7.23	0.12
Hot Carcass Weight (HCW) (Kg)	3.85	0.08
Cold Carcass Weight (CCW) (Kg)	3.72	0.08
Chilling Losses (CH) (%)	3.22	0.35
HCW/FLW (%)	46.46	0.65
HCW/SLW (%)	49.47	0.66
CCW/SLW (%)	47.90	0.67
HCW/EBW (%)	53.05	0.43
CCW/EBW (%)	51.37	0.47
Subcutaneous Fatness (1-5)	1.23	0.07

Table 2. Carcass linear measurements and index for suckling Blanca Andaluza kids. There were no significant (*P* > 0.05) among productions systems and gender.

Item	Means	Standard error of mean
Internal Carcass Length (L) (cm)	38.91	0.43
External Carcass Length (K) (cm)	36.37	0.26
Leg Length (F) (cm)	23.89	0.15
Buttock Width (G) (cm)	8.71	0.11
Buttock Perimeter (cm)	28.97	0.48
Chest Depth (Th (cm))	17.05	0.10
Thorax Width (Wr) (cm)	9.83	0.12
Thoracic Perimeter (cm)	42.75	0.22
Relation carcass depth/ length (Th/K)	0.470	0.00
Relation depth/width (Th/G)	1.97	0.02
Relation carcass length/width (L/G)	4.77	0.08
Buttock/leg index (G/F)	0.365	0.00
Chest roundness index (Wr/Th)	0.58	0.01
Carcass compactness index (Cold Carcass Weight/ L)	85.27	4.29
Leg compactness index (Leg Weight /F)	25.70	0.53

Table 3. Non-carcass components (means and Standard error of mean) for suckling Blanca Andaluza kids according to production system and gender. There were no significant (P > 0.05) among gender.

Item[a]	Production system		S.E.M.[b]	Significance[c]	Gender
	Conventional (n=24)	Organic (n=24)			
Blood	5.35	5.02	0.08	**	5.20±0.08
Skin	10.48	10.51	0.12	ns	10.49±0.12
Head	6.87	7.53	0.12	*	7.18±0.13
Feet	5.02	4.62	0.06	*	4.83±0.06
Heart	0.63	0.53	0.01	***	0.58±0.01
Lungs+Trachea	1.74	1.78	0.04	ns	1.76±0.04
Liver	2.45	2.17	0.04	**	2.32±0.04
Spleen	0.27	0.24	0.01	*	0.25±0.01
Thymus	0.14	0.20	0.01	ns	0.17±0.01
Gastro intestinal tract	10.56	10.30	0.31	ns	10.44±0.31

[a] Percentage on empty body weight.

[b] Standard error of mean.

[c] ns= no significant (P > 0.05); *P < 0.05; **P < 0.01; ***P < 0.001.

Table 4. Percentage contribution of primal and minor cuts of carcasses for suckling Blanca Andaluza kids. There were no significant (P > 0.05) among productions systems and gender.

Item [a]	Means	Standard error of mean
Half carcass left (Kg)	1.92	0.04
Shoulder (%)	22.01	0.22
Leg (%)	32.24	0.20
Neck (%)	9.42	0.19
Ribs (%)	21.36	0.34
Flank (%)	9.64	0.20
Tail (%)	0.54	0.02
Kidney (%)	1.054	0.02
Perirenal fat (%)	1.74	0.20
Pelvic fat (%)	0.30	0.04
Extra category[b] (%)	53.61	0.33
First category (%)	22.01	0.79
Second category (%)	19.05	0.24

[a] Half-carcass left side (with testis, kidney and tail). Percentage of the half carcass left weight. [b] Extra category (leg and ribs), First (shoulder) and Second (neck and flank).

Table 5. Tissue composition of the shoulder for suckling Blanca Andaluza kids. There were no significant ($P > 0.05$) among productions systems and gender.

Item (Percentage on shoulder weight)	Means	Standard error of mean.
Muscle (%)	56.71	0.59
Bone (%)	25.39	0.42
Intermuscular fat (%)	9.4	0.63
Subcutaneous fat (%)	3.72	0.33
Other tissues (%)	4.78	0.22
Muscle/ Bone	2.25	0.04
Muscle/ Fat	5.31	0.88
Freezing loss (%)	2.13	0.25
Dissection loss (%)	1.16	0.16

Table 6. Chemical composition and rheological parameters of the *Triceps brachii* and the *Longissimus* muscle, respectively, for suckling Blanca Andaluza. There were no significant ($P > 0.05$) among productions systems and gender.

Item (Percentage on dry matter)	Means	Standard error of mean
Triceps brachii weight (% half-carcass left)	2.48	0.04
Longissimus weight (% half-carcass left)	5.68	0.08
DM (%)	13.52	0.38
Ashes (%)	4.90	0.08
Fat (%)	7.90	0.35
Protein (%)	7.34	0.56
Freezing loss (%)	1.42	0.16
Cooking loss (%)	37.37	0.68
WBSF[1] on cooked meat (kg/cm^2)	5.59	0.27
Water holding capacity (% of water expelled)	17.49	0.46
Myoglobin (mg/g)	0.63	0.14

[1]WBSF: Warner–Bratzler shear force

Table 7. pH and colorimetric parameters (means and S.E.M.) of the *Longissimus* muscle for suckling Blanca Andaluza kids, according to production system and time. There were no significant differences of gender equality or the interaction between these factors ($P > 0.05$).

Item [c]	Production system[b]		Time[a b]				
	Conventional (n=24)	Organic (n=24)	0h	45´	24h	72h	Standard error of mean
pH	6.45a	6.58a	6.93a	6.87a	6.30b	5.98c	0.05
L*	44.46a	40.44b	40.59c	40.61c	42.95b	45.62a	0.51
a*	6.95b	8.42a	6.73c	7.14b	8.22a	8.65a	0.25
b*	9.05a	7.43b	7.01c	6.39d	8.61b	10.95a	0.39
Chroma	11.60a	11.28a	9.93c	9.79c	12.32b	13.72a	0.27
Hue (º)	51.84a	39.16b	46.78b	41.35c	43.93bc	49.94a	1.56

[a] 0h, 45´, 24h and 72h, measures taken at the time of slaughter and at 45´, 24h and 72h respectively

[b] Different letters in the same line and the same factor shown statistical differences ($P < 0.001$)

[c] L*: luminosity; a*: red index; b*: yellowness index); saturation Chroma = $(a^{*2} + b^{*2})^{0.5}$; tone Hue (°) = $Tan^{-1}(b^*/a^*)$ expressed in degrees (CIE, 1986).

Trabajo nº 3 (pendiente de publicación).

Calidad sensorial de la carne de cabritos lechales criados en sistemas de producción basados en pastoreo.

Calidad sensorial de la carne de cabritos lechales criados en sistemas de producción basados en pastoreo.

Sensory meat quality of suckling kids raised in grazing-based livestock production system.

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Resumen: En España, hay un interés creciente por la conservación de las razas autóctonas con sistemas de explotación basados en el pastoreo y por la posibilidad de transformación en producciones ecológicas. El objetivo ha sido evaluar las características sensoriales de la carne de cabrito lechal de dos razas autóctonas, criados en sistemas de producción convencional y ecológica, basados en el pastoreo. Se utilizaron 21 cabritos lechales de los cuales 12 fueron criados en un sistema ecológico (6 de raza Payoya y 6 de raza Blanca Andaluza) y 9 en un sistema convencional (3 de raza Payoya y 6 de raza Blanca Andaluza). Se evaluó la calidad sensorial de la carne mediante un panel entrenado de 7 miembros. Los cabritos del sistema ecológico y los de raza Blanca Andaluza presentaron carnes más tiernas, más jugosas, con mayor facilidad de masticación y con menos intensidad de olor global. Los cabritos de raza Payoya y criados en sistema ecológico mostraron una menor dureza que los criados en sistema convencional. Existen claras diferencias entre sistemas para los descriptores del olor y aroma y sabores básicos estudiados.Estos resultados preliminares podrían ser favorables para la transformación de las explotaciones convencionales, basadas en pastoreo, a ecológicas.

Palabras clave: Calidad sensorial, carne, cabrito, ecológico.

Abstract

Sensory meat quality of suckling kids raised in grazing-based livestock production system.

Interest in the preservation of autochthonous breeds raised under grazing-based management and the possibility of conversion in organic products, has recently increased among Spanish farmers. The aim of this study was to evaluate sensory quality of two autochthonous breeds suckling kid meat, raised in conventional and organic production system under grazing-based management. We used 21 suckling kid, 12 under organic grazing-based management system (6 Blanca Andaluza breed and 6 Payoya breed) and 9 under conventional grazing-based management system (3 Payoya breed and 6 Blanca Andaluza breed). The meat was evaluated by a sensorial panel of 7 trained judges. Meat of Blanca Andaluza kids under organic grazing-based management system showed less odor intensity and better scores in tender, juiciness and mastication. Payoya kids raised under organic grazing-based management system showed betters scores in tender than kids under conventional management system. There were clear differences between production systems for odor descriptions, aroma and basic savor studied. In conclusion, these preliminary results would be favorable for transforming conventional grazing-based management system on organic grazing-based management system.

Key Words: Quality, meat, kid, organic.

Introducción

Actualmente hay un interés creciente, por parte de la administración y de los ganaderos españoles, en la conservación de las razas autóctonas, criadas en sistemas extensivos o semiextensivos, basados en el pastoreo. Muchas de estas razas, como es el caso de las razas caprinas Blanca Andaluza y Payoya, están consideradas como razas en peligro de extinción (Real Decreto 2129/2008). La mayor parte de las explotaciones caprinas de estas dos razas están localizadas en zonas de sierra de difícil acceso; la Blanca Andaluza en Sierra Morena, Sierra de Segura y Cazorla (Jaén) y en la Sierra Norte de Sevilla y de Huelva y la Payoya en la Sierra de Grazalema (Cádiz) y Serranía de Ronda (Málaga).

La raza Blanca Andaluza es una raza claramente de aptitud cárnica. En la actualidad, aunque se sigue produciendo el "chivo" (animal criado a pasto con la madre, sacrificado a los 5 meses de edad con 25-30 kg. de peso vivo), principalmente en zonas donde es tradicional el consumo de la carne de estos animales, el tipo comercial más en uso es también el "cabrito lechal" (FEAGAS, 2014). La raza Payoya es una de las mejores representantes de las razas caprinas de producción de leche basada en pastoreo. El principal objetivo de las explotaciones es la producción láctea y de manera secundaria la de carne de "cabrito lechal", sacrificado con un peso de 8 a 9 kg (Mena *et al.*, 2005), favorecido por su alto precio en el mercado.

De acuerdo con los requerimientos de la producción ecológica, las explotaciones de estas razas pueden ser fácilmente transformados en explotaciones ecológicas (Mena *et al.*, 2009a, b). El estudio de las posibilidades de transformación necesita, además del análisis de viabilidad técnica y económica, el estudio de la calidad de los productos. En este sentido y tomando como base las mismas explotaciones que las utilizadas en el presente trabajo, nuestro grupo ha publicado dos trabajos sobre el perfil de ácidos grasos (De la Vega *et al.*, 2013a, b), en los que se concluye que no hay diferencias significativas en la gran mayoría de los ácidos grasos presentes en la grasa intramuscular o en otros depósitos grasos entre los cabritos criados en explotaciones convencionales y ecológicas, con lo que la transformación, desde este punto de vista, podría realizarse fácilmente. Puesto que no se conocen trabajos sobre la calidad sensorial de la carne de cabrito de estas razas autóctonas que comparen ambos sistemas de producción, el objetivo de este estudio ha sido estudiar la calidad sensorial de la carne de los cabritos de las razas Payoya y Blanca Andaluza en sistemas de producción ecológicos y convencionales basados en el pastoreo.

Material y métodos

Animales

Para este trabajo se han utilizado cabritos lechales pertenecientes a 4 explotaciones caprinas con sistemas semiextensivos (De la Vega *et al.*, 2013a, b), una de cada tipo de producción (convencional y ecológica, con certificación según el Reglamento (CE) nº 834/2007 del Consejo) y de cada raza (Payoya y Blanca Andaluza). Las cabras de todas las explotaciones han tenido una alimentación basada en pastos naturales compuestos por especies de plantas herbáceas, junto con hojas y tallos de arbustos y árboles mediterráneos (principalmente *Mirtus communis*, *Pistacia lentiscus*, *Quercus ilex, Cistus salvifolius* and *Arbutus unedo*). Además, fueron suplementados con alimentos concentrados a razón de 1 kg y 0,5 kg por cabeza y día en las explotaciones convencionales y ecológicas, respectivamente, de raza Payoya; así como 0,6 kg y 0,35 kg en las explotaciones convencionales y ecológicas, respectivamente, de raza Blanca Andaluza (De la Vega *et al.*, 2013a, b).

Se han utilizado 21 cabritos lechales, nacidos de partos dobles: 12 cabritos criados en un sistema ecológico (6 de raza Payoya y 6 de raza Blanca Andaluza) y 9 cabritos criados en un sistema convencional (3 de raza Payoya y 6 de raza Blanca Andaluza). Los cabritos, durante todo el periodo de lactación, tuvieron acceso a las madres pero no a otros alimentos.

Todos los procedimientos fueron realizados por personal capacitado en estricta conformidad con las directrices españolas para la protección de los animales de experimentación (RD 53/2013).

Sacrificio y muestreo

Todos los cabritos fueron sacrificados con un peso vivo de 8,12 ± 0,49 kg (Payoya) y 7,52 ± 0,64 kg (Blanca Andaluza) en un matadero oficial de Huelva (España), después de 16,00 ± 0,75 h (Payoya) y 19,81 ± 2,49 h (Blanca Andaluza) de ayuno con libre acceso al agua. Después del sacrificio, las canales fueron refrigeradas a 4 °C durante un período de maduración de 24 horas. A continuación se obtuvo la media canal izquierda que se transportó refrigerada a las instalaciones de la Universidad de Huelva. Allí se procedió al despiece y obtención de las piernas (Colomer-Rocher *et al.*, 1987), que se envasaron al vacio y se congelaron a -20 ºC hasta su posterior análisis. Los pesos medios de las piernas fueron de 0,65 ± 0,03 kg en los cabritos de raza Payoya y 0,56 ± 0,07 kg en los de raza Blanca Andaluza.

Análisis sensorial

Previamente al análisis sensorial, las piernas se descongelaron dentro de la bolsa de vacío, por inmersión en agua corriente a una temperatura de 17-19 °C. Las piernas enteras se cocinaron en un horno eléctrico, hasta llegar a una temperatura de 65-70 ºC, controlada con un termopar (JENWAY 2000). Una vez cocinada la carne, se extrajo el músculo *Semimembranosus* y se cortó en submuestras de 2 x 2 cm, siendo posteriormente envueltas individualmente en papel de aluminio, previamente codificado con un número aleatorio de tres cifras. Las muestras se sirvieron en las cabinas de cata, donde se mantuvieron calientes en un horno eléctrico precalentado a 60 ºC hasta el momento del análisis. Fueron servidas aleatoriamente a un panel entrenado de 7 miembros, seleccionados y entrenados según las normas internacionales ISO 8586-1, y pertenecientes al panel analítico del Laboratorio Sensorial del Departamento de Bromatología y Tecnología de los Alimentos de la Universidad de Córdoba. Todos los análisis se realizaron en horario de mañana (12:00 a 13:00 horas) en la sala de cata de la Escuela de Hostelería de Córdoba. Las muestras se presentaron aleatoriamente y se analizaron independientemente. Entre muestras, los jueces utilizaron agua mineral para limpiarse las papilas. Las muestras de las 21 piernas se analizaron en 6 sesiones de no más de 1 hora de duración, evaluándose un máximo de 4 muestras por sesión. La metodología seguida es una adaptación de la propuesta por Guerrero *et al.* (2000) para el análisis sensorial de carnes de pequeños rumiantes. Se realizó un análisis descriptivo cuantitativo en el que se evaluaron 5 atributos sensoriales: 1 de olor (intensidad de olor global por vía directa), 3 de textura (dureza, facilidad de masticación y jugosidad) y 1 de aroma (intensidad de aroma global por vía retronasal) en una escala lineal no estructurada de 10 cm de longitud anclada a 1 cm de cada extremo y medidos de menos favorables a más favorables. Además, se evaluaron cualitativamente los atributos de olor y aroma (carne de cocido, hígado, cabrito, orina, animal) y sabores básicos (sabroso, ácido, metálico, umami).

Análisis estadístico

Los parámetros del análisis sensorial descriptivo cuantitativo fueron analizados mediante un análisis ANOVA, usando el Modelo Lineal General (GLM) del paquete estadístico IBM SPSS para Windows (versión 22.0; IBM Corp., Armonk Nueva York, USA), incluyendo como factores fijos el sistema de explotación, la raza y el catador. Con todos los parámetros analizados se realizó un análisis factorial utilizando el método de los componentes principales (CP) y seleccionando aquellos factores con un autovalor asociado mayor a 1.

Resultados y Discusión

En la Tabla 1 se presentan los valores medios de los distintos atributos de calidad estudiados para cada sistema de explotación y raza. El análisis de varianza muestra que la carne procedente de cabritos de raza Blanca Andaluza, en comparación a la raza Payoya, ha mostrado una mayor jugosidad ($P<0,01$) y una menor intensidad del olor ($P<0,001$), sin que se observen diferencias, entre ambas razas, para la facilidad de masticación o la intensidad del aroma ($P>0,05$). Algunos autores también han encontrado algunas diferencias sensoriales entre razas o diferentes genotipos (Lemes *et al.*, 2011; Ngambu *et al.*, 2011) pero apenas hay publicaciones que estudien la calidad sensorial de las dos razas autóctonas estudiadas en el presente trabajo y ninguno que las compare. Como ya indicaba Sañudo (2008), la raza es un factor que puede hacer variar la calidad del producto y que en muchos casos justifica, por si sola, la existencia de marcas de calidad.

En cuanto a los dos sistemas de producción comparados, todos los atributos de calidad analizados, exceptuando la intensidad del aroma ($P>0,05$), se han visto afectados. La carne procedente de cabritos criados en sistema ecológico tiene una mayor jugosidad ($P<0,05$) y una menor intensidad del olor ($P<0,001$) que la carne procedente de explotación convencional. Aunque no tenemos referencia de trabajos similares publicados para establecer diferencias en los atributos de calidad entre los cabritos lechales pertenecientes a ambos sistemas, sí hay algunos trabajos que han estudiado las diferencias observadas entre diferentes regímenes de alimentación. Así, el trabajo de Germano Costa *et al.* (2008), estudiando similares atributos de calidad sensorial, también en cabritos de raza Blanca Andaluza, pero de mayor peso (19 kg) que la de los cabritos del presente estudio, solamente encontraron diferencias para la intensidad del sabor en los cabritos criados en sistemas intensivos (6,24) en comparación a los criados en sistemas extensivos (5,18), explicando estas diferencias en función de un mayor contenido en grasa en los cabritos criados en sistema intensivo. Por otro lado, hay autores que también han encontrado diferencias sensoriales en la carne de cabritos lechales alimentados con leche natural o con un lacto-reemplazante, observando un mayor olor y flavor en los cabritos alimentados con este último, a pesar de no encontrar diferencias en el porcentaje de grasa intramuscular entre las dos dietas (Bañon *et al.*, 2006). Estos autores indican que las diferencias podrían estar relacionadas con las variaciones en el grado de insaturación de esa grasa intramuscular, como consecuencia de las diferencias en la alimentación. En el presente trabajo y de forma general la alimentación recibida por las madres, y por ello la calidad de la leche ingerida por los cabritos, ha sido similar, las pequeñas variaciones entre explotaciones en los aportes nutritivos procedentes del pastoreo y concentrados suplementados (De la Vega *et al.*, 2013a, b) podrían ser la causa de las diferencias sensoriales obtenidas. En estos dos trabajos, los cabritos no presentaron diferencias significativas en el contenido de grasa intramuscular, no obstante los porcentajes de los ácidos grasos C17:0, C17:1, C20:1, C20:4 n-6, C22:2 y algunos ácidos grasos n-3 (el ácido omega-3 docosahexaenoico C22:5 –DPA- y el ácido C22:6 –DHA-), fueron más altos en la grasa intramuscular de los cabritos ecológicos de raza Blanca Andaluza (De la Vega *et al.*, 2013a) y los porcentajes de C14:0, C18:1 trans-11- (VA) y de los ácidos grasos n-3 C20:5 (EPA), DHA y DPA fueron también más altos en la grasa intramuscular de los cabritos ecológicos de raza Payoya (De la Vega *et al.*, 2013b), lo que podría explicar las diferencias en estos atributos sensoriales. En este sentido, en un estudio reciente sobre la alimentación con lactorreemplazantes (16 % de materia seca) de cabritos (Moreno-Indias *et al.*, 2012), la evaluación de la calidad sensorial de la carne ha mostrado que la adición de una alta dosis de DHA (1,8 %) da lugar a carnes con olor y sabor desagradables y puntuaciones bajas de aceptación general, en comparación a dosis bajas

(0,9 %), lo que podría indicar que al ser animales muy jóvenes este ácido graso seguramente se depositó en la grasa intramuscular en cantidades altas y eso daría lugar a una peor valoración sensorial. En nuestro trabajo no se ha determinado la ingestión de DHA en la dieta de los cabritos, pero aunque los animales ecológicos han presentado significativamente un mayor % de DHA en la carne (0,13-0,19 % en los cabritos ecológicos y 0,09-0,10 % en los convencionales), sus características sensoriales no han sido más negativas que la de los cabritos convencionales. La pequeña diferencia en este ácido n-3 entre cabritos, junto al efecto y relaciones con otros ácidos grasos podrían explicar los resultados sensoriales encontrados en el presente estudio.

La dureza ha mostrado una interacción significativa entre el sistema de explotación y la raza (Tabla 1, Figura 1), de manera que los cabritos de raza Payoya y criados en sistema ecológico mostraron una menor dureza que los criados en sistema convencional ($P<0,05$) mientras que no se observaron diferencias significativas entre los dos sistemas para la raza Blanca Andaluza ($P>0,05$). Respecto a la facilidad de masticación, sólo se ha observado efecto del sistema de explotación ($P<0,001$), mostrando una mayor facilidad a la masticación los cabritos criados en sistema ecológico en comparación a los criados en sistema convencional. Sin embargo, nuestro equipo no ha encontrado diferencias significativas entre ambos sistemas de explotación, en ninguna de las dos razas, ni para la textura ni para la capacidad de retención de agua (resultados no publicados), parámetros que nos darían idea sobre la dureza o jugosidad de la carne.

La menor intensidad del olor, una mayor jugosidad, una menor dureza (solo en cabritos de raza Payoya) junto con una mayor facilidad a la masticación encontrada en la carne de los cabritos criados bajo un sistema de explotación ecológico, entendemos que pueden ser atributos de la calidad de la carne positivos, sobre todo en un mercado en el que predominan consumidores no habituados a este tipo de carne de cabrito.

En la Tabla 2 se presentan los resultados del análisis cualitativo para cada una de las razas y en cada sistema de explotación estudiado. De manera general, es importante mencionar que, salvo dos muestras analizadas del sistema convencional, todas las demás presentaron unas características sensoriales muy agradables para el panel de catadores. En el caso de la raza Blanca andaluza, los resultados muestran que existen claras diferencias para los descriptores del olor y aroma y sabores básicos para todas las muestras de carne analizadas entre sistema de explotación, excepto una (sesión 3ª). Los animales procedentes del sistema convencional de alimentación fueron descritos en términos de olor y aroma a hígado y cabrito y sabor básico ácido frente a los animales procedentes del sistema ecológico que fueros descritos en términos de olor y aroma a carne de cocido y sabores básicos a metálico. En cambio, en la raza Payoya no se observan claras diferencias entre sistema de explotación para los descriptores de olor y aroma, pero sí para los sabores básicos. En este sentido, la carne convencional resulta metálica mientras que la ecológica puede resultar también más sabrosa y ácida.

Para intentar agrupar las muestras según el sistema de explotación y la raza de procedencia se realizó un análisis de componentes principales. Los dos primeros CP explican casi el 66 % del total de la varianza de los atributos de calidad sensorial (Tabla 3). El CP_1 estaría formado principalmente por las siguientes medidas de la textura de la carne: por un lado la facilidad de masticación y la jugosidad, situada a la derecha del gráfico, y por otro, la dureza situada a la izquierda del gráfico (Figura 2). El CP_2 se caracteriza por la intensidad del olor y del aroma, ambos atributos de calidad situados en la parte superior del gráfico (Figura 2). La Figura 3 muestra la proyección de los cabritos, para los dos sistemas de explotación, en el plano definido por los dos CP. Aunque las muestras de carne han presentado gran variación, el sistema ecológico está preferentemente localizado en la parte derecha (mayor jugosidad y facilidad de masticación y menor dureza) e inferior (menos intensidad de olor y aroma) de la figura, mientras que el sistema convencional se localiza preferentemente en la parte izquierda y superior. La Figura 4 muestra la proyección de los cabritos para las razas, en el plano definido por los dos CP. A pesar de la variabilidad de los datos al igual que para el sistema, se pueden observar dos grupos, uno en la parte inferior del gráfico que se corresponde con la raza Blanca Andaluza (menos intensidad de olor y aroma) y otro a la izquierda del gráfico correspondiente a la raza Payoya (menos jugosidad y facilidad de masticación).

Conclusión

Los cabritos procedentes del sistema ecológico y los procedentes de la raza Blanca andaluza, en comparación a los del sistema convencional y de la raza Payoya, presentaron en general carnes con mejores atributos sensoriales (más tiernas, más jugosas, con mayor facilidad a la masticación) y menos intensidad de olor. En la raza Blanca andaluza existen claras diferencias entre sistemas para los descriptores del olor y aroma y sabores básicos, en cambio, en la raza Payoya sólo se observan claras diferencias entre sistema para los sabores básicos. Aunque la muestra presenta una gran variabilidad, siendo necesarios nuevos estudios con mayor número de animales, estos resultados preliminares serían favorables para promocionar la transformación de las explotaciones convencionales en ecológicas basadas en sistemas de pastoreo.

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Tabla 1. Valores medios (± E.S.M.) de los atributos del análisis sensorial descriptivo cuantitativo de la carne de cabritos lechales clasificados según el sistema de explotación y la raza.

Table 1. Mean (± E.S.M.) of the sensory quality measurements in kid meat, stratified by production system and breed.

Atributos	Sistema de Explotación(SE)		Raza (R)		Significación[1]		
	Ecológico (n=12)	Convencional (n=9)	Blanca (n=12)	Payoya (n=9)	SE	R	S × R
Intensidad de olor	5,81±0,07	6,17±0,08	5,80±0,08	6,18±0,05	***	***	ns
Dureza	4,31±0,11	4,95±0,17	4,53±0,13	4,65±0,17	***	**	*
Facilidad de masticación	4,97±0,15	4,45±0,19	4,91±0,16	4,52±0,17	***	ns	ns
Jugosidad	4,14±0,12	3,75±0,16	4,22±0,15	3,65±0,07	*	**	ns
Intensidad de aroma	5,36±0,07	5,84±0,10	5,38±0,07	5,82±0,09	ns	ns	ns

[1]* P < 0,05; ** P < 0,01; *** P < 0,001; ns: no significativo, P > 0,05. No ha habido efecto significativo del catador.

[1]* P < 0,05; ** P < 0,01; *** P < 0,001; ns: not significant, P > 0,05. There was no significant effect of the taster.

Tabla 2. Resultados del análisis sensorial cualitativo de la carne de cabritos lechales clasificados según el sistema de explotación y la raza.

Table 2. Qualitative analysis in kid meat, stratified by production system and breed.

Sesión	Blanca Andaluza				Payoya			
	Sistema ecológico (n=6)		Sistema convencional (n=6)		Sistema ecológico (n=6)		Sistema convencional (n=3)	
	Olor y aroma	Sabores básicos	Olor y aroma	Sabores básicos	Olor y aroma	Sabores básicos	Olor y aroma	Sabores básicos
1ª	Carne de cocido	-	Carne de cocido Hígado Cabrito	Sabrosa	Hígado	Metálico	Carne de cocido	-
2ª	Carne de cocido	Sabrosa Umami Metálico	Hígado Cabrito	Ácida	Carne de cocido	Sabrosa Umami	Hígado	Metálico
3ª	Carne de cocido Hígado	-	Carne de cocido Hígado	-	Carne de cocido Hígado Animal	Ácida	Hígado Animal	Metálico
4ª	Carne de cocido	Metálico	Carne de cocido Hígado	Ácida	Carne de cocido Hígado	Sabrosa Metálico		
5ª	Carne de cocido	Metálico	Carne de cocido Hígado Orina	Ácida	Carne de cocido	Sabrosa		
6ª	Carne de cocido	Metálico	Hígado Cabrito	-	Carne de cocido	-		

Tabla 3. Autovalor y varianza explicada para los dos primeros componentes principales de las medidas de calidad sensorial de la carne de cabritos de los dos sistemas de producción y las dos razas.

Table 3. Eigen value and explained variance for the first two principal components of the sensory quality measurements in kid meat of both production system and both breed.

Componentes	Autovalor	Varianza explicada (%)	Varianza acumulada (%)
1	2,27	37,86	37,86
2	1,67	27,88	65,74

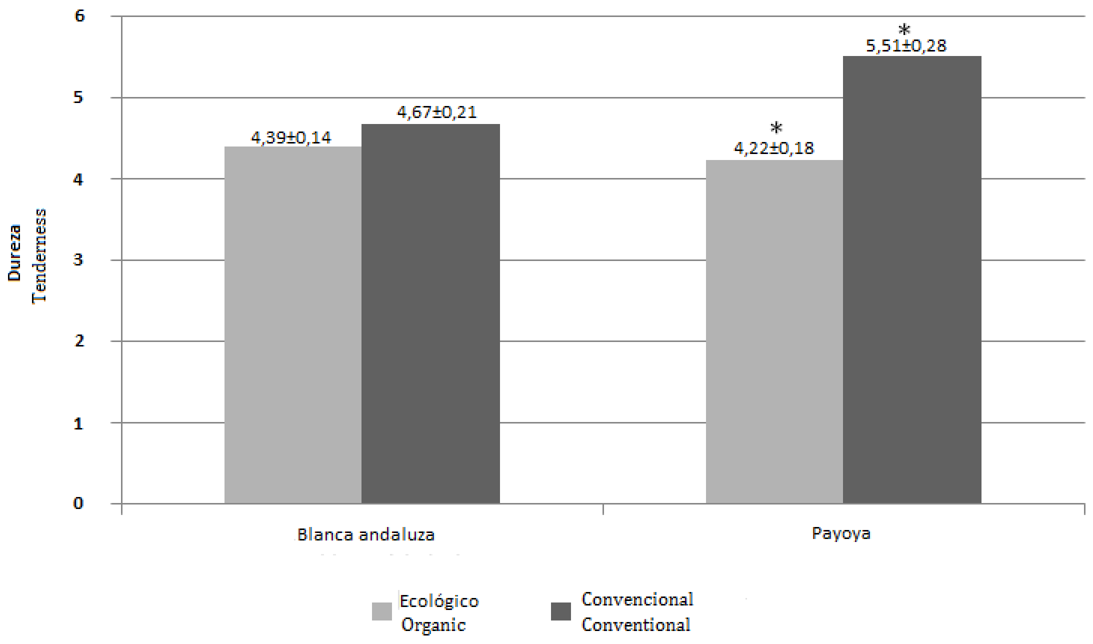

Figura 1. Efecto del sistema de producción ecológico (barras gris claro) y convencional (barras gris oscuro) en la dureza de la carne de cabritos lechales de las razas Blanca Andaluza y Payoya. * Medias para los sistemas ecológico y convencional, dentro de cada raza, son significativamente diferentes (P>0,05).

Figure 1. Organic (ligths bars) and conventional (dark bars) system effect on the tenderness in Blanca Andaluza and Payoya breads. * indicate significant differences among systems means.

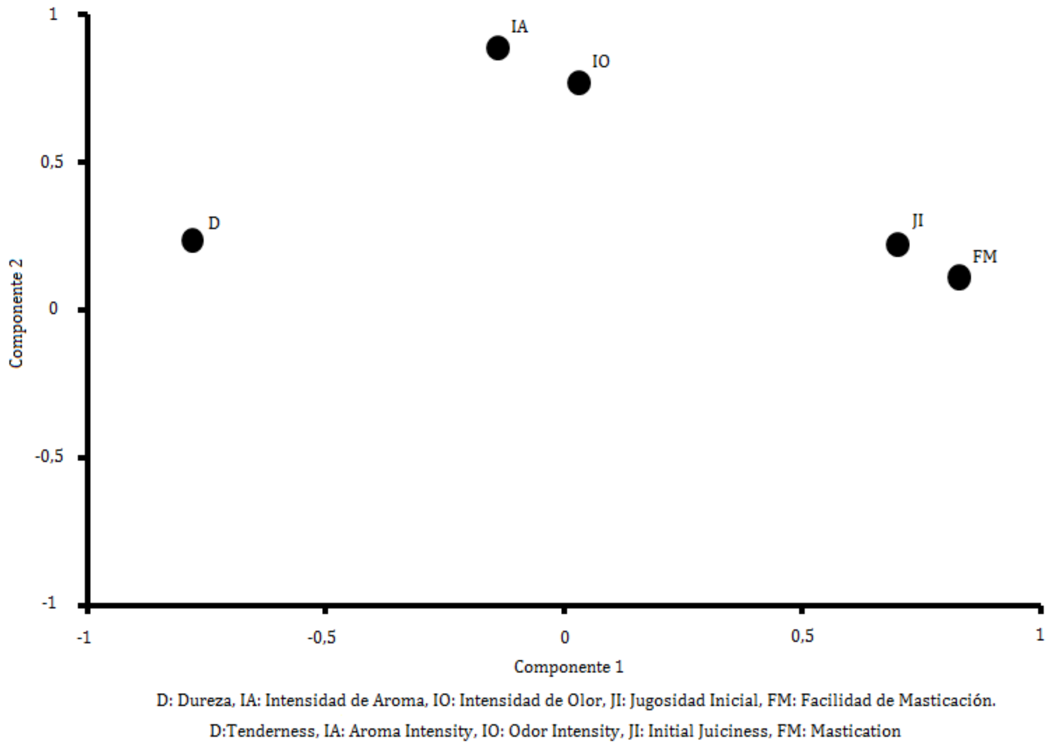

Figura 2. Proyección de los atributos de calidad sensorial de la carne de cabrito en el plano definido por los dos componentes principales

Figure 2. Projection of the sensorial quality measurements in kid meat in the plane defined by the two principal components.

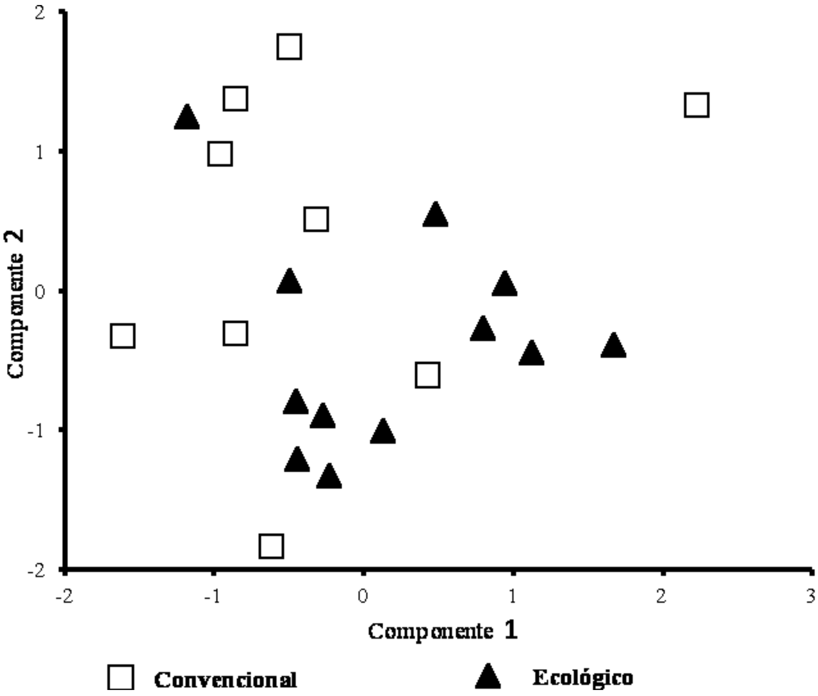

Figura 3. Proyección de los cabritos, para los dos sistemas de producción estudiados, en el plano definido por los dos componentes principales

Figure 3. Kids projection, for the two management systems studied, in the plane defined by the two principal components.

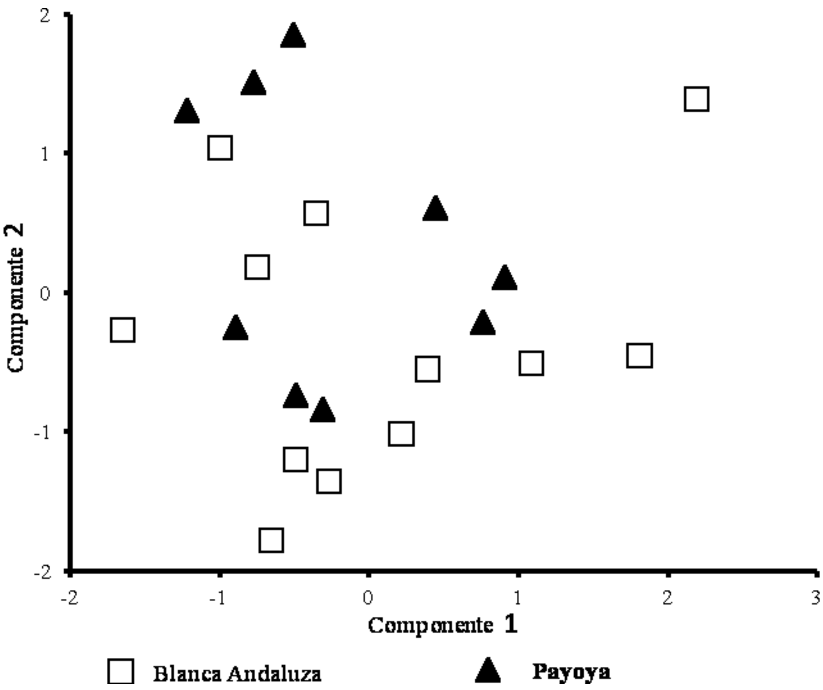

Figura 4. Proyección de los cabritos, para las dos razas estudiadas, en el plano definido por los dos componentes principales

Figure 4. Kids projection, for the two breads studied, in the plane defined by the two principal components.