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Published online: 02 Mar 2020.

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Effect of production system on growth performances and meat traits of suckling Messinese goat kids

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ABSTRACT

The aim of this study was to evaluate the effect of the production system on growth performances and meat quality of suckling Messinese goat kids. At birth, 102 suckling kids were divided into two homogeneous groups for sex and body weight (3.4 kg); animals of the SES group were fed exclusively with spontaneous pasture and kept in the stable during the evening; animals of the ES group were fed exclusively with spontaneous pasture, characterised by the presence of *Quercus suber*, and kept exclusively outdoors. From birth to weaning, kids were weighed every 10 days. At slaughter, carcase yields and meat quality traits on the *Longissimus dorsi* muscle were studied. Data were subjected to ANOVA. ES group showed the highest final body weight (10.53 kg vs. 9.40 kg; $p < .001$). As regard the meat traits, ES group showed the lowest final pH (5.63 vs. 5.96; $p < .001$), the lowest value of Hue (46.24 vs. 62.64; $p < .005$) and the highest values of cooking loss (ES 25.53% vs. SES 19.60%; $p < .05$) and shear force (ES 5.04 kg/cm^2 vs. SES 3.63 kg/cm^2; $p < .05$). Chemical composition showed similar values in both groups. Meat fatty acid composition showed the highest values of MUFA (45.89% vs. 40.90%; $p < .05$) and PUFA (0.14% vs. 0.11%; $p < .05$) and the lowest of $\omega - 6/\omega - 3$ ratio (4.89 vs. 6.98; $p < .05$) and Thrombogenic Index (1.64 vs. 1.98; $p < .05$) in the ES group. The results confirm the favourable characteristics of goat meat and the relation between the typical production system of goats in the Nebrodi area and their performances.

HIGHLIGHTS

- The production system did not affect the weight of kids at birth, while there were significant differences in kid's performance in relation to the breeding system.
- The chemical composition of the LD muscle was not affect by the production system.
- The production system significantly influenced the fatty acid composition of the meat.
- The meat quality parameters studied reflect the modern guidelines for a healthy diet recommend, that reduce the animal fat consumption, especially if rich in saturated fatty acids, and could be a tool to identify and characterise a product with Protected Designation of Origin (PDO) as 'capretto Messinese'.

Introduction

Goats are prolific and resilient small ruminant livestock with a wide ecological adaptation. Goat is a worldwide spread species with different specialties and aptitudes, the meat production is one of these. Its consumption varies widely depending on the region of the world considered. However, a common factor is the presence of few studies in comparison with ovine, especially those that characterise the quality of its products (related to carcase and meat). Availability and diffusion of characteristics of this species and its production, coming from scientific studies, could help breeders and society on the knowledge and on raising global awareness of its importance, conservation and productive possibilities. Goat has its own specific characteristics related to quality of its products with a presumed good acceptability by consumers. The main factors that influence goat carcase and meat quality are: breed or local breed, age, gender, weight at slaughter and some extrinsic factors as production system (Guzman et al. 2019), type of suckling (Ripoll, Alcalde et al. 2019;

Ripoll, De Guia Cordoba et al. 2019) and aging (Nudda et al. 2008; Guerrero et al. 2018).

In the marginal areas of South Italy, sheep and goat farming is traditionally performed using autochthonous breeds thanks to their good adaptability to the environment and exploitation of the poor feed resources available. Animals graze on natural pastures and receive supplementary feeding based on concentrates formulated in relation to their productive and physiological requirements. Natural pastures are in decline due to the climatic changes and to continuous human interference with the environment, and so they are unable to fulfil animal needs. This forces breeders to choose between sowing herbages or changing to intensive breeding systems. The former solution has the advantage of being cheap and respectful of eco-sustainability despite moderate profitability, while the latter increases farm management expenses in turn of higher productivity (Caputi Jambrenghi et al. 2007).

In Sicily (Italy), autochthonous goat breeds (Girgentana, Argentata dell'Etna and Messinese) are protected by regional policies through Local, National and European Operative Programmes of different institutions. Autochthonous and population caprine breeds are well adapted to marginal areas and they could produce by utilising these areas. In this region, the interest in caprine breeding used to be minimal, but it is improving probably in relation to the utilisation of forage resources in the mountain and in hilly areas, not used for other purposes, and thanks to their dietetic and nutritional characteristics of milk, cheese and meat. In Sicily 118,572 goats are reared (Annuario Statistico Italiano, 2017). Messinese goats are raised in the Nebrodi mountains, an area that extends for approximately 70 km in north-eastern Sicily, from the Peloritani mountains to the Madonie.

This study was undertaken to assess the influence of the breeding system of the Messinese suckling kids, raised in the Sicilian Nebrodi mountains, on growth performances and meat quality.

Materials and methods

Animals and diets

All the procedures used in this research were in compliance with the European guidelines for the care and use of animals in research (Directive 2010/63/EU 2010).

The study was carried out on 102 suckling Messinese kids, birth of multiparous goats, divided at birth into two groups homogeneous for sex and body weight called: group SES represented by fifty kids (30 males, 20 females) reared with their dams bred in a semi-extensive system, and group ES represented by fifty-two kids (29 males, 23 females) reared with their dams bred in an extensive system. Dams of the group SES were fed exclusively spontaneous pasture; in the evening, the dams were kept in the stable. Dams of the group ES were kept exclusively outdoors and their pasture areas were characterised by the presence of *Quercus suber*; therefore, the animals were fed also acorn (dry matter *ad libitum* (DM) 454.70 g/kg; crude protein 35.90 g/kg DM; ether extract 24.60 g/kg DM; crude fibre 13.40 g/kg DM; ash 15.0 g/kg DM). Each kid was weighed every 10 days, from birth to weaning (average 50 days). All kids were weighed just before slaughtering in an authorised, commercial, EU-licensed abattoir, following the recommendations of the European Council (Council Regulation (EC) No 1099/2009 2009) concerning the protection of animals at the time of killing. At slaughter, the weight of the hot carcase was determined and the relative yield was calculated as dressing percentage.

Meat technological characteristics

Instrumental meat quality characteristics investigated in the current study were carcase pH, cooking loss, Warner-Bratzler shear force and meat colour. Carcase pH was measured at 24 h post-slaughter, after refrigerated storage at 4 °C, using a WTW 330/SET 1 (Weilheim, Germany) pH-meter, equipped with a Hamilton Double-pore glass piercing electrode and an automatic temperature compensator. The pH measurement was performed directly on *Longissimus dorsi* (LD) muscle between 12th and 13th thoracic vertebrae. The LD muscle was removed from the both sides of carcase at 24-h post-mortem in order to assess instrumental meat quality characteristics and the right side of the carcase was used for cooking loss and Warner-Bratzler shear force determination, while samples from the left side was used for meat colour measurements (7–8 lumbar vertebrae included).

The colour was measured on a 2.5-cm thick slice of LD muscle following the Commission Internationale de l'Eclairage/International Commission on Illumination (1978) system colour profile for lightness (L^*), redness (a^*) and yellowness (b^*) using a desktop photometer (Spectral scanner, DV Tecnologie d'Avanguardia, Padova, Italy) calibrated against a standard white tile using illuminant source D65. Prior to colour evaluation, each sample was allowed to oxygenate at 4 °C for 45 min, covered with an oxygen permeable polyethylene film. After removing the polyethylene film, the meat colour was determined on one reading for the

whole slice of each sample. Cooking losses were determined on the samples, each 190 g on average, cooked by immersing the individual bags in a 95 °C water bath (WB-OD24, FALC Instruments, Italy) for several minutes until the internal temperature reached 75 °C; the sample temperature was detected using a thermocouple thermometer AMA-DIGIT (Buddeberg GmbH, Germany). After cooking, the bags were tempered at room temperature before opening to drain the liquid. Cooking loss was calculated using the formula:

$$\left[\frac{(\text{weight of raw meat} - \text{weight of cooked meat})}{\text{weight of raw meat}} \right] \times 100.$$

Tenderness of the cooked sample was measured as a shear force, using a Warner-Bratzler (WBSF) cell mounted on an Instron 5542 (Instron, High Wycombe, UK) universal testing machine. Measurement were recorded as the peak yield force in kg/cm^2, required to shear, at a 200 mm/min crosshead speed, perpendicularly to the direction of the fibres, three cylindrical cross-sections (10 mm diameter and 25 mm length) replicates from each sample (ASPA 1996).

Meat nutritional characteristics

Each sample of LD muscle was analysed in triplicate.

In each sample, the chemical composition was analysed according to AOAC (2016) methods for moisture (no. 950.46 2010), crude protein (no. 981.10 1983) and ash (no. 920.153 and no. 923.03) and according to ISTISAN (1996/34 met. B page 41) for total lipids (method with acid hydrolysis).

To determine the fatty acids profile, total fat was previously extracted (Folch et al. 1957) and subsequently turned into methyl esters (FAMEs) by direct transesterification (Christie 1993) according to Chiofalo et al. (2010). The oil extracted from each sample was suspended in a mixture of sulphuric acid/methanol (1:9, mL/mL) and heated for 3 h. The FAMEs were isolated by adding 1.0 mL of n-hexane. The mixture was shaken and, after 2 min, the formed top-layer with n-hexane was transferred into the vial for the GC injection. The FAMEs were analysed by GC-FID (Agilent Technologies 6890 N, Palo Alto, CA, USA) with a split/splitless injector, a flame ionisation detector and fused silica capillary column Omegawax 250 (Supelco, Bellefonte, PA, U.S.A.; 30 m × 0.25 mm I.D., 0.25-μm film thickness). Column temperature was programmed: initial isotherm of 160 °C (6 min), increment of 3 °C/min and final isotherm of 250 °C (30 min). Temperature of the injector and detector: 250 °C. Injection volume: 1.0 μL. Carrier gas: helium (1 mL/min). Split ratio: 1:50. Identification of fatty acids was made by comparing the relative retention times of FAME peaks from samples with standards from Supelco (Bellefonte, PA, USA). Chromatogram peak areas were acquired and calculated by Chemstation software (Agilent, Palo Alto, CA, USA). The concentration of each fatty acid was expressed as g/100 g, considering 100 g the summation of the areas of all fatty acid methyl esters identified. For each sample, the chromatographic analysis was replicated three times.

On the basis of the identified fatty acids, the Atherogenic Index (AI) and the Thrombogenic Index (TI) were estimated using the equations proposed by Ulbricht and Southgate (1991).

Statistical analysis

For performance parameters, animal means served as the experimental unit for statistical analysis. Data were analysed by ANOVA with the GLM procedure (v. 8.2, SAS Institute Inc., Cary, NC, USA; SAS/STAT; 2001), using production system as the classification factor with the following model:

$$Y_{ijkl} = \mu + D_i + P_j + A_k(i) + \varepsilon_{ijkl}$$

where Y_{ijkl} are observations, μ the overall mean, D_i the fixed effect of production system ($i = 2$), P_j the fixed effect of period ($j = 6$ for body weight; $j = 5$ for ADG), $A_k(i)$ is the random effect of animal k nested within diet i and ε_{ijkl} is the random residual.

Data of the technological and nutritional characteristics were analysed using a mixed model (Proc. MIXED of SAS, Version 8.2, 2001), which included the effect of the production system (SES, ES) as fixed factor and individual animal as a random effect.

The effect of sex was initially included in the model but it was not significant ($p = .50–.90$); thus, it was ultimately excluded.

Least square means and root mean square error were calculated. Comparisons between LS means were performed using the Tukey test. Differences were considered significant at $p < .05$.

Results

Production system did not affect the weight of kids at birth, while there were significant differences in kid's performance in relation to the production system; kids from ES group showed significant higher average daily gains and final body weight at slaughter than those of the SES group (Table 1). However, no significant difference was observed for the carcase yield at slaughter

Table 1. Influence of production system (extensive vs. semi-extensive) on growth performance and slaughter traits.

	SES	ES		
No. of observations	50	52	SEM	p value
Birth weight, kg	3.22	3.57	0.08	.191
Age, days	50	50	–	–
Final body weight, kg	9.40	10.53	1.74	.001
Average daily gain, g/kg	126.12	142.04	0.17	.042
Net warm dressing percentage, %	58.42	57.31	4.94	.320

SES group: fifty kids (30 males, 20 females) reared with their dams in a semi-extensive system.
ES group: fifty-two kids (29 males, 23 females) reared with their dams in an extensive system.
SEM: standard error of the mean.

Table 2. Influence of production system (extensive vs. semi-extensive) on technological parameters of *Longissimus dorsi* muscle.

	SES	ES		
No. of observations	50	52	SEM	p value
pH ultimate	5.96	5.63	0.08	.0001
Lightness (L^*)	42.68	39.30	1.74	.008
Redness (a^*)	4.24	6.66	0.58	.008
Yellowness (b^*)	8.05	6.98	0.77	.082
Hue angle[a]	62.64	46.24	0.94	.003
Chroma[b]	9.18	9.68	0.50	.267
Cooking loss, %	19.60	25.53	1.55	.049
Warner-Bratzler shear force, kg/cm^2	3.63	5.04	1.18	.016

SES group: fifty kids (30 males, 20 females) reared with their dams in a semi-extensive system.
ES group: fifty-two kids (29 males, 23 females) reared with their dams in an extensive system.
Warner-Bratzler shear force was analysed on three cylindrical cross-section for each sample of *Longissimus dorsi* muscle.
SEM: standard error of the mean.
[a]$H = ARCTG\ b^*/a^*$.
[b]$C = (a^2 + b^2)^{1/2}$.

Table 3. Influence of production system (extensive vs. semi-extensive) on chemical composition of *Longissimus dorsi* muscle (g/100 g of edible meat).

	SES	ES		
No. of observations	50	52	SEM	p value
Moisture	74.70	74.32	0.50	.159
Crude protein	22.19	22.14	0.55	.439
Intramuscular fat	1.17	1.12	0.11	.276
Ash	1.22	1.21	0.04	.413

SES group: fifty kids (30 males, 20 females) reared with their dams in a semi-extensive system.
ES group: fifty-two kids (29 males, 23 females) reared with their dams in an extensive system.
Each sample of *Longissimus dorsi* muscle was analysed in triplicate.
SEM: standard error of the mean.

Table 4. Influence of production system (extensive vs. semi-extensive) on meat fatty acids content (g/100 g)[a] of *Longissimus dorsi* muscle.

	SES	ES		
No. of observations	50	52	SEM	p value
C14:0	5.53	6.19	0.15	.357
C15:0	0.70	0.55	0.09	.070
C16:0	27.64	26.18	0.72	.379
C16:1	2.09	2.08	0.15	.992
C17:0	1.07	0.67	0.01	.010
C17:1	0.54	0.59	0.07	.522
C18:0	18.21	15.13	0.61	.163
C18:1n9	37.59	41.30	4.29	.023
C18:2n6	4.44	5.15	0.18	.038
C18:3n3	1.02	0.90	0.07	.438
C20:0	0.18	0.28	0.03	.031
C20:1n9	0.68	0.57	0.08	.236
C20:2n6	0.31	0.41	0.11	.238

SES group: fifty kids (30 males, 20 females) reared with their dams in a semi-extensive system.
ES group: fifty-two kids (29 males, 23 females) reared with their dams in an extensive system.
Each sample of *Longissimus dorsi* muscle was analysed in triplicate.
SEM: standard error of the mean.
[a]g/100 g, considering 100 g the summation of the areas of all fatty acid methyl esters identified.

(Table 1). The final pH showed significantly lower values in the LD muscle of the kids of the ES (Table 2).

Results of Lightness and Hue angle values showed significant lower mean values in the LD muscle of the kids of the ES than that of the SES group (Table 2); the L^* value of the muscle of SES group is indicative of extremely pale meats.

The cooking loss was significantly higher in the LD muscle of the kids of the ES than that of the SES group (Table 2).

Shear force values of Messinese kid meat was significantly higher in the LD muscle of the kids of the ES than that of the SES group (Table 2).

The chemical composition of the LD muscle was not affected by the production system (Table 3) and evidenced good protein contents and low lipid levels.

The production system significantly influenced the fatty acid composition of the meat (Tables 4 and 5). It can be observed that saturated fatty acids (SFA) were significantly lower in ES than SES groups. By contrast, monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids were significantly higher in ES than SES groups (Table 5) mainly for the higher ($p < .05$)

content of oleic and linoleic acids (Table 4). As regards the ratios of nutritional interest, the PUFA/SFA was significantly ($p < .05$) higher in ES than SES groups whereas, $\omega - 6/\omega - 3$ ratios and quality indexes (AI, TI) were significantly ($p < .05$) lower in the LD muscle of the kids of the ES than that of the SES group (Table 5).

Discussion

Results on final body weight could be due to the different pasturage pabulum of the dams that could have influenced the qualitative characteristics of the milk, in accordance to the results reported by Ugur et al. (2004) and Ozcan et al. (2014). Final body weight recorded for the kids of the ES group is similar to Todaro et al.'s observations (Todaro et al. 2004) on Messinese goats at 47 days of age, and higher than those reported for the Sarda (Vacca et al. 2014) and

Table 5. Influence of production system (extensive vs. semi-extensive) on meat fatty acid classes and nutritional indices of *Longissimus dorsi* muscle.

No. of observations	SES 50	ES 52	SEM	p value
SFA g/100 g[a]	52.26	47.12	0.28	.036
MUFA g/100 g[a]	40.90	45.89	0.67	.034
PUFA g/100 g[a]	5.44	6.73	0.13	.044
PUFA/SFA	0.11	0.14	0.11	.054
$\omega - 6/\omega - 3$ ratio	6.98	4.89	0.21	.040
AI	1.11	0.98	0.15	.081
TI	1.98	1.64	0.09	.043

SES group: fifty kids (30 males, 20 females) reared with their dams in a semi-extensive system.
ES group: fifty-two kids (29 males, 23 females) reared with their dams in an extensive system.
Each sample of *Longissimus dorsi* muscle was analysed in triplicate.
SEM: standard error of the mean.
SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; AI: Atherogenic Index; TI: Thrombogenic Index.
[a]g/100 g, considering 100 g the summation of the areas of all fatty acid methyl esters identified.

Garganica (Todaro et al. 2002) breeds slaughtered at the same age and Spanish breeds slaughtered between 42 and 46 days (Horcada et al. 2012). As expected, pH was highly correlated with meat colour parameters (Teixeira et al. 2011); the results observed in ES group are in agreement with Solomon et al.'s observations (Solomon et al. 1986) that reported a difference in pH in animals with greater glycogen concentrations in relation to the high-energy diets. Muscle colour is extremely important in suckling kid production whose carcases should be pale or pink (Santos et al. 2007). The ultimate pH is important to the chilled meat because it affects its shelf life, colour and quality; a high ultimate pH (above 5.8) can indicate stressed animals during pre-slaughter handling and generally means lower quality of meat (Lawrie 1998; Dhanda et al. 2003). However, the ultimate pH of the ES group recorded in this trial was in an acceptable range (5.6–5.8), considered optimal for high-quality goat meat (Solaiman et al. 2011).

From an economic point of view, cooking loss is considered as the most important technological trait, reflecting the water-holding capacity of the meat and meat products (Lawrie 1998). In general, the lower the cooking loss, the better the juiciness of the meat. This is another valuable quality trait, useful in market promotion efforts. Overall, the mean values recorded for both groups are within the normal range reported for goat meat from 19.1% to 25.4% (Bonvillani et al. 2010) and are in agreement with those by Safari et al. (2001) who have found a very low correlation between pH and WBSF in different sheep genotypes.

There was a significant effect of final body weight and carcase weight on WBSF maximum load. These results agree with those of several studies (Dhanda

et al. 1999, 2003; Marichal et al. 2003; Argüello et al. 2005), which stated that the cutting force increases as carcase weight increases. Nevertheless, WBSF can be qualified as very good for both groups considering that the WBSF values of kid meat over 5.5 kg/cm² are often be considered as objectionably tough both by a trained sensory panel and by the consumers (Weeb et al. 2005).

The result of meat composition was close to the often-quoted standard composition (Zurita-Herrera et al. 2013). The low lipid level was probably in relation to a low capacity of goats, compared to the sheep, of deposition of intramuscular fat as observed in the 'Merino precoce lambs' slaughtered at 25–32 days of age (Pérez et al. 2012) and in the 'Agnello di Sardegna PGI' slaughtered at 30–40 days of age (Addis et al. 2013) which shows about a twofold percentage of intramuscular lipids. Moreover, the Messinese kid meat had less intramuscular fat content than the other Sicilian breeds such as Maltese and Girgentana reared in the same environment and slaughtered at a similar age (Vicenti et al. 2001; Todaro et al. 2002) and the Sarda and Garganica kids slaughtered at 9–10 kg of body weight at approximately 6 weeks of age (Nudda et al. 2008; Longobardi et al. 2012). The fat content was similar to that found in LD muscle of Portuguese native breeds by Santos et al. (2008) and in two Spanish meat goat breeds (Blanca Andaluza and Blanca Celtibérica) and one dairy breed (Malagueña) slaughtered at between 42 and 46 days of age (Horcada et al. 2012). In terms of fat, both the chemical and physical properties of fat influence the sensory, keeping and healthy properties of meat (Weeb et al. 2005; Webb and O'Neill 2008).

Our results are very interesting from the nutritional point of view and confirm the favourable characteristics of goat meat for health-conscious consumers (Mahgoub et al. 2002). The degree of saturation of fat (ratio between SFA, MUFA and PUFA) influences the consistency, chemical composition and sensory characteristics of carcase fat and the shelf life of meat products (Weeb 2014). Muscles with a high percentage of unsaturated fatty acids (UFA) are desirable because they had no adverse implications on consumers health (Banskalieva et al. 2000). On the contrary, the SFAs are recognised as health risk factors (Ulbricht and Southgate 1991). A high prominence is attributed to the MUFA, and particularly by the oleic acids that reducing the oxidation of the cholesterol LDL may slow the progression of atherosclerosis (Parthasarathy et al. 1990). Specifically, the obtained results for oleic acid and MUFA in the meat of ES group could be

related to the pasture area, where the dams were kept and characterised by the presence of *Q. suber* with a 53.58% of oleic acid content that increased the content of these acids in the meat of the kids of ES group. Similar observations are reported by Pamukowa et al. (2018) in the milk of Bulgarian white dairy goat pasture-raised. In the view of food traceability, the *Q. suber* could represent a biomarker of the feed chain and, at the same time, an added value for animal and consumer health. Moreover, it is well known that PUFA's have a beneficial effect on health by, for example, decreasing the risk of stroke, reducing serum triacylglycerol levels, reducing blood pressure and insulin resistance and modulating the glucose metabolism (Li et al. 2003). Among the PUFAs, fatty acids are known with anti-atheratogenic action belonging to the $\omega - 6$ PUFAs class, and anti-thrombogenetic effect (Ulbricht and Southgate 1991) belonging to the $\omega - 3$ PUFAs class. Within PUFA, the ratio of $\omega - 6/\omega - 3$ of less than 5 is acceptable (Raes et al. 2004) as observed in the LD muscle of the kids of the ES (4.89) than that of the SES group (6.98). The optimal nutritional value of the $\omega - 6/\omega - 3$ ratio has still not been completely assessed both for human and animals; studies on the relationship between $\omega - 6/\omega - 3$ ratio and the pathogenesis of many diseases, including cancer, cardiovascular, inflammatory and autoimmune diseases, indicate that the optimal ratio may vary with the disease or condition under consideration. This is consistent with the fact that chronic diseases are multigenic and multifactorial. In this study, the breeding system improved the unsaturation (MUFA and PUFA) degree and the $\omega - 6/\omega - 3$ ratio.

According to Ulbricht and Southgate (1991), atherogenic and thrombogenic indices might better characterise the health properties of vegetables or animal food with respect to a simple approach based on total saturated fatty acids or on the ratio of polyunsaturated/saturated fatty acids. Fatty acids profiles and the atherogenic and thrombogenic indices of goat meat showed significant differences, with more favourable fatty acid profile in the goats raised in extensive conditions. Such variability indicates that breeding strategy can enhance the favourable fatty acids that may positively impact the health of the consumer, lowering the risk of hypercholesterolaemia, atherosclerosis and thrombogenesis.

Conclusions

The production system did not affect the weight at birth, carcase yield and the chemical composition of the meat, while it affected some performance characteristics that showed a better average daily gain and final body weight in kids bred in an extensive production system. Furthermore, the production system has significantly influenced the meat fatty acid composition, showing a lower saturated fatty acid content, a higher level of monounsaturated and polyunsaturated fatty acids, a better atherogenic and thrombogenic index and a ratio $\omega - 6/\omega - 3$ acceptable of the meat of the kids bred in an extensive production system. The results should encourage Sicilian farmers to choose a cheap and eco-sustainable production system looking to the production of a 'local niche' food obtained from indigenous goats, whose breeding is moderately profitable but actively contributing to the maintenance of the fragile Sicilian environment.

In this perspective, the production system could be a tool to identify and characterise a product to develop a specific production specification that leads to the protected designation of origin (DOP) as 'capretto Messinese'.

Author contributions

L.L. and V.C. contributed to the project administration, conceptualisation and writing original draft; V.L.P. performed the analyses; B.C. supported the acquisition and interpretation of data and contributed in writing the article. All the authors gave final approval to the manuscript and any revised version submitted.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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