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Meat quality of suckling goat raised in differents feeding systems

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ABSTRACT. The objective of this work was to evaluate the effect of three breeding systems on the organoleptic quality and the physico-chemical composition of kids goat meat. Were used thirty newborn baby goats of 3.35 kg ± 0.65 kg crossed Parda Alpina x Undefined Race (SPRD) submitted to three breeding systems: Traditional system-TS; Intensive Feeding System without Concentrate- IS and Intensive Feeding System with Concentrate- IS+C. When the goats reached 12 kg, the animals were slaughtered and chemical and physical analyzes were performed in the evaluation of the meat and sensorial. The experimental design was completely randomized, submitted to analysis of variance and compared by the Tukey test and Ryan-Einot-Gabriel-Welsh at 5%. All analyzed variables were also submitted to Pearson correlation. The meat of the goats submitted to IS+C and IS presented higher intramuscular fat content and better flavor and aroma scores. A of Goats that used concentrated ration (TS and IS+C) showed a more intense red color in the meat than the animals that did not receive concentrate in their diets, besides presenting higher lipid contents in their composition, better scores for these two organoleptic characteristics. The chemical composition of goat meat in both breeding systems indicates that it is low in fat and high in moisture and therefore classified as very tender and juicy. The meat obtained from the IS+C, in general, presented better attributes than the others, believing it in the markets of meat of high quality.

Keywords: flavour; lean meat; kids; tenderness.

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Introduction

In Brazil, the use of dairy goats for meat production presents a promising market for expansion, due to the great demand of this product in some regions of the country (Madruga & Bressan, 2011). The meat of the suckling kid is a typical delicacy very appreciated and used in the high gastronomy, serving a niche market of high quality and, therefore, of greater added value to the product. The value of this meat is due to its sensorial and nutritional qualities, particularly because it has a pleasant taste and odor, very similar to milk (Longobardi et al., 2012).

The Northeast region of Brazil stands out for having the largest effective goat herd, and in some states of this region a consolidated milk basin (Anuário da Pecuária Brasileira [ANUALPEC], 2019). In specialized local herds for goat milk production, this product represents the main source of income for producers. In this context, kid goats are sometimes discarded soon after birth, since their use in meat production still constitutes an uneconomic activity for the local reality.

The substitution of goats' milk for milk substitutes during the suckling of goats is a good option since, on average, goat's milk is priced twice as high as cow's milk, being, according to Peña et al. (2009), one of the factors that determine the abandonment of the traditional system of goat production and its replacement by the breeding system using artificial breast-feeding with milk substitutes. According to Goetsch, Merkel, and Gipson (2011), the consumption of milk through breastfeeding by the neonate can impact on its characteristics of the meat when compared to a dietary substitute milk.

The quality of goat meat is influenced by biotic and abiotic factors, such as: animal age, sex, physiological state of the living animal, postmortem muscle biochemistry, fat, connective tissue, carcass composition, feed effect on taste, protein and fat content, as well as the effect of the genetic make-up of goats. Thus, Peña et al. (2009) cited that exclusively milk feeding by kids in the first 6-8 weeks improves their growth and housing characteristics. Additionally, Argüello, Castro, Capote, and Solomon (2005) reported that kids fed with natural breastfeeding present slightly softer and juicier meat than animals raised with concentrate.

The objective of this study was to evaluate the effects of different breeding systems of breastfed kid on the sensorial quality and physical and chemical characteristics of the meat.

Material and methods

The experiment was conducted simultaneously in two properties with different management systems, both located in the semi-arid region of the state of Paraíba, Brazil. In the first property, characterized as a traditional farm, located in the geographical coordinates (7° 37'8002 "S and 36° 52'1198" W), altitude 458 m and average temperature of 24°C, having as main economic activity dairy goat. The second area, characterized as an intensified production system, located at the Experimental Station of Pendência, belonging to the State Agricultural Research Company of Paraíba (EMEPA-PB), located in the geographical coordinates with a latitude of 7° 8 '18 "S and 36° 27 '2 "W, with an altitude of 534 m and an average temperature of 30°C.

The study protocol of this research was approved by the Ethics Committee on the use of animals of the Federal University of Paraíba (CEUA nº 0203/13). A total of 30 male newborns (10 per treatment) were selected from a homogenous stock, with an initial weight of 3.35 kg ± 0.65 kg, mixed breed Parda Alpina x without defined racial pattern (SPRD). Animals were divided into three groups, according to their breeding systems: 1) Traditional system - TS; 2) Intensive feeding system without concentrate – IS and Intensive feeding system with concentrate – IS+C.

In the traditional system, goats were managed with the same practices with which the local farmer drove his herd. The animals at birth were given all necessary care (cleaning and disinfecting the navel, supplying colostrum, weighing and identification with numbered earrings), remaining with their mothers throughout the experimental period. Breastfeeding of these pups was carried out in a controlled natural way twice, consisting of the residual milk left after the daily milking of the goats. The goats, with their mothers, had free access to pasture with buffel grass (*Cenchrus ciliaris* L.), remaining with them until the end of the afternoon, when they were then separated from the goats and placed in a collective stall.

After the second week of life, they received feed supplementation in the trough, consisting of fodder palm (*Opuntia fícus-indica* L.), chopped (*ad libitum*) and standard meal concentrate concentrated standardized meal based on crushed corn, soybean meal, wheat bran and cotton pie (91.9% dry matter, 17.5% crude protein, 2.0% ethereal extract and 6.0% ash) corresponding to approximately 1.0% of the live weight of each animal.

In the two intensive systems, kids stayed with their respective mothers during the first 24 h of life, receiving colostrum and postpartum care during this period, and then separated from their mothers, weighed and identified with earrings and driven to a protected shed with collective bays equipped with feeders and drinking fountains; and received throughout the experimental period pasteurized bovine milk, supplied at a temperature of approximately 38ºC in two meals a day, at 07:30 hours and at 15:30 hours in gutters. The dairy diet was supplied individually in plastic containers, each animal receiving the total daily volume corresponding to 20% of its live weight. This supply being adjusted every 7 days up to the limit of 1.5 liters of cow's milk per day distributed in two blowjobs. In addition to the liquid diet, in the IS treatment, animals received Tifton hay *ad libitum*. Already in the IS+C system, in addition to the ad libitum Tifton hay acess, a commercial pellet concentrate (87.0% dry matter, 22.0% crude protein, 3.0% ethereal extract, 8.5% Ash), and it is gradually offered up to a maximum of 0.250 kg/animal/day.

The body weight of the animals were determined as the criterion for slaughter when the animals reached the average live weight of 12 kg and were subjected to previous fasting of solids and liquids for approximately 18 hours. The slaughtering procedures were carried out in the experimental station of Pendência, following the rules of the Technical Regulation of Inspection of Animal Products -RISPOA.

After slaughter, the carcasses were washed, weighed and hung by the calcaneal tendons on appropriate hooks and spaced from each other. Afterwards, they were sent to the cold room at 4ºC for 24 hours. The *Longissimus lumborum* and *Longissimus dorsi* muscles were then packed in a vacuum bag, identified and stored under freezing at -20ºC until further analysis.

The analyzes were carried out at the Food Analysis Laboratory of the Nutrition Department of the Health Sciences Center of the Federal University of Paraíba, João Pessoa-PB. For the analysis of the chemical composition, the samples were thawed in a conventional refrigerator for 24 hours, after the toilet and with the withdrawal of connective tissue, the trituration was carried out in a domestic blender until a homogeneous mass was obtained.

Left-side samples of the *Longissimus dorsi* (LD) muscle from each treatment were used to determine the centesimal evaluation. The moisture content, ashes and protein of the meat were carried out according to the techniques recommended by Association Official Analytical Chemist (AOAC, 2005) in articles 985.41; 920,153 and 928.08, respectively. Total lipids were measured according to the methodology described by Folch, Lees, and Sloane-Stanley (1957), all analyzes being performed in duplicate and presented in natural matter. For the analysis of the fatty acid profile of the meat samples, the lipid extract resulting from the fat determination was used, which were saponified and esterified as described by Hartman and Lago (1973). This material was then subjected to separation using a gas chromatograph (model GCMSQP5050A, SHIMADZU, Brazil) coupled to a flame ionization detector. It has a capillary column of fused silica with dimensions of 60 m of length by 0.53 mm of internal diameter and 1 µm of film thickness.

The analyzes of weight loss by cooking (PPC) were determined according to the procedure cited by Duckett, Klein, Dodson, and Snowder (1998a). The texture was evaluated by shear force (HR), according to the methodology described by Duckett et al. (1998b). Water retention capacity (CRA) was determined according to the method proposed by Miller and Groninger Junior (1976).

Samples of the *Longissimus lumborum* (LL) muscle were used to evaluate the sensorial attributes of the meat. The panel consisted of nine testers, five women and four men, aged 25-35 years old, selected and trained according to the methodology detailed by Stone, Sidel, Oliver, Woolsey, and Singleton (1974).

Meat samples of each treatment were cut into cubes with 2.0 cm of edge, then they were submitted to the dry cooking process in electric grill at 170°C, until the temperature in the center point of the cube, monitored through of a digital thermometer (Delta OHM model HD 9218, Caselle di Selvazzano, Italy), reached 71°C, which took approximately eight minutes. No salt or condiments were added to the samples. Subsequently, the meat cubes were packed in aluminum foil, transferred to treatment-coded beakers and packed in a heater at 55°C to maintain the temperature until sensory evaluation. The sensory evaluation was performed in three sessions, and in each of them, the panelist received in a disposable plastic dish a sample of the respective treatment, coded with random numbers of three digits. The meat cubes were served following the balance of the position of the samples proposed by Macfie, Bratchell, Greehoff, and Vallis (1989), in order to avoid possible order effects and first-order effects and transition. The tests were performed in individual booths, under controlled illumination and temperature conditions. The tasters evaluated the following attributes of the meat: appearance, aroma, softness, juiciness, flavor and overall evaluation. A glossary developed during the training was used as reference for this evaluation. At each session, the panelists individually filled out an evaluation form with a semi-structured nine-point scale, with the ends anchored at less (1) and more (9) favorable for each characteristic under analysis.

The design used for the evaluation of the variables was completely randomized, with three treatments (breeding systems), each with 10 replicates. The data were submitted to analysis of variance (ANOVA) and their means were compared by the Tukey test at 5% for the physico-chemical characteristics and Ryan-Einot-Gabriel-Welsh at 5% for the sensory parameters, using the statistical package Statistical Analysis Software (SAS, 2004). All analyzed variables were also submitted to Pearson correlation analysis.

Results and discussion

The feeding system affected ($p < 0.05$) the parameters of appearance, aroma and flavor (Table 1) of the sukling goat meat. Similar data were found by Bañón, Vila, Price, Ferrandini, and Garrido (2006), who reported that the use of milk substitute in goats provided a greater intensity of odor and flavor in cooked meat.

Table 1. Sensory attributes of the meat goats raised in different feeding systems.

Variables	Systems			P-*value*
	TS	IS	IS+C	
Appearance	3.77a±0.38	2.97 b±0.28	3.88 a±0.41	0.0059
Aroma	3.33 b±0.45	4.19 a±0.51	4.29 a±0.51	0.0356
Softness	5.01±0.42	5.77±0.28	4.97±0.41	0.0500
Succulence	4.15±0.40	4.22±0.33	4.56±0.37	0.3672
Flavor	2.90 c±0.36	3.42 b±0.38	4.00a±0.41	0.0002
Acceptance	6.63±0.20	6.86±0.22	6.90±0.17	0.3452

Averages followed by distinct letters on the same line differ by Ryan-Einot-Gabriel-Welsch at 5%.

The meats of the different feeding systems presented similarities ($p > 0.05$) for the attributes of softness, succulence and global acceptance. This fact can be justified by the homogeneity of the genotype used and the similarity of weights and ages of the animals to slaughter in both treatments. The appearance of the meat is intrinsically related to the color of presentation of the same to the consumer. The light color is associated with the idea that it comes from young animals, giving greater preference of commercialization to pale or pink meats.

The best appearance scores for TS (3.77) and IS+C (3.88) should be noted that in both treatments that the animals received concentrated ration. Possibly, this solid supplemental feed with concentrate attributed to the meat coloration more red than those that did not receive it. According to Ozcan et al. (2014), the color differences in goat meat between production systems may be the combined result of the pre-slaughter live weight, the exercise level of the animals and the different diets. At IS system, the *in natura* meat had a pale pink presentation and therefore, obtained a lower score by the evaluators. According to Sañudo et al. (2012), animals fed exclusively with milk and slaughtered at an early stage present the paler meat in relation to those receiving the highest amount of concentrate. This pallor is probably linked to the small amount of iron contained in the substitute provided to the goats.

According to Webb, Casey, and Simela (2005), flavor and aroma are two complex attributes of the meat, affected by the species, age, fat, tissue type, location, sex, diet and cooking method. These two attributes are directly related to the fat content present in the muscle. It is possible to observe that the treatments that presented the highest scores in the aroma and flavor attributes were IS+C (4.29 and 4.00) and IS (4.18 and 3.42), respectively. These two systems also presented the highest mean meat lipids content (2.18% and 1.96%, respectively). Costa, Silva, Medeiros, and Batista (2011) evaluating two systems of goat rearing, also observed that the intensity of flavor was influenced by the breeding system, finding meat superiority in animals raised intensively.

The breeding systems influenced ($p < 0.001$) the lipids content of the meat, with the IS+C showing a higher value (2.18%), the TS lower (1.79%) and the IS similar to the others. Probably, the increase in energy levels in the diet of goats may have raised the lipid levels of meat.

The moisture content found in fresh meat samples ranged from 75.4% to 76.2% (Table 2). The highest concentration of moisture was detected in TS (76.28%) and IS (76.12%), thus the meat of goats submitted to these treatments are considered leaner and with lower fat content than that of IS+C. It is observed that the moisture and lipid concentrations of the different systems present an inversely proportional behavior.

The water retention capacity was not affected by the type of feeding system, the mean value among the treatments, 99.8%, can be considered suitable fot this variable. It is known that there is a high and positive correlation between the water retention capacity and the succulence (Caldara et al., 2012) of the meat and this fact was verified in the present study, considering that the meat of the goats also presented adequate value for succulence (Table 1).

Table 2. Centesimal omposition of centesimal and physical charcacteristics of the meat goats raised in different feeding systems

Variables	Sistems			p-value
	TS	IS	IS+C	
Moisture (%)	76.284 a±0.174	76.121 a±0.202	75.493 b±0.155	0.0067
Ash (%)	0.959 b±0.015	0.965 b±0.025	1.056 a±0.012	0.0005
Lipids (%)	1.795 b±0.085	1.967 ab±0.073	2.180 a±0.076	0.0040
Protein (%)	20.960±0.122	20.946±0.174	21.269±0.103	0.1760
PPC (%)[a]	42.311±1.606	43.002±0.731	43.048±1.935	0.9284
FC(kg/cm^2)[b]	4.141 a±0.209	3.898 a±0.231	2.421 b±0.184	0.0001
WHC (%)[c]	99.777±0.023	99.750±0.019	99.755±0.019	0.6165

Means followed by distinct letters in the same line differ significantly by Turkey 5%. [a]PPC: loss by cooking; [b]FC: shear force; [c]CRA = water holding capacity.

The shear force evaluates the softness of the meat, the higher the shear force, the lower the softness (Dhanda, Taylor, & Murray, 2003), and the suckling kids meat should preferentially have a high softness. Differences between the production systems were observed, once ST and IS showed the highest values (4.14 kgf cm^{-2} and 3.89 kg cm^{-2}, respectively. The IS+C showed the lowest shear force in the meat (2.42 kgf cm^{-2}), being thus the softer meat. Probably, its softness may be associated with higher intramuscular fat content. Animals receiving concnetrate in the diet produce meat that is softer than those fed on forage, since feed rich in concentrates produces meat with a higher degree of fat cover (Goetsch et al., 2011).

The results of the Pearson correlation analysis for breastfed goat meat are shown in Table 3, and it is possible to evaluate the degree of association between the centesimal composition, the physical composition and the sensory attributes of goat meat in three feeding systems. There is a high ($p < 0.001$) and negative correlation between the moisture variable and the lipid ($r = - 0.74$) and protein ($r = - 0.89$) content, indicating that because they are animals young people, the nutrients they eat were not intended for fat deposition but for the formation of muscle tissues. The characteristic organoleptic appearance showed a highly significant correlation ($p < 0.001$) and positive with aroma ($r = 0.65$) and flavor ($r = 0.67$).

Table 3. Pearson correlation matrix among the quality parameters of the breastfed kid's meat

	Moisture	Grey	Lipids	Protein	FC	Appearance	Aroma	Softness	Succulence	Flavor	Acceptance
Moisture	-	-0,26*	-0,74***	-0,89***	0,37**	-0,11^{ns}	-0,27*	0,16^{ns}	0,05^{ns}	-0,30*	0,17^{ns}
Grey			0,31*	0,022^{ns}	-0,34**	-0,011^{ns}	-0,009^{ns}	-0,17^{ns}	-0,010^{ns}	0,14^{ns}	0,035^{ns}
Lipids			-	0,37**	-0,25^{ns}	-0,12^{ns}	0,01^{ns}	-0,11^{ns}	-0,022^{ns}	0,23^{ns}	-0,04^{ns}
Protein				-	-0,30*	0,22^{ns}	0,31^{ns}	-0,14^{ns}	-0,06^{ns}	0,25^{ns}	-0,22^{ns}
FC					-	-0,06^{ns}	-0,04^{ns}	-0,10^{ns}	-0,20^{ns}	-0,14^{ns}	-0,20^{ns}
Appearance						-	0,65***	-0,15^{ns}	-0,59***	0,67***	-0,13^{ns}
Aroma							-	-0,11^{ns}	-0,62***	0,84***	-0,23^{ns}
Softness								-	0,49***	-0,20^{ns}	0,10^{ns}
Succulence									-	-0,59***	0,19^{ns}
Flavor										-	-0,10^{ns}
Acceptance											-

FC: shear force; ns: not significant. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

In the present study, possibly, the appearance influenced the behavior of the panelists interfering in the judgment of the aroma and flavor variables.

The aroma attribute was correlated ($p < 0.05$) and negatively with juiciness ($r = -0.62$), and, positively with flavor ($r = 0.84$). The reduction in the amount of subcutaneous and intermuscular fat present in the kid meat can interfere in the profile of some fatty acids, which influence in the aroma of the same one. By virtue of these changes there is a softening of the fat, which certainly affect the succulence of the flesh.

Table 4 shows the fatty acid profile and the total concentrations of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFAs) present internally in the *Longissimus dorsi* muscle of goats submitted to different systems of production.

It was detected 28 fatty acids that represent the sum of the fatty acids present in the neutral lipid fraction, composed of triglycerides and small amounts of free fatty acids. From this total, it was observed that the acids: oleic (29%), palmitic (28.34%) and stearic (17.65%) together represented approximately 75% of the total fatty acids present in the samples. This proportion is in agreement with that commonly found in goat meat (Zurita-Herrera, Bermejo, Henríquez, Vallejo, & Costa, 2013). The percentages of SFA determined in the analyzes of the samples varied from 48.0% to 65.3%, similar values were reported by Zurita-Herrera et al. (2013) in animals with similar characteristics. In general, diet effects on tissue fatty acid (FA) concentrations in goats kids appear similar to those for other ruminant livestock species because of incomplete ruminal microbial biohydrogenation. However, effects of the dietary FA profile are not always easy to predict, with consideration necessary for factors such as differences among FA in extent of absorption and degree ofinhibition of de novo tissue synthesis. Levels of saturated and monounsaturated FA are greater in goats consuming concentrate in confinement (Goetsch et al., 2011).

The feeding system affected ($p < 0.05$) the intramuscular saturated fatty acid (SFA) profile. The IS+C treatment had a higher concentration (65.3%) when compared to IS (48.5%) and ST was similar to the others. Possibly, the supply of concentrated ration in the diet favored the increase in the concentration of SFA. Management influenced ($p < 0.05$) the concentration of PUFA in the different groups, with the animals fed the IS higher concentration (16.5%) and the kids submitted to the TS lower (7.75%), having obtained IS+C similar the other systems.

Table 4. Fatty acids profilein the intramuscular lipid fraction of the *Longissimus dorsi* of the meat goats raised in different feeding systems.

	Feeding systems			
Fatty acids (%)	Traditional	IS	IS+C	P-*value*
C10:0	0.0120	0.0180	0.0180	0.9557
C12:0	0.2560	0.2960	0.3580	0.3835
C14:0	3.2640	4.1840	5.3740	0.0621
C14:1n5c	0.0540 ^{b}	0.2460 ^{ab}	0.4280 ^{a}	0.0201
C15:0	0.5520 ^{b}	0.7320 ^{ab}	0.9580 ^{a}	0.0016
C16:0	24.282 ^{b}	26.588 ^{ab}	34.158 ^{a}	0.0244
C16:1n7c	1.1920 ^{b}	1.9800 ^{ab}	2.7340 ^{a}	0.0178
C17:0	1.3220 ^{ab}	1.0780 ^{b}	1.6040 ^{a}	0.0348
C17:1n7c	0.6640	0.5540	0.4480	0.5449
C18:0	18.616	14.972	19.370	0.1529
C18:1n9c	34.864	30.572	21.588	0.2242
C18:1n9trans	2.2360	1.8420	1.4880	0.7193
C18:1n11c	4.954	0.230	0.120	0.1100
C18:2n6c	1.254^{b}	9.010 ^{a}	2.858 ^{ab}	0.0280
C18:2n6trans	0.0100	0.0220	0.0060	0.7215
C18:3n6c	0.1000	0.1500	0.0620	0.3268
C18:3n3	0.2000	0.3460	0.0980	0.2914
C19:0	0.0760 ^{b}	ND	0.4120 ^{a}	0.0092
C20:0	0.0920	0.0600	0.1200	0.5919
C20:1n9c	0.0800	0.0740	0.1160	0.7342
C20:2n6c	0.7380	0.7760	0.8820	0.8492
C20:3n6c	0.3520	1.1700	0.4720	0.1658
C20:3n3c	4.724	4.626	2.984	0.6812
C20:4n6c	0.0280	0.0200	0.1100	0.1767
C20:5n3c	0.0820	0.4080	0.2760	0.2397
C21:0	ND	ND	2.8520 ^{a}	0.0173
C22:0	ND	ND	0.040 ^{a}	0.3966
C24:0	ND	0.0400	0.0760	0.5707
SFA	48.472 ^{ab}	47.968 ^{b}	65.340 ^{a}	0.0289
MUFA	44.044	35.498	26.922	0.0721
PUFA	7.488 ^{b}	16.528 ^{a}	7.748 ^{ab}	0.0283
PUFA/SFA	0.1515 ^{b}	0.3506 ^{a}	0.1270 ^{b}	0.0088
MUFA/SFA	0.9284 ^{a}	0.7440 ^{ab}	0.4753 ^{b}	0.0475
n-3/n-6	3.254 ^{a}	0.480 ^{b}	1.557 ^{ab}	0.0518

a, bMeans followed by distinct letters differ from one another by the Tukey test at 5% probability. ND - not detected.

The PUFA/SFA ratio was higher ($p < 0.05$) for the meat of the goats submitted to IS with an average of 0.35, being very close to the recommendation suggested by Wood et al. (2004). The PUFA/SFA and n−6/n−3 ratios are two indices to determine how fatty acids affect human health and the PUFA/SFA balance to prevent of coronary heart disease is 0.4, while for n−6/n−3 PUFA, a value 4 is recommended.

Conclusion

Goats kids that received concentrated ration (TS and IS+C) presented better organoleptic characteristics, being able to serve high quality meat markets.

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