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Effect of Forage Feeding on Goat Meat Production: Carcass Characteristics and Composition of Creole Kids Reared Either at Pasture or Indoors in the Humid Tropics

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ABSTRACT : Forage diets provide good quality carcasses in sheep but very little is known in tropical goats. An experiment was designed with Creole male goats using grass-based systems to assess carcass yield, scores, cuts and composition. After weaning (84 d, 9.2 kg LW) two modes of forage feeding were compared with two replicates of each. Feeding groups were: PF for animals reared at pasture (n = 62) and IF when reared indoors (n = 60). Given that forage finishing will result in low ADG it appeared necessary to study different fattening lengths. The kids were equally divided into 4 groups: group A (n = 32), 4mo after weaning; group B (n = 32), 4mo after A; group C (n = 30), 3mo after B and group D (n = 28), 2mo after C. The animals grazed (in two sub-flocks) on irrigated tropical pastures managed in a rotational system (28 d of re-growth) at a mean stocking rate of 1,200 kg/ha/yr LW. The IF groups were reared in collective pens on a slatted floor (2 replicates of 7 or 8 kids each). They were fed the same stand of tropical grass (25% DM, 12% CP) as that of pasture that was cut daily and provided *ad libitum*. The ADG (-10%), the weights of omental fat (-60%) and fat in shoulder (-18%), the ultimate pH of carcass (-12%), the meat colour score (-24%), the "a" parameter accounting for redness (12%) and the DM and lipid contents (-4%) were significantly lower ($p<0.05$) in PF than in IF, while the liver was heavier (+23%, $p<0.05$). Feeding conditions seemed to be similar, thus, differences could be related to gastrointestinal parasitism in the PF system and hypotheses are discussed. Increasing the fattening duration, resulted in significant difference ($p<0.01$) in many traits: the weights at slaughter and of carcass increased by 40% and 60% from groups A to D and consequently the weights of body compartments and carcass cuts (1.5 to 2.0 fold more). When the results were presented as percentage of empty body weight and carcass weight, these preliminary results (carcass weight 9kg and yield 53%, muscle proportion 70%) and qualitative parameters (low fat score 2/5, fat proportion 5%), seem to be a good incentive for the sector to develop a niche market to meet consumer lean meat expectations. The indoors system could be implemented where there was low availability of grazing areas or problems of dog attacks. (**Key Words :** Goat, Tropical Grass, Carcass Cut, Carcass Composition, Pasture, Indoors)

INTRODUCTION

Meat production, i.e. fattening performances and carcass characteristics are dependent on genetic and environmental effects. Among the latter, diet has been shown to be one of the main factors influencing the carcass yield, cutability and qualities in many species (Wood et al., 2008) and specifically in goats (Warmington and Kirton, 1990; Webb et al., 2005). The increased consumer awareness of food safety issues and environmental concerns are contributing to the increasing interest of forage feeding systems. Grass-based or pasture diets provide a good nutritional quality meat as reported with tropical cattle in Brasil (Prado et al., 2008) and also with sheep for fat depots (Zervas et al., 1999), fatty acids composition (Priolo et al., 2002) or hedonic criterions (Sañudo et al., 2007). Beside the contribution to landscape maintenance and nature preservation, the grass feeding system remains an important selling point to satisfy consumer expectations.

These points are also of high concern in the West Indian goat sector (Alexandre et al., 2008). The Creole breed and pasture rearing are the main characteristics of the goat farming systems in this region. In order to promote grazing systems and make these activities economically viable for local producers, a high dressing percentage, a satisfactory conformation and great amounts of retail cuts are required. There is a high demand from the butchers for heavier goat

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carcasses than the 6-7 kg provided under the most common rearing and slaughtering practices in the region. However, pasture alone and more specifically tropical grass (Humphreys, 1991) does not ensure growing animals a sufficient amount of energy intake to attain appropriate growth rates for high slaughter weight, heavy and well-conformed carcass. Hence, it is arguable whether large and well-conformed goat carcasses could be produced through forage fattening while preserving the carcass quality advantages. It is obvious that forage finishing will result in much lower daily gains and consequently much longer fattening duration. For this reason the influence of fattening duration must be included in experiments which assess the effects of grass feeding.

Although the systems of meat-producing ruminants rely basically on the use of grazed pastures in many regions, it is increasingly believed that outdoor rearing conditions are hazardous. Many studies, have reported that free-roaming dogs may chase and kill the animals reared under pasture conditions such as the study with domestic sheep in Norway (Christiansen et al., 2001) and different livestock in Italy (Ciucci and Boitani, 1998) or in Australia (Fleming et al., 2006). These global trends of dog attacks are responsible for heavy animal and economic losses. In the West Indian conditions, many reports outline that the small ruminant (SR) industry face big problems not only of dog attacks but also of praedial larceny (IICA, 2006; FAO-Carib-Agri, 2007). Thus housing systems of production, providing shelter to the SR are recommended in many countries (Jaitner et al., 2001; Haenlein and Abdellatif, 2004). However, feeding management under housing systems, still has to be addressed as stated for sheep (Bhatta et al., 2004) and specifically in relation with fattening performances and carcass production.

With grazing areas gradually disappearing in small territories and production systems changing from grazing to confinement it appeared relevant to build an experiment comparing fattening system at pasture and indoors. At present, no information, with Creole goats, on the efficacy of using grass-based finishing systems to increase carcass weight, while maintaining desirable carcass cutability and composition, has been published. Therefore, the objective of this study was to compare two forage feeding modes, either at pasture or indoors, and to assess their relative impact on carcass characteristics and qualities of Creole kids. In addition different fattening durations were tested in order to suggest slaughtering strategies under grass feeding conditions.

MATERIALS AND METHODS

This study was carried out in Guadeloupe, a humid tropical island in the Caribbean (16.1°N, 61.6°W). The experimental farm was located in the driest region where annual rainfall averaged 1,280 mm, with a dry season lasting from January to May with less than 70 mm per month. Maximum air temperature varied from 27°C (January) to 32°C (August) with the minimum from 21°C to 25°C, respectively. The relative humidity was usually above 70% and the day length ranged from 11 to 13 h.

Feeding and animal management

One hundred and twenty two male kids of the Creole genotype were used in this experiment. Two modes of forage feeding (F) were compared in two replicates. Feeding groups were defined as PF for animals reared at pasture (n = 62) and IF for animals reared indoors (n = 60). The kids of both PF and IF were allocated after weaning (84 days, 9.2 kg LW), according to their birth and weaning weight and preweaning growth rate.

At pasture the animals were separated in two sub-flocks and grazed on irrigated pastures (a mix of *Digitaria decumbens* and *Dichantium sp.*) managed in a rotation system (7d in, 28 d out of the paddock) at a mean stocking rate of 1,200 kg/ha/yr LW. Under this pasture grazing condition, regular drenching were carried out in order to control nematode infestation every two months. Ticks were controlled by spraying all the animals every two weeks with an acaricid. The IF groups were reared in collective pens on a slatted floor, there were two replicates of 7 or 8 kids each. They were fed the same stand of tropical grass (a mix of *Digitaria decumbens* and *Dichantium sp.*) as that of pasture, grown in adjacent paddock. The grass (28 days old) was cut early in the morning and forage was provided *ad libitum* twice during the day. The quantity distributed at the trough was 1.3 fold the intake capacity of growing goats that was assessed to vary from 60 to 70 DM g/kg$^{0.75}$ according to works of Morand-Fehr (1991).

Fattening lengths

In the most common conditions at pasture, which is the control system of this experiment, the kids were weaned approximately at 3 months and then the male goats were slaughtered at 11-12 months of age (i.e. at least 8 months of fattening). It appeared reasonable to test shorter and longer fattening lengths (fL). Four groups of fL were defined in each feeding system as follows:

Group A (n = 32; PFA = 16 and IFA = 16): the male goats were slaughtered 4 months after weaning (fL approximated 4mo);

Group B (n = 32; PFB =16 and IFB = 16): the male goats were slaughtered 4 months later A (A+4mo, fL approximated 8mo);

Group C (n = 30; PFC = 16 and IFC = 14): the male goats were slaughtered 3 months later B (B+3mo, fL

approximated 11mo);

Group D (n = 28; PFD = 14 and IFD = 14): the male goats were slaughtered 2 months later C (C+2mo, fL approximated 13mo).

Slaughtering procedure

Animals were weighed and fasted the day before slaughter, and the next day when fasting just before slaughter. After bleeding, the full gastro intestinal (GI) tract was removed, weighed full and then separated by compartment, emptied and reweighed. The peritoneal and mesenteric fat were removed and weighed. The weights of head, feet, skin, liver, heart/trachea/lungs and the rest (pancreas, bladder, testes, vessels) were recorded.

Dressed carcasses were weighed within 1 h (hot carcass weight), and then chilled for 24 h at 4°C, and then weighed again (cold carcass weight). Each cold carcass was rated (from 1 to 5) according to conformation, internal and external fat based on a lightweight lamb grid (OFIVAL, 2005). The perirenal fat was removed and weighed. The carcass was then cut in half lengthwise and the left side was cut according to Colomer-Rocher et al. (1987) into five carcass cuts (shoulder, neck, ribs, flank, long leg). Every cut was weighed and the left shoulder was dissected in fat (subcutaneal plus intermuscular deposits), muscles and bones. Other tissues such as tendons, lymph nodes, etc were separated as waste.

Several linear measurements were taken on the entire carcass (back length and buttock width) and on the half carcass (carcass length, leg length and thorax width).

Chemical analyses

On forage : In each PF×fL group and in each of the 2 sub-flocks, every four weeks, the herbage offered (before the animals were led into the paddock) was analysed. The grass was cut on 10×0.09 m^2 quadrats with hand-held electric clippers. Samples were mixed fresh and a 300 g subsample was used for dry matter determination and chemical analysis. In the IF system, the forage was provided in the trough. Samples of offered forage (two sub-samples of 200 g) were taken everyday. One of the sub-samples was kept for daily dry matter determination. All the samples of the feed provided for two weeks were mixed together for each group and a new sub-sample (300 g) was used for chemical analyses.

On carcass : The right shoulder was removed and kept for chemical analysis. The shoulders were stored frozen and were cut as frozen, with a MAGURIT machine (Unitcut 545 SC model). Then, they were ground using a 3-mm grid (BIRO AFMG 48/52, BIRO France) and homogenized. Aliquots were freeze-dried and were finely ground in a ball grinder (Dangoumill 300, Prolabo, Paris, France). A total of 100 g of samples were used for chemical analysis.

On both forage and carcass samples : The diet and carcass samples were analysed by AFNOR methods (AFNOR, 2005) as follows: dry matter (DM, AFNOR NF V18-109), ash (AFNOR NF V18-101), crude protein (CP, N ×6.25, AFNOR NF V18-120), ether extract (EE, AFNOR NF V18-117). Cell partition components of diet samples as neutral-detergent fibre (NDF), acid-detergent fibre (ADF) and acid-detergent lignin (ADL) were determined according to Van Soest et al. (1991).

Data calculations and statistical analyses

The availability of forage at pasture was assessed taking into account the forage biomass when the animal were led into their paddock and the paddock area. In the rotational grazing system (7 d in, and 28 d out), each sub-group of kids stayed one week per paddock. Given that the animals are known to have a very high level of refusals at pasture (Morand-Fehr, 1991) the forage on offer (for each sub-group of kids and on a week basis) was calculated with a level of 45% of refusals recorded by Ortega et al. (2006) with Creole goats grazing in similar conditions.

Empty body weight (EBW) was calculated by subtracting values of gut content from fasted slaughter weight. The dressing percentage was calculated as cold carcass weight related to EBW. The different proportions (%) of tissues in either shoulder or leg were calculated on a half-carcass weight basis. The proportions of carcass, components and cuts were calculated relative to EBW, and weight of carcass, respectively; and proportions of tissues relative to the shoulder weight.

Growth performance and carcass traits were submitted to an analysis of variance including the effects of forage feeding system (F) and fattening length (fL) and the interaction forage feeding×fattening length (F×fL) as fixed effects (GLM procedure, SAS Institute, 1997). The slaughter weight (kg) was added as covariable for weights of body compartments, carcass cuts and tissues dissected in the shoulder and was kept in the model when significant. Means comparison was performed according to the Pdiff option of GLM procedure of SAS, using Tukey test for contrasts.

RESULTS

The characteristics (biomass and chemical composition) of the forage provided at pasture and indoors are presented in Table 1. The forage on offer at pasture was assessed to be 711 g/d/kid DM and the quantity distributed at the trough was assessed to be 693 g/d/kid DM on average.

Effect of mode of forage feeding

Significant ($p<0.05$) variations appeared between PF and IF (Table 2) for ADG (+10%), weight of liver (-23%)

Table 1. Chemical composition (% DM) of tropical grass and biomass (DM) provided to Creole kids reared at pasture or indoors

Forage feeding (F)	Pasture: PF	Indoors: IF
DM %	24.3	25.6
Metabolizable energy (MJ/kg DM)		9.92
Chemical composition (g/kg DM)		
Ash	87	88
CP	119	126
EE	12	14
NDF	722	702
ADF	373	337
ADL	53	39
Assessment of forage on offer	Biomass at the entrance: kg/ha DM 3,215 per paddock[1]	Quantity provided at the trough: g DM 5,200 per day per stall[2]

[1] The paddock area averaged 225 m^2 per sub-flock; i.e. 72.34 kg DM for 8 kids for 7 days representing 1,292 g/d/kid DM, given 45% refusals at pasture recorded with Creole goats grazing in similar conditions (Ortega et al., 2006), this could lead to 711 g/d/kid DM.
[2] The sub-group is composed of either 8 or 7 kids; i.e. 693 g/d/kid DM.

and fat deposits. The omental fat increased approximately 60 g more ($p<0.05$) for the IF kids while the perirenal fat increased 20 g more ($p<0.05$) for PF kids. Also, the weights of fat tissues (Table 3) in the shoulder varied significantly according to the mode of forage feeding (approximately 18% less in PF than in IF carcass, $p<0.05$).

Significant differences ($p<0.05$) were observed within the feeding groups (Table 3), for weights of neck and flank (11 to 14% less for PF carcasses than for IF), the other carcass pieces tended to be heavier also but values did not reach significance.

The ultimate pH of the PF carcasses (Table 5) was significantly lower ($p<0.05$) than for IF. The meat colour score of the PF kids was pale pink (score = 2.1 on a 4 point-scale) and more red ($p<0.05$) for IF kids (score = 2.9). The instrumental lightness and "b" parameters, did not significantly vary. The "a" parameter accounting for redness, was lower ($p<0.05$) in PF carcass than in IF. The DM and lipid contents were lower ($p<0.05$) in PF than in IF while the ash and protein contents did not differ.

Table 2. Fattening performances, body compartments, carcass scores and linear measurements of Creole kids according to grass feeding mode: pasture vs. indoors

Forage feeding	Pasture	Indoors	Sign.
Fattening performances			
ADG (g/d)	42.3±8.9	46.8±7.9	p<0.05
Slaughter weight (kg)	20.2±4.6	21.3±4.8	p<0.05
EBW (kg)	14.3±3.6	14.9±3.8	NS
Hot carcass weight (kg)	7.9±2.4	8.2±2.4	NS
Carcass yield (% EBW)	52.7±3.6	53.3±2.8	NS
Body compartment			
Skin (g)	1,162±317	1,209±357	NS
Head (g)	1,458±346	1,523±361	NS
Feet (g)	480±94	491±90	NS
Liver (g)	377±71	298±56	p<0.01
Lung/heart (g)	337±72	344±80	NS
Kidney (g)	59±9.7	51±8.4	NS
Empty GI tract (g)	1,829±332	1,862±367	NS
Kidney-pelvic fat (g)	102±81	83±49	p<0.05
Omental fat (g)	86±68	139±93	p<0.01
Qualitative scores			
Conformation score (1 to 5)	2.9±1.0	3.0±0.9	NS
Fat cover score (1 to 5)	2.0±0.6	1.8±0.5	NS
Internal fat score (1 to 5)	2.4±0.9	2.3±0.8	NS
Colour score (1 to 4)	2.1±0.3	2.6±0.4	p<0.05
Linear measurements			
Carcass length (cm)	54±3.9	54±5.1	NS
Back length (cm)	45±3.3	45±3.9	NS
Leg length (cm)	32±2.4	32±3.3	NS
Buttock width (cm)	13±1.5	14±1.4	NS
Thorax width (cm)	23±1.9	23±2.1	NS

Table 3. Carcass cuts and shoulder dissection of Creole kids according to grass feeding mode: pasture vs. indoors

Forage feeding	Pasture	Indoors	Significance
Carcass cuts			
Shoulder (g)	736±215	776±216	p<0.05
Neck (g)	470±179	511±198	p<0.05
Long leg(g)	1,282±335	1,227±320	NS
Ribs+loin (g)	891±321	902±324	NS
Flank (g)	537±161	589±161	p<0.05
Shoulder (%)	19.3±0.9	19.4±0.8	NS
Neck (%)	12.3±1.5	12.8±1.7	NS
Long leg (%)	31.0±1.5	30.6±1.3	NS
Ribs+loin (%)	23.3±1.8	22.5±1.3	NS
Flank (%)	14.1±2.1	14.7±1.5	NS
Shoulder dissection			
Bone (g)	162±35	170±37	NS
Muscle (g)	519±165	549±166	NS
Fat (g)	36±21	42±18	p<0.05
Bone (%)	22.6±2.7	22.4±2.4	NS
Muscle (%)	70.0±3.9	70.2±3.6	NS
Fat (%)	4.7±2.0	5.5±1.7	p<0.05

Table 4. *Longissimus* muscle quality characteristics, ultimate pH and instrumental colour parameters, and chemical analysis: dry matter (%): ash, crude protein and lipids (g/kg DM) of Creole kids reared according to grass feeding mode: pasture vs. indoors

Forage feeding	Pasture	Indoors	Sign.
Physical measurements			
Ultimate pH	5.7±0.3	6.4±0.7	p<0.05
L (lightness)	44.7±3.5	43.9±4.8	NS
a (redness)	15.5±2.1	17.3±1.5	p<0.01
b (yellowness)	5.8±1.5	5.7±1.4	NS
Chemical composition			
Dry matter (%)	32.0±2.4	33.3±2.5	p<0.05
Ash (g/kg DM)	18.1±2.5	17.7±1.9	NS
Total lipids (g/kg DM)	20.2±4.2	21.0±3.9	p<0.05
Crude protein (g/kg DM)	61.9±3.6	61.6±2.7	NS

Effects of fattening length

Increasing the fattening duration, resulted in significant difference in many traits studied (Table 5). The weights at slaughter and of carcass increased (p<0.01) by 40% and 60% (between the two extreme groups, respectively) and consequently the weights of body compartments and carcass cuts (1.5 to 2.0 fold more). Then the results are presented as percentage of EBW and carcass weight, respectively (Table 5). The organ proportion decreased significantly (p<0.05) with fattening duration while those of skin and head did not varied significantly. Among the carcass cuts, only the proportion of neck increased significantly (p<0.01). The weights of fat tissues and their proportions increased (p<0.05) steadily with fL, also the scores of internal and external fat gained 0.5 to 1 point more (between the two extreme groups). There was a 65% significant difference from group A to group D in the conformation grade and colour score. The lengths of carcass and back increased steadily until the group C, then after 11

Table 5. Growth performances, body compartments, carcass scores, carcass linear measurements, cut proportion and shoulder dissection of Creole kids fed forage according to fattening length

Group of fattening length stage of growth (W = weaning)	A W+4mo	B A+4mo	C B+3mo	D C+2mo	Significance
Fattening performances					
ADG (g/d)	48.5[a]	45.2[b]	35.8[c]	31.8[d]	p<0.01
Age at slaughter (d)	221[a]	339[b]	428[c]	486[d]	p<0.01
Slaughter weight (kg)	15.4[a]	20.8[b]	21.4[b]	21.6[b]	p<0.05
EBW (kg)	10.3[a]	13.6[b]	17.0[c]	16.8[c]	p<0.01
Hot carcass weight (kg)	5.6[a]	7.6[b]	9.6[c]	9.5[c]	p<0.01
Carcass yield (% EBW)	51.9[a]	53.7[b]	55.0[c]	54.2[b]	p<0.05
Body compartment (%EBW)					
Skin+head+feet	22.4	21.4	21.8	21.7	NS
Red organs	5.8[a]	5.4[a]	4.7[b]	5.0[b]	p<0.05
Empty GI tract	14.5[a]	14.1[b]	11.9[c]	11.9[c]	p<0.01
Abdominal fat	2.4[a]	3.1[b]	3.0[b]	2.7[a]	p<0.05
Qualitative scores					
Conformation score (1 to 5)	2.1[a]	3.0[b]	3.3[c]	3.4[c]	p<0.05
Fat cover score (1 to 5)	1.3[a]	2.3[b]	2.4[b]	1.9[a]	p<0.05
Internal fat score (1 to 5)	1.5[a]	2.6[b]	2.8[b]	2.6[b]	p<0.05
Colour score (1 to 4)	1.9[a]	2.4[b]	2.6[b]	2.8[c]	p<0.05
Linear measurements					
Carcass length (cm)	49[a]	53[b]	57[c]	56[c]	p<0.05
Back length (cm)	42[a]	44[b]	48[c]	47[c]	p<0.05
Leg length (cm)	30[a]	31[a]	34[b]	34[b]	p<0.05
Buttock width (cm)	11[a]	13[b]	14[b]	14[b]	p<0.05
Thorax width (cm)	21[a]	23[b]	25[b]	24[b]	p<0.05
Carcass cuts (% carcass)					
Shoulder (%)	19.6	19.1	19.2	19.5	NS
Neck (%)	11.1[a]	11.7[a]	13.1[b]	13.2[b]	p<0.05
Long leg (%)	32.0	30.9	30.4	30.4	NS
Ribs+loin (%)	22.3	22.8	23.6	22.8	NS
Flank (%)	14.8	14.5	13.6	14.0	NS
Shoulder dissection					
Bone (% shoulder)	24.5[a]	22.7[b]	20.9[c]	21.3[c]	p<0.05
Muscle (% shoulder)	68.3[a]	69.2[a]	71.2[b]	72.2[b]	p<0.05
Fat[1] (% shoulder)	4.7[a]	5.6[b]	5.3[b]	4.4[a]	p<0.01

[a, b, c, d] Means with different letter were significantly different. The interaction feeding mode*fattening length was not significant for all the analyzed parameters.

[1] Subcutaneal plus intermuscular fat.

Table 6. *Longissimus* muscle quality characteristics, ultimate pH and instrumental colour parameters, and chemical analysis: dry matter (%); ash, crude protein and lipids (g/kg DM) of Creole kids fed forage according to fattening length

Group of fattening length stage of growth (W = weaning)	A W+4mo	B A+4mo	C B+3mo	D C+2mo	Significance
Physical measurements					
Ultimate pH	5.7[a]	6.3[b]	6.0[a]	6.2[a]	p<0.05
L (lightness)	48.0[a]	45.8[b]	42.4[c]	41.8[c]	p<0.01
a (redness)	15.8[a]	16.5[b]	18.0[c]	17.9[c]	p<0.05
b (yellowness)	6.1	5.9	5.9	5.8	NS
Chemical composition					
Dry matter (%)	30.7[a]	31.8[b]	32.9[b]	36.2[c]	p<0.05
Ash (% DM)	19.3[a]	17.7[b]	17.1[b]	15.9[c]	p<0.05
Total lipids (% DM)	18.6[a]	20.5[b]	21.3[b]	22.7[c]	p<0.05
Crude protein (% DM)	62.9	62.5	62.1	61.0	NS

[a, b, c] Means with different letter were significantly different. The interaction feeding mode*fattening length was not significant for all the analyzed parameters.

months of fattening no significant difference appeared. The widths were the lowest only for the kids slaughtered 4 months after weaning and did not vary with fattening duration.

There was a significant fattening length effect ($p<0.05$) on the physical measures and chemical composition (Table 6): the values of lightness decreased (6 points less) while the ultimate pH and the parameter "a" (redness) increased. The DM and lipids content increased (approximately 18% of increase) while ash contents decreased (approximately 20% of decrease) within age groups.

Although the interaction was not significant ($p>0.05$), there were differences within combinations of feeding mode×fattening length for some traits during fattening and at slaughter. The kid's ADG decreased from group A to group D in PF (Figure 1) while it decreased slightly only for the last group of fattening in IF. For male goats reared at pasture, the threshold values appeared after 8 months of fattening for the slaughter weight (Figure 2) and carcass weight (Figure 3). Similar trends were observed for conformation score, the leg and flank weights and linear measurements. For male goats reared indoors, carcass

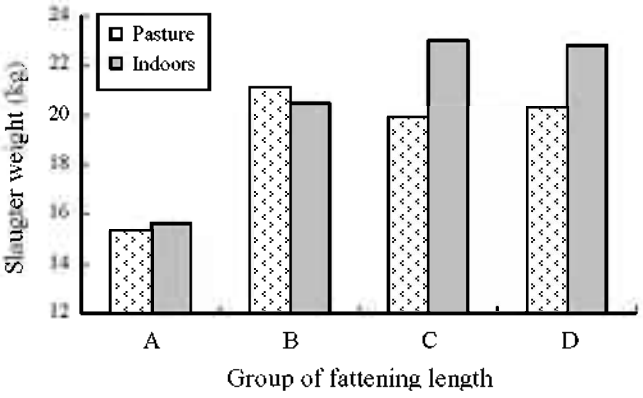

Figure 2. Slaughter weight (kg) of Creole kids according to the different sub-groups (grass feeding mode and fattening length). Groups of fattening length are defined in the text: A (= Weaning+4 mo); B (= A+4mo); C (= B+3mo) and D (= C+2 mo).

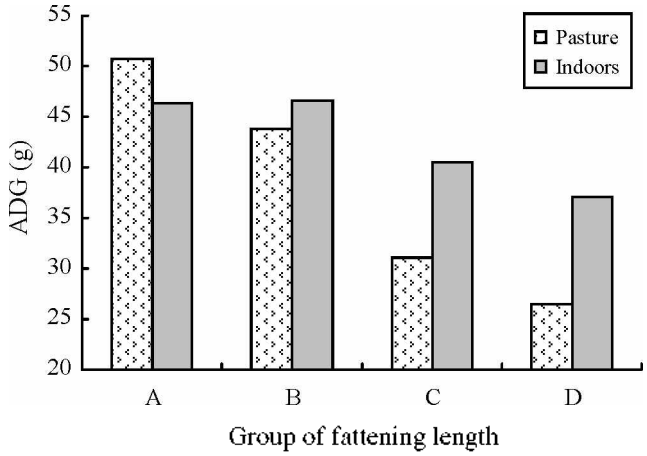

Figure 1. Average daily gain (g) of Creole kids according to the different sub-groups (grass feeding mode and fattening length). Groups of fattening length are defined in the text: A (= Weaning+4 mo); B (= A+4mo); C (= B+3mo) and D (= C+2 mo).

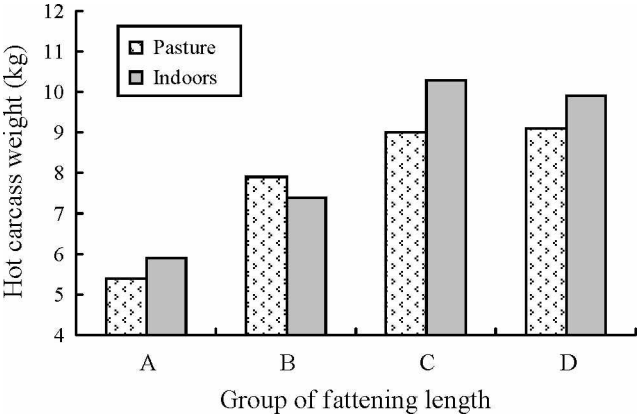

Figure 3. Hot carcass weight (kg) of Creole kids according to the different sub-groups (grass feeding mode and fattening length). Groups of fattening length are defined in the text: A (=Weaning+4 mo); B (= A+4mo); C (= B+3mo) and D (= C+2 mo).

pieces, qualitative scores and linear measurements gradually increased or improved until the group C which corresponds to an 11 month-duration.

DISCUSSION

Effect of forage feeding

The level of ADG obtained in this present study was satisfactory with regards to previous results (Alexandre et al., 1997) or other tropical works (Moniruzzaman et al., 2002; Mesfin Tadesse, 2007; Phengvichith and Ledin, 2007). The weight at slaughter (up to 21 kg) and consequently of carcass (up to 9 kg) could be considered satisfactory with regards to grass feeding value. There was no significant effect of the grass feeding mode on the carcass yield, but a good level yield (54%) was obtained and was higher than other tropical breeds fed only forage (Mahgoub et al., 2005; Phengvichith and Ledin, 2007) or tropical pasture plus some supplements (Moniruzzaman et al., 2002). The carcass conformation score of 3 to 3.6 (on a 5 point-scale of light carcass grid) can be considered as a medium level given that the animals were fed only forage. Regardless of the carcass weight, the distribution of prime cuts (calculated as a percentage of carcass weight) approximated 63%. Creole kids, fed only forage, seemed to present cut proportions that are higher than the values recorded for bucks reared under similar conditions by Gallo et al. (Criollo goats in Chile; 1996), by Sen et al. (local goats in India, 2004) and by Almeida et al. (Boer goat in South Africa; 2006), even though it is difficult to compare cutting techniques. The proportion of muscles was approximately 70%. Similarly, the fat cover scores remained at a very satisfactory low level of 2 on 5 points-scale. The forage fed Creole goat carcass was rated as a valuable lean carcass which ought to meet the standards of the consumers' expectations. In addition only 3% of internal fat has been observed. This value remained within the lower range reported by Gallo et al. (1996) and Sen et al. (2004).

One of the best attribute observed is the low level of lipids measured in the shoulder (an average 20% of shoulder DM) compared to other reported values in literatures (Almeida et al., 2006; Abdullah and Musallam, 2007).

In this first phase of research on the influence of forage feeding on goat meat production, determining the quantitative effects was important for the establishment of relevant issues and direction for further studies. It would be recommended to focus on the eating quality of the goat meat and on the fatty acids composition of the different depots.

Comparison of forage feeding mode

This study has sought to test the effects of grass-based and pasture diets for fattening Creole goats; comparing in a single experiment the two grass feeding modes. Although many authors have reported on the positive influence of the grass based diets either under indoor conditions (in studies comparing different ratios of grass to concentrate) or grazing pasture, no attempt has been made to compare in a single experiment the relative effects of each grass feeding mode. Moniruzzaman et al. (2002) have compared the effect of different feeding systems (in stall or grazing) on carcass and non-carcass parameters of goat, but the animals were supplemented. Even in recent works, indoor system experiment meant a system with access to mixed diet or supplements as in sheep (Cañeque et al., 2003) or cattle studies (Moreno et al., 2007).

The indoor feeding system, compared to grazing, resulted in higher growth rate of kids and consequently heavier carcass. The forage chemical composition was similar in both PF and IF and reached satisfactory levels (120 to 140 CP g/kg DM) which is not very common for tropical forages. The forage allowance was assessed to be 711 and 693 g DM per kid and per day for PF and IF groups, this tends to suggest that the feeding conditions would not be responsible for differences appearing between the two feeding modes. Comparisons between pasture and indoors systems with growing goats are scarce (Moniruzzaman et al., 2002), but current studies undergone in the West Indian conditions with sheep (Fanchonne et al., 2008) are observing that the forage DM intake may vary between grazing and indoor due not only to forage prehensibility but also to the specific feeding behaviour at pasture differing from the one at the trough (Morand-Fehr, 1991). Nevertheless, it is still arguable if such conclusions could be obtained with grazing goats, given their high selective grazing behaviour (Morand-Fehr, 1991). Future studies focused on assessing forage intake are highly recommended.

The lower ADG observed in kid's fed at pasture could be explained by the direct climatic effect (although the Creole goat is heat tolerant (Berbigier, 1988) or the higher feed requirements due to walking when comparing outside conditions to confinement. Otherwise the exposure to parasitic infestations (Aumont et al., 1997) associated with pasture grazing as against indoor feeding can be hypothesised. The negative effects of gastrointestinal parasites on goat carcass traits have been reported in studies conducted in other tropical countries such as in Philippines (Howlader et al., 1996) and Laos (Phengvichith and Ledin, 2007). The differences in liver weights in this present study are in line with this hypothesis. Higher liver weight of kids reared under pasture conditions could be related to liver activities. Liver is known to be involved in lipid metabolism but, recent research has shown that components of the innate immune system are intimately associated with liver activities (Fausto, 2006). Also, the weight of different

Table 7. Faecal egg count (FEC, eggs per gram) and packed cell volume (PCV, %) of Creole male goats reared at pasture under routine measurements according to Mandonnet et al. (2006)

Age (min-max)	Variables	FEC	PCV
180 d-360 d	Mean	1,409.4	23.9
	Standard deviation	1,160.1	3.9

fat tissues varied according to the forage feeding mode in this study, although it is known that forage energy supply is insufficient as regard fattening requirements. Further research are required for a better understanding of these results as it related to the lipid metabolism (variation in liver and fat deposits) even with these unsupplemented kids. The accretion of adipose tissue is essential for all herbivores development, it allows them to survive away from limited supply of food. Body fat reserves are preferentially accumulated in the abdomen of goats compared to other species (Kempster, 1981; Warmington and Kirton, 1990). It will be interesting to investigate further if this presumably is a kind of physiological adaptation of hardy breeds reared in tropical conditions, such as the Creole goat, which would tend to allocate their nutrients to body reserves accretion and immunoreactions (Kyriazakis and Houdijk, 2006) rather than to protein and muscle accretion. Not only protein, but also energy nutrition is increasingly considered (Walkden-Brown and Kahn, 2002) to be an important factor in the immune response. Valderrabano et al. (2006) reported that the fat mass stored by ewes during their reproductive life is associated with the expression of immunity against GI nematodes. In our study, the growing kids reared at pasture (compared to the IF ones) encountered nematode parasites albeit anthelmintic drenching. Contemporaries male goats reared at pasture which were under routine measurements (Mandonnet et al., 2006) exhibited high levels of infection (Table 7, FEC up to 1,400 eggs per g and PCV lower than 25%).

The ultimate pH of the PF carcasses was significantly lower than IF, probably animals reared outdoors were more susceptible to stress than the IF system (kids fed twice daily by attendants). The meat colour score and the instrumental "a" parameter accounting for redness, which was lower in PF carcass than in IF suggest that the aforementioned gastro-intestinal parasitism could be responsible for this difference. Nematodes are known to be hematophagous, so animals under such impact would most likely experience anaemia as described for Creole does (Mahieu et al., 2007) and iron deficiencies as reported for sheep (Dagie and Allomby, 1975). Although more accurate analyses such as haem pigments extraction (Warriss, 1979) are required to be more consistent in this conclusion. The results of this present study are in line with the study of Arsenos et al. (2007) assessing the parasitism effects on lamb meat quality. They also showed that there were differences in the L colour values, pH of meat, intermuscular fat and total fat content relative to the parasitism impact. Thus based on these initial results, we can conclude along with Arsenos et al. (2007) and Phengvichith and Ledin (2007) that an important question, which has not been addressed, is to what extent does GI parasitism with nematodes affect the quality of the SR meat produced.

Effects of fattening length

The longer the duration of fattening, the higher the variation in weights as expected. This resulted in significant increase for the weights of carcass, body components and carcass pieces and also for the linear measurements. These conclusions fell within the range of variations previously reported by Ruvuna et al. (1992) and Chowdhury and Faruque (2004). The more pronounced and regular variation was observed for the neck weight. Generally, age is known to be responsible for sexual maturation in the entire male. This is also underlined by the 60% variation obtained for the head weight. Available information on goats are limited, but Mahgoub and Lodge (1998) indicated similar trends with Batina goats having high proportion of muscles in the neck and shoulder regions.

The fattening length effect on carcass qualities is well known: the values of lightness decreased while the parameter "a" accounting for redness, as well as the colour score, increased in accordance with the conclusions of Dhanda et al. (2003) comparing different goat genotypes. These latter authors observed the same trend with different age group of kids but reported lower values for lightness (41) and "a" (13) colour parameters than for the Creole bucks (44 and 17, respectively) probably because of the different feeding levels in the two studies. The carcass protein content decreased while the lipid content increased with age, which maybe related to the increase observed in the shoulder fat proportions. Values obtained in this present study were higher for DM (4 points more) and lower for lipid content (18 points less) compared to values reported by Almeida et al. (2006) in Boer goats fed forage.

Rearing and slaughtering conditions

The different combinations, feeding mode×fattening length, showed some differences during the fattening growth and at slaughter. At pasture (groups PF), the threshold values, for many traits, appeared after approximately an 8 month-duration for many traits. While for kids reared indoors (groups IF), it was after an 11 month-duration. Probably, the conditions at pasture were so limiting that they induced increasing constraints and this resulted in lowering performances with prolonged time of presence at pasture. In Creole male goats reared at pasture, Mandonnet et al. (2001) observed an age effect on susceptibility to GI nematodes. When reared at pasture,

animals may suffer from gastrointestinal parasitism even with regular drenching given the global trends of GI resistance to anthelmintic drugs (Walkden-Brown and Kahn, 2002; Kyriazakis and Houdijk, 2006). Practically it can be deliberated either to slaughtering at a fixed age or at a fixed weight. It is therefore recommended to slaughter animals reared at pasture before 11 months of age. In indoor feeding, the fattening duration must be shortened also, for practical and economic reasons. The differences observed between the different groups of fattening duration must be discussed, it is not advisable to prolong the fattening duration and tend to attain high SW because it could be more costly with no higher and relevant carcass attributes.

The main criterion that informs the decision making depends largely on the growth potential of the kid; in fact a high individual variability (20%) appeared for the ADG both at pasture and indoors. The Creole goats are a native tropical breed which is not yet selected for growth performances and the variability observed, under the most prevalent feeding system of the region, could be a good incentive for a breeding program.

Moreover, the choices must be adapted to the main system of the farmer. As another example, tethering meat goats, that is common in cut-and-carry or zero-grazing systems may rise in the future as reported by Patra et al. (2008). In a weaner system for meat production, it could be interesting to give priorities to the suckling flock to obtain high levels of productivity as reported by Ortega et al. (2003) for grazing Creole goat, and to use the ability of the doe to compensate for the numerous limiting factors existing at pasture and to rear animals indoors during the post weaning growth stage.

CONCLUSION

Fattening kids on forage feeding only resulted in relatively satisfactory animal performances, provided rearing and slaughtering practices are adequate. Based on the main carcass traits (yield, weights of carcass cuts, muscle proportions) and qualitative parameters (low fat scores, proportions and lipid content), these preliminary results seem to be a good incentive for the goat sector to preserve the use of forage feeding for consumer lean meat expectations. Given that husbandry of native breeds in grassland areas can provide an opportunity for sustainable use of natural ecosystems and support development of marginal areas, this study could support labelling of Creole breed reared with forage and developing a niche market.

In grazing systems gastrointestinal parasitism must be addressed and experiments are required to assess its effect on meat parameters. However significant, the variations observed within the two feeding modes were not very large, but the indoors system could be implemented in case of low availability of grazing areas or problems of dog attacks. It follows that high productive forages and by-products could be valuable resources to be used.

In any case, it is not advisable to prolong the fattening duration and tend to attain high SW because it could be more costly with no higher and relevant carcass attributes. It is therefore recommended to slaughter animals fed forage only before 11 months of age.

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