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Effects of feeding system and nitrogen source on lamb growth, meat characteristics and fatty acid composition

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ABSTRACT

For this study, 28 lambs were allocated to four groups: two groups were raised in stalls and fed a hay-concentrate ration. The two remaining groups were reared on dry pasture and received concentrate in stalls. In each feeding system, two *iso*-nitrogen concentrates were used, soya bean and soya plus faba bean. At the end of the growth trial (77 days), all lambs were slaughtered. Samples of *longissimus dorsi* muscle were used for muscle analysis and fatty acid (FA) composition determination. Average daily gain (134 g) was similar for all treatments. Stall lambs deposited significantly ($p < 0.001$) more fat per day (13 vs 5 g) and slightly more muscle (41 vs 35 g) than pasture grazing ones; the first had more fat tissue (5.2 kg) than the later (4.6 kg). All these parameters were not influenced by nitrogen source. FA profile and meat characteristics were similar for all dietary treatments. It could be concluded that dry pasture did not affect meat quality but lead to the leaner lambs.

1. Introduction

Meat from lambs raised on pastures is often considered to be of superior quality to that of stall raised lambs (Atti & Abdouli, 2001; Murphy, Loerch, McClure, & Solomon, 1994; Popova, 2007; Ådnøy et al., 2004). Meat of lambs reared on pasture contained less total lipid and triacy-glycerol than that of lambs fed a concentrate based diet (Aurousseau, Bauchart, Calichon, Micol, & Priolo, 2004; Engle & Spears, 2004; Popova, 2007; Rowe, Macedo, Visentainer, Sousa, & Matsushita, 1999). When compared to grain feeding, pasture increases the $n-3$ PUFA content and decreases C18:2$n-6$/C18:3$n-3$ ratio (Nuernberg et al., 2005; Aurousseau et al., 2004; Popova, 2007).

On the other hand, in arid and semi-arid areas, natural pasture supply is too poor, particularly in summer, to meet the nutritional requirements of growing lambs. Furthermore, oat hay which is the main forage used indoors, has a low nutritive value (INRA, 1978; Nefzaoui & Chermiti, 1989). Thus, the supplementation of these feedstuffs becomes necessary to increase lamb growth rate. Soya bean is the most common nitrogen source included in the concentrate. It is important to find alternative sources in the aim to replace soya bean in the ruminant diets. Legumes seeds, such as faba beans, lupins and peas, have attracted attention as supplements for ruminants in recent years. Indeed, faba bean has a high protein (30%) and starch (42%) content (Yu, Goelema, Leury, Tamminga, & Egan, 2002) and is a potentially valuable protein and energy supplements for animals. Thus, the objective of this study was to compare the effect of rearing system (indoors vs pasture) and nitrogen source (soya bean vs faba bean) on growth, tissue composition, meat quality and fatty acid composition of fat-tailed lambs.

2. Material and methods

2.1. Experimental design

The experiment was carried out at the National Institute of Agricultural Research of Tunisia (INRAT). The experiment started in mid May with a total of 28 fat-tailed Barbarine male lambs treated against internal and external parasites and entero-toxemia. They were 6 months old and had an average body weight (BW) of 36.4 ± 1.9 kg. They were divided into four equal groups according to live weight, and calculated muscle and fat weights (Table 1). Two groups were raised in stalls (S) and fed in individual boxes a ration based on oat hay and concentrate. The concentrate amount (800 g per head) and the hay to concentrate ratio (40:60) were fixed as in smallholder practice. So, the hay was offered at 90% of ad libitum intake. Distributed quantities were calculated on a dry matter (DM) basis as 37 g/kg BW (15 and 22 g/kg BW of oat hay

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Table 1
Initial body weight (BW), muscle and fat weights of fat-tailed lamb according to feeding system and nitrogen source

	Treatment groups[a]				p	SEM	Rearing	Nitrogen
	G-FB	G-SB	S-FB	S-SB				
Number of lambs	7	7	7	7				
Initial BW (kg)	36.0	36.0	36.8	37.1	ns	0.46	ns	ns
Initial muscle (kg)[b]	7.7	7.9	7.8	7.8	ns	0.16	ns	ns
Initial fat (kg)	4.3	4.2	4.2	4.1	ns	0.13	ns	ns

ns: not significant.
[a] G-FB: grazing lambs receiving faba bean; G-SB: grazing lambs receiving soya bean; S-FB: stall lambs receiving faba bean; S-SB: stall lambs receiving soya bean.
[b] Initial muscle and fat were calculated according to equations (Atti & Ben Hamouda, 2004).

and concentrate, respectively). In this case, the diet supplied 91% of energetic requirements of lambs (INRA, 1988). The two remaining groups were reared on dry Mediterranean pasture, grazing (G) 6 h per day (6–10 and 17–19), with a stocking rate of 10 lambs per ha, they received indoor a supplement as 22 g of concentrate per kg BW at 12 h. In each feeding system, two kinds of *iso*-nitrogenous concentrate were used (Table 2). The first one was based on barley (77%), soya bean (20%) and mineral–vitamin supplement (3%). In the second concentrate, faba bean partially (50% on CP basis) substituted soya bean. Animals of all groups had free access to water. They were weighed weekly just prior to feed distribution. Quantities of feeds offered were recorded daily. Fat-tail circumference, width and depth were recorded at the beginning and at the end of experiment and then muscle and adipose tissue contents at these stages were calculated according to equations (carcass muscle = 1092 + 0.297 BW −186 length (RSD (g) = 659); Carcass fat = −3284 + 67 MTC + 119 MTW + 0.067 BW (RSD (g) = 561)) established from BW and fat tail measurements (Atti & Ben Hamouda, 2004). At the end of the growth trial (77days), all animals were slaughtered at an average body weight of 46 kg. The left half-carcasses were cut according to Colomer Rocher, Dumont, and Murillo (1972) into six joints (leg, lumbar region, flank, thoracic region, neck and shoulder). However, only the legs (separated at level of 6th lumbar vertebra) were dissected into fat, muscle and bones. Samples of *longissimus dorsi* (LD) muscle (6th to 13th rib) were taken for, chemical analysis and intra muscular (IM) FA composition.

2.2. Laboratory analysis

Samples of meat were dried by lyophilisation, ground (1 mm screen) and stored for subsequent analyses. Mineral content was then determined by ashing at 600 °C for 8 h. Nitrogen was determined by Kjeldahl method (CP = N × 6.25), lipids were extracted by soxhlet method using the hexane as solvent (AOAC, 1990).

The fatty acid composition of the IM fat was analyzed after extraction (Bligh & Dyer, 1959) and methylation with K-OH (Eichhorn et al., 1986). Methyl esters were analyzed on a Hewlett-Packard chromatograph (HP-5890) equipped with a flame ionization detector and split (1:24) injector. Separations were performed using a HP-FFAP capillary column (25 cm × .2mm i.d. × .3μm). The sum of saturated fatty acids (SFA), polyunsaturated (PUFA) as well as the PUFA: SFA and $n-3/n-6$ ratios were calculated.

Table 2
Chemical composition and constituents of experimental foods

	Hay	Concentrate	
		Soya	Faba bean
Composition			
Dry matter (g/kg)	842	925	935
Organic matter (g/kg DM)	914	955	960
Crude protein (g/kg DM)	69	165	160
Crude fiber (g/kg DM)	285	79	76
Ash (g/Kg DM)	86	45	40
Energy (FU/kg DM)[a]	0.6	1.0	1.0
Ingredients (g/kg)			
Barley	–	770	680
Soya bean meal		200	100
Faba bean		0	190
MVS[b]	–	30	30

[a] FU: forage unity = French energetic system for ruminants (I FU = 1883 Kcal net energy, INRA, 1978).
[b] MVS: Mineral-vitamin-supplement (100 Ca, 35 P, 80 Na, 44 Mg, 4% S, 4% Zn, 2 Mn, 2 Fe in g/kg).

2.3. Statistical analysis

Data were analyzed using the General Linear Model of SAS (1989) in a balanced 2 × 2 factorial experiment (2 rearing systems and 2 nitrogen sources). Duncan's multiple range test was then used to compare diet mean effects ($\alpha = 0.05$). In the aim to avoid the effect of the variation of the final weight on meat characteristics, the data were analyzed using a final weight as a covariate.

3. Results

3.1. Feed intake and lamb growth

All feeds (hay and concentrate) offered were consumed. The average daily gain was statistically similar for all groups (134 g/d in average). However, lambs maintained indoors tended to have a final body weight (47 kg) and an average daily gain (142 g/d) higher than those on pasture (44.9 kg and 127 g/d, respectively). Also, there were no significant differences in BW gain associated with nitrogen source for both rearing systems (Table 3).

3.2. Body composition

Nitrogen source did affect neither the final tissue weights nor the muscle and adipose tissues daily gains. However, rearing system affected some of these parameters (Table 3). Thus, all diet treatments led to the same final weight or daily gain of muscle tissues (10.7 kg and 38 g/d, respectively). However, stall animals had more ($p < 0.01$) fat tissue (5.2 kg) than those of grazing groups (4.6 kg), although initial fat weights (4.2 kg) were equal (Table 1). Stall animals deposited significantly more fat per day ($p < 0.001$) and slightly more muscle than did the grazing ones. The fat daily accretion was 13 g/d for the former vs 5 g/d for the latter ones ($p > 0.05$), the muscle daily accretion range was 41–35 g/d for all lambs (Table 3). The analysis of gain composition in terms of g/kg tissues gain (muscle plus fat) also showed an increase in fat concentration ($p < 0.001$) and a decrease ($p < 0.05$) in muscle proportions for stall treatment (Table 3). According to the leg dissection results, the stall diet also increased ($p < 0.05$) the fat concentration (g/kg) and decreased the muscle one but without significant