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Original article

Effects of grass and concentrate feed on growth performances of rumbi lamb and meat fat composition

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This study aims to evaluate and compare the effect of grass and standard feed on lamb zoo technical parameters and meat fatty acid (FA) composition. 36 lambs of Rumbi breed were used in this trial, of which 24 lambs were organized in 2 groups (n=12) grazing on pasture at Semi-Arid (SA) and Wet (W) areas in west of Algeria during 100days. The third group was bred indoors by Concentrate feed (C). At the end of the experiment, lambs from group C were heavier (48.04 vs 28.13 and 24.23kg pre-slaughter). After slaughter, carcasses from SA and W groups were leaner (14.38 and 11.63 vs 23.93kg after cooling). Samples of longissimus dorsi (LD) were removed and analyzed. The results showed much fat in meat from group C (16.44 vs 6.87 and 5.89%)(P<0.001). The percentages of polyunsaturated fatty acids (PUFA) in meat from grazing lamb were higher (7.01 and 8.71 vs 5.05%)(P<0.05). All PUFA n-3 in meat from pasture have promoted significant amounts (2.07 and 2.67 vs 0.41%)(P<0.001), most importantly in terms of C18:3n-3 (ALA) (1.16 and 1.42 vs 0.2%)(P<0.001) while there was no significance for C18:2 n-6 (LA) (3.40 and 3.94 vs 3.40%). However the LA/ALA and n-6/n-3 ratios were much desirable for health in grazing lamb meat respectively (4.01 and 2.90 vs 14.31)(P<0.001), (2.86 and 2.25 vs 12.08)(P<0.001). Based on these results and from a fattening perspective, grazing is declared to be a husbandry system economically sustainable. It needs a promotion to seek new opportunities for the production of the main organic food such as light lamb.

1. Introduction

Red meat especially ovine products hold an important part in the Mediterranean diet. In Algeria, lamb meat is a main product 172000t (MADR, 2010). The quality of Rumbi lamb meat from pastures is poorly documented and the results are partial. The energy provided by grass between 1092-1456kcal/kg of DM makes the spontaneous forage and perennial weeds such as Atriplex halimus, Lygeum spartum and Herba a good alternative of the standard feed (Nefzaoui and Chermiti, 1991). Good adaptation to difficult conditions based primarily on its rusticity makes Rumbi breed able to take advantage of poor vegetations particularly in wetlands, semi-arid and arid areas. Among the large range of lamb types locally produced, previous studies declare that the Rumbi breed grazing outdoors yields light lambs and gives some specific characteristics to meat, whereas the intensive system provides fatty lambs (Saad, 2002).

It should be highlighted that red meat from small ruminants is rich in saturated fatty acids (SFA) because of the biohydrogenation process, however, diet and production system can change that fact. Wood et al. (2008) and Prache et al. (2011) reported that the nutritional quality of meat is influenced by its lipid component, of which healthcare FA concentrations increase by the copious consumption of herb as explained by (Bauchart et al. 2012). Furthermore, Nürnberg et al. (1998) have noted that the C18:3 n-3 amount from grass was 2.4 times higher than conventional feed, thus increasing the amount of PUFAs and their counterparts (EPA eicosapentaenoic acid, DHA docosahexaenoic acid, DPA docosapentaenoic acid) in meat especially during spring months (Maene et al. 2002). Moreover, the grass content of C18:3n-3 varies according to its vegetative stage; it increases in young shoots of spring but it would be greatly reduced during the wilting of the grass feed used as hay (Morand-Fehr and Tran, 2001).

Considering the consumers' interest in organic food products, a durable management system for rural space and animal resources is strongly recommended. This strategy can enhance livestock products (Collomb et al. 2004, Rymer et al. 2005 and Chilliard et al. 2007). To emphasize this idea, we carried a quantitative and qualitative experiment on animal performances, carcasses and meat fat profile from the two diets.

2. Materials and methods

2.1. Animals and diets

Animals of the study were from Rumbi (Ovis aries), which is an important local breed, resulting from crossing the muffled rams of "Djebel Amour" and "Ouled Djellal" sheep. Its apportionment is from Chott Chergui west Algeria to Wadi Taouil east. Thirty six male lambs aged of three months, with an average weight of (12.25 ± 2kg) were divided into three groups (n=12). Two groups were put out to pasture from the end of February to June 2011 in semi-arid SA and wet W areas respectively Oued Sefioune (latitude 35° 11' 38''N and longitude 0° 38' 29''W (650m) and Borgia coast line (latitude: 35° 50'N and longitude 0° 5'.3 E). These lambs were allowed to graze freely both young and leafy spring grass until haymaking season. The grazing system is the rotational warm bold, where the animals have frequently a young grass. The sampling plan for diets consists of taking 1 to 2kg of crude grass randomly through all the territories grazed by several handles. The third group (n=12) was housed indoors near Mostaganem city (latitude 35°56'0'' N and Longitude 0° 5' 0'' E), and was given a standard concentrate feed composed of(60% corn, 22% soybean meal, 17% brain and 1% minerals) without access to pasture. The concentrate diet was distributed ad libitum with forage after an adaptation period. At the test beginning, animals were not allotted. These animals belonging to herds in extensive and intensive areas of experimentation accompanied their mothers before and after weaning. The water was always available for all animals raised in intensive mainly.

2.2. Slaughter and sampling

At the end of the experiment which lasted 100 days, The grazing lambs (SA, W) and lambs fed on concentrate were slaughtered at the age of 180 days (± 10 days) with weight of 28.13kg, 24.23kg and 48.04kg respectively. They were processed and eviscerated in a local commercial slaughterhouse. The samples were removed from each carcass and were transported in icebox to laboratory of Food Technology and Nutrition of Mostaganem University. The dissected muscles of Longissimus dorsi were trimmed, minced in a meat grinder, packed in aluminum and stored at (-20°C) for further analysis of total lipid (TL) and FA (FA) composition.

2.3. Measurement and analysis

The lambs were weighed every week during the trial. The body weight gains were calculated weekly. The animals were slaughtered when their fatness was considered satisfactory. After chilling for 24h at 4°C, cold carcass weight was evaluated. The measurements were operated also for the appreciation of fat percentage of fresh weight and thickness of cover fat using a caliper. The diets samples were analyzed for energy value, nitrogen value (Jarrige, 1988 and Guerin et al. 1989) and chemical composition including dry mater (DM) and crude ash (CA) using respectively the drying oven at 103°C for 24h and aching at 550°C for 4h (AOAC, 1990). The crude protein (CP) was determined according to the Dumas method (2002). The neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were measured using the Van Soest method (1991). TL of each sample (diet or meat) were extracted by chloroform-methanol (2:1) according the Folch et al. (1957) method. Lipid FA were freed by saponification (NaOH), and then methylated by methanol–BF3 (Morrison and Smith, 1964). The methylic esters of FA were separated and quantified by gas chromatograph (Perkin -Elmer Auto System XL) equipped with flame ionization detector and a capillary column (30m x 0.25 mm internal diameter). The operating conditions of the gas chromatograph were as follows: temperature injector and detector of 220 and 280°C respectively. The oven temperature was programmed 45 - 240°C, with 20 - 35°C.min-1. Aliquots of 1µl were injected with bicyanopropyl phenyl silicone as a stationary phase. Hydrogen was used as a conductor gas. FA peaks were identified by comparison with retention times of FA methyl standards. Quantification was made by an internal standard (C17:0). Finally, to assess the nutritional properties, the n-6/n-3 and LA/ALA were calculated.

2.4. Statistical analysis

Data was analyzed using statistical analysis system (SAS) software (GLM) procedure, (SAS Institute, 1989) and expressed as means and standard deviations (SD). Parametric values were compared with one way analysis of variance (ANOVA) and Bonferroni's tests. The level ($P<0.05$) was considered as the cut-off for significance.

3. Results

3.1. Diets composition

The diets vary chemical composition and have different nitrogen and energy values which are presented in (Table 1) and (Table 2). In average, there was a slight difference in CP. The NDF, ADF and ADL were greatly higher for SA and W than C diet. Furthermore, the TL content in group C was higher than (SA, W) groups. Concerning FA, grass contained much SFA but less monounsaturated FA (MUFA) than standard feed especially in W diet. The dietary FA contents of palmitic, stearic and alpha linolenic acids in grass were larger compared to concentrate feed respectively. The oleic and linoleic acids were clearly higher in concentrate than grass SA and W respectively.

3.2. Growth performances and carcass parameters

Growth performances and carcass parameters are assembled in (Table 3). The pre-slaughter bodyweights of animals from concentrate diet were widely higher than animals from pasture. The calculated daily weight gain showed significant differences in growth performances between the two types of production. After cooling, the carcasses from pastures have presented weights approximately twice lower compared to those of animals fed the concentrate. The thickness measurements of subcutaneous adipose tissue and fat quantities expressed in percentages of carcass fresh weight showed differences of fattening states between the three groups in favor of the concentrate.

Table 1
Chemical composition and dietary fatty acid (in % of identified FA).

	SA	W	C
Dry mater (% of fresh tissue)	80.44	74.13	82.22
Crude ash (% of fresh tissue)	4.00	7.33	2.00
Crude fat (%)	3.23	3.32	4.73
Crude protein (%)	12.33	15.22	11.05
NDF(%)	41.16	38.11	16.10
ADF(%)	25.51	23.77	4.75
ADL(%)	5.27	7.84	1.05
C14:0	2.05	0.83	0.20
C16:0	16.47	19.11	13.16
C18:0	3.79	3.62	2.50
C18:1 n-9c	19.81	14.63	26.34
C18:2 n-6c	13.28	37.11	50.99
C18:3 n-3	30.25	15.67	2.19
C18:3 n-6	0.64	0.00	0.00
SFA	27.76	27.52	17.00
MUFA	26.42	18.37	28.25
PUFA	45.82	54.12	54.75

Table 2
Energy and nitrogen values of diets.

	SA	W	C
GE (kcal/kg of DM)a	4622	4512	4676
OMD (kg of FM)b	63	73	67
DE (kcal/kg of FM)c	2739	3155	2994
ME (kcal/kg of FM)d	2187	2504	2485
UFV (per Kg of FM)e	0.65	0.81	0.79
UFL (per kg of FM)f	0.74	0.88	0.86
DN (g/kg of FM) g	85	110	63

aGE(gross energy), bOMD (organic matter digestibility), cDE(digestible energy), dME(metabolizable energy), eUFV(fodder unit meat), fUFL(fodder unit milk), gDN(digestible nitrogen), FM(fresh matter).

Table 3
Growth performances and carcass parameters.

	SA	W	C
Body weight at start (kg)	12.05±1.39	11.40±1.28	12.53±1.24
Weight at slaughter (kg)	28.13±2.18	24.23±2.74	48.04±2.98
Weight gain (kg.day-1)	0.16±0.02	0.13±0.02	0.36±0.02
Cold carcass weight (kg)	14.38±0.96	11.63±1.57	23.93±1.91
Cover fat thickness (mm)	2.12±0.5	1.02±0.1	9.85±1.12
Fat (% of fresch weight)	14.27±0.45	4.53±0.66	29.79±1.95
Carcass yield (%)	51.23±2.83	47.92±2.13	49.79±1.96

3.3. Meat fatty acids

The TL contents of meat from different pastures (SA, W) were lower than those from concentrate diet (Table 4). In comparison with concentrate group, meat from pasture displayed more SFA ($P<0.01$) and low contents of MUFA were observed ($P<0.001$) especially in W. However, the PUFA promoted much more substantial quantities in meat from both SA and W groups at (P<0.05). The total n-3 FA was significantly higher (P<0.001) namely for ALA. No significance of total n-6 FA was seen mainly for LA.

Table 4

Total lipids and fatty acid composition of meat (in % of identified FA).

	SA	W	C	SD	Effect
TL	6.87b	5.89b	16.44a	5.83	***
C10:0	0.20	0.26	0.15	0.06	NS
C12:0	0.26ab	0.39a	0.11b	0.14	*
C14:0	3.90	4.63	2.94	0.85	NS
C16:0	25.76	25.37	24.67	0.56	NS
C16:1 n-9	0.42ab	0.51a	0.37b	0.07	**
C18:0	16.84b	21.49a	19.23ab	2.33	*
C18:1 n-9t	0.05	0.04	0.04	0.01	NS
C18:1 n-9c	41.06a	34.68b	42.79a	4.27	***
C18:1 n-7	1.70	0.77	1.70	0.54	NS
C18:2 n-6t	0.16b	0.16b	0.66a	0.29	***
C18:2 n-6c	3.40	3.94	3.40	0.31	NS
C18:3 n-3	1.16a	1.42a	0.26b	0.61	***
C20:0	0.11b	0.26a	0.12b	0.08	***
C20:2	0.12a	0.15a	0.00b	0.08	**
C20:3 n-6	0.11a	0.13a	0.02b	0.06	***
C20:4 n-6	0.83ab	1.37a	0.31b	0.53	**
C20:4 n-3	0.34a	0.50a	0.00b	0.26	**
C20:5 n-3(EPA)	0.02	0.05	0.01	0.02	NS
C22:4 n-6	0.11	0.17	0.07	0.05	NS
C22:5 n-3(DPA)	0.39a	0.56a	0.04b	0.27	***
C22:6 n-3(DHA)	0.09a	0.10a	0.01b	0.05	*
SFA	47.74b	53.38a	48.00b	3.18	**
MUFA	45.26a	37.91b	46.95a	4.81	***
PUFA	7.01ab	8.71a	5.05b	1.83	*
n-6	4.82	5.89	4.64	0.68	NS
n-3	2.07a	2.67a	0.41b	1.17	***
LA/ALA	4.01b	2.90b	14.31a	6.29	***
n-6/n-3	2.86b	2.25b	12.08a	5.51	***

[a,b] Means in the same line with different superscripts are significantly different.
NS = non-significant; * P<0.05, **P<0.01, ***P<0.001.

4. Discussion

4.1. Diets composition

The different grass diets showed variations in TL and FA composition due to maturity and variety of botanical species and soil of origin (Gilliland et al. 2002) taking into account that under grazing conditions, animals might select differently even within individual roughage species. These dietary proportions varied in agreement with the findings of Diaz et al. (2002) and Luciano et al. (2009) contrary to Petron et al. (2006). The C18:3n-6 was present only in grass particularly in SA area as a biomarker. In addition, the C18:3n-3 (ALA) displayed obvious higher amounts in grass than concentrate alike with Aurousseau et al. (2004) (59.9 vs 3.6%).

4.2. Growth performances and carcass parameters

The evaluation of body weight at slaughter and carcass weight after cooling showed that lambs fed the concentrate diet were heavy compared to grazing lambs SA and W respectively, and their daily growth rate was twice higher. These parameters agree with previous studies, due to the abundance of energy in concentrate diet, and low loss of thermogenisis and limited movement, according to Petron et al. (2006). The positive effect could appear with old grass (Eugene et al. 2010).

4.3. Meat fatty acids

The significantly low amounts of fat in meats from grass were due to the low energy values related to the poor vegetation (Harper and Pethick, 2004; Popova et al. 2006) (Table 2). Majdoub et al. (2001) describes much deposition in meat from concentrate feed following an availability of net higher energy from carbohydrates which simulates the novo lipogenisis (Scollan et al. 2005). The SFA results were similar to Velasco et al. (2001) and Aurousseau et al. (2004). The medium-chain FA were predominant in lamb meat from pasture because of their presence in maternal milk (Oreani et al. 2005). The palmitic acid (C16:0) presented no significance and was a subject to contradictory observations between Aurousseau et al. (2004) and Banskalieva et al. (2005). The stearic acid (C18:0) had a significant difference between the groups with a predominance in W area as found by Rowe et al. (1999). The oleic acid results were in agreement with Popova et al. (2006) and Chiliard et al. (2007), but in contrast with Gatellier et al. (2005) who did not detect differences between intensive and extensive reared animals. The quantities of PUFA were higher in meat from grazing lamb especially in W and SA areas respectively, similar to Ådnøy et al. (2005), evenly in different pastures like lowland mountains. The total n-3 FA was significantly higher ($P<0.001$), due to n-3 grass lipid as reported by different authors like McAfee et al. (2010). The ALA increased significantly ($P<0.001$) and so did its long chain PUFA counterparts C20:4 n-3 ($P<0.01$), C22:5 n-3 ($P<0.001$), C22:6 n-3 ($P<0.05$), because of escaping the hydrogenating rumen process (Wood et al. 2003). The observed differences between levels of these PUFA series approve with results from the literature concerning the effect of feeding grass or grain diets to ruminants on meat FA composition (Sanudo et al. 2000 and Piasentier, 2003). In the other hand, there was no significance of total n-6 FA mainly for LA even though the C20:3n-6 and C20:4n-6 have presented higher significant proportions in grazing lamb meat at ($P<0.001$) and ($P<0.01$) respectively. Also the increase of LA in meat from concentrate feed was due to the complete inhibition of C18:1 to C18:0 hydrogenation as reported by Jenkins (1992). Other authors showed that available carbohydrates reduce the stay of food in the rumen decreasing biohydrogenation of polyenic FA (Petrova et al. 1994; Sauvant and Bas, 2001). Further, increasing crude fiber in SA and W diets respectively was associated with the decrease of C18:2n-6 in meat from pasture (Bas and Mohrand-Fehr, 2000). The trans oleic acid (C18:1n-9t) did not display any significant differences but Moloney et al. (2001) found a high accumulation in rumen biohydrogenation binding to the patterns of CLA by the way of Δ9 desaturase (Raes et al. 2004). These contradictory findings were probably related to the FA metabolism, season or rearing system steers (Priolo et al. 2002). In conclusion, Dufey and Colomb (2008) said that the concentrations of FA are linear in terms of the amount of total fat, but their slope is different depending on diet. As a consequence, the significant decrease of LA/ALA and n-6/n-3 ratios in grass fed lambs was observed ($P<0.001$), meeting the nutritional recommendations of world health organization (2003).

5. Conclusion

These results provide a net and clear comparison between lamb growth performances of the two different breeding systems in favor of the intensive. It should be noticed that the herbage in both areas yielded less fat proportions in carcasses, however the meat fatty acid profile from pasture seemed better from a health perspective, probably due to some nutritional properties naming LA/ALA and n-6/n-3 indexes that might be used in promotion of local lamb breed and develop certain food resources previously unused or underused.

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