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Effect of concentrate level and slaughter body weight on growth performances, carcass traits and meat quality of Barbarine lambs fed oat hay based diet

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ABSTRACT

This study was conducted to evaluate concentrate level (CL) and slaughter body weight (SW) effects on growth performances, carcass traits and meat quality of Barbarine lambs. Twenty-four weaned male lambs (23.1 kg), receiving an oat-hay based diet, were allotted into two groups. The LCL group received low concentrate level (300 g) and the HCL group received high concentrate level (600 g). Lambs were slaughtered at two prefixed weights (35 and 42 kg). For each group and each weight, six lambs were slaughtered. Lambs from HCL group had higher ADG, carcass yields, carcass compactness and subcutaneous fat thickness, and lower carcass meat proportion. CL increase did not affect meat pH, meat and fat color, chemical and fatty acid composition. Late slaughtering improved carcass yields and increased carcass adiposity. However, it did not affect carcass meat proportion and shoulder tissue composition. SW had effect on meat color and fatty acid composition.

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1. Introduction

Barbarine is the predominant sheep breed in Tunisia. It is a fat-tailed sheep breed raised traditionally on natural pasture, in an extensive system. Actually, some of these grasslands used for pasture are transformed for field crop. In the semi-arid and arid areas of Tunisia, feed available from natural pasture is becoming limited and of a very poor quality, especially when rainfall is scarce. For these reasons, farmers are adopting more and more the semi-intensive and intensive systems for growing and fattening lambs. Those systems, based mainly on oat hay and concentrate are considered expensive. In fact, the price of oat hay is very fluctuant and affected by rainfall. Main feed components in concentrate are frequently imported and with ever increasing prices. Increasing concentrate level and energy supply for growing and fattening lambs improved growth performances and eventually carcass yield (Dixon & Stockdale, 1999; Papi, Mostafa-Tehrani, Amanlou, & Memarian, 2011). However, high-energy supply could affect negatively the carcass fatness and nutritional meat quality (Papi et al., 2011). Carcass quality was also associated to slaughter body weight (Abdullah & Qudsieh, 2008). Sheep producers need to know the optimal slaughter weight, in relation to production cost, carcass weight and quality. Consumers need also to know the optimal slaughter weight for carcass and meat quality, especially fat content and fatty acid composition. Santos-Silva and Portugal (2001) and Abdullah and Qudsieh (2008) reported that increasing slaughter body weight (SW) above 35 kg could improve dressing percentage without having detrimental effects on carcass and meat quality. Barbarine lambs are mainly slaughtered at a body weight below 35 kg. It could be better to increase the SW up to 40–45 kg. This last SW is essentially preferred for festivities. Therefore, in our study, we aimed to determine the effects of two concentrate levels and two slaughter body weights on growth, carcass traits and meat fat composition in Barbarine lambs receiving oat hay based diet.

2. Materials and methods

2.1. Experimental design and animal management

The experiment was conducted at the experimental farm of the Institut Supérieur Agronomique de Chott Mariem, Tunisia. Twenty four, 6 month old, weaned Barbarine lambs of an average body weight of 23.1 ± 0.4 kg were used. Prior to weaning, lambs grazed with their mothers on natural pasture. They were allotted into eight pens (3 lambs per pen). The eight pens were assigned randomly to two treatments. All animals received chopped oat hay ad libitum and a commercial concentrate composed of 16.5% of soybean meal, 25% of wheat bran, 53.5% of corn grain and 5% of mineral vitamin supplement. The chemical composition of the feeds is shown in Table 1. For the first treatment, animals received a low concentrate level (200 to 300 g/d, LCL) and for the second treatment, lambs received a high concentrate level (400 to 600 g/d, HCL). Concentrate quantity was adjusted to lamb body weight increase and was determined based on French feeding system (INRA, 1988). Concentrate was allowed twice a day. Lambs had free access to water. To determine

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Table 1
Chemical composition of experimental feeds (g/kg DM).

	DM (g/kg)	Ash	Crude fiber	Crude protein
Oat hay	957.4	62.9	369.8	37.5
Concentrate	892.9	43.8	52.00	185.6

intake, allowed and refused feed were weighed daily for each pen. Lambs were weighed in the beginning of the trial, each 15 days and before slaughter. Linear regression was used to determine individual average daily gain (ADG) and feed conversion rate was calculated for each pen.

2.2. Slaughter procedure, carcass measurements and dissection

Two slaughter body weights were predetermined: 35 (SW1) and 42 kg (SW2). The day before slaughtering, lambs were weighed in the experimental farm. They were then fasted for 12 h, with free access to water. They were transported to a commercial slaughterhouse, where they were re-weighed just before slaughtering. Lambs were slaughtered according to the Muslim rite and under veterinarian control. Hot carcass, viscera (liver, heart, lungs, and empty digestive tract) and gastro-intestinal content were weighed. Dressing percentage was determined as the rate of hot carcass weight over empty body weight. Viscera proportions were expressed in relation to pre-slaughter body weight. Carcasses were then chilled at 4 °C for 24 h. They were then re-weighed. Commercial dressing percentage was calculated as the rate between cold carcass and pre-slaughter body weight. Kidney, kidney fat, testis and tail were removed and weighed. Carcasses were split along the midline. The left sides were separated into seven joints, as described by Fisher and De Boer (1994). The different joints were weighed to estimate their proportions based on the cold carcass. Proportions of higher-priced joints (leg + shoulder + loin) were also determined. All the joints were deboned to evaluate meat dressing. Shoulder and tail were dissected into fat, muscle and bone. In fact, according to Rodriguez et al. (2008) shoulder was considered as the best joint to predict carcass tissue composition.

Carcass length (C1), internal carcass length (C2), chest or thoracic depth (T1) and rump circumference (B1) were recorded based on Fisher and De Boer (1994) measures. Leg length (L1) and leg circumference were measured as presented by Laville et al. (2002). These measurements were used to evaluate carcass compactness (cold carcass weight/C2), leg compactness (leg weight/L1), based on the work of Carrasco et al. (2009). Subcutaneous fat thickness was measured using a digital calibrator at 4 cm from the spinal column and at the level of the 13th rib (Fisher & De Boer, 1994).

Meat and fat color was determined 24 h after slaughter with a chromameter (Minolta CR-401, Ltd Japan), using the L* (Lightness), a* (redness) and b* (yellowness) system and the D_{65} illuminant. Meat color was measured in the *m. longissimus lumborum*. Muscles were maintained at 4 °C and exposed to air for 10 min before measuring color. Fat color was measured in the tail and in the subcutaneous fat over the lumbar region. The pH of the *m. longissimus thoracis* was recorded 1 h and 24 h after slaughter using a pH-meter WTW-340, equipped with penetrating electrode (pH senTix 6, sp).

Longissimus lumborum was dissected to eliminate subcutaneous fat, ground and frozen at −20 °C for chemical analyses. Dry matter, crude protein and total ash were analyzed according to AOAC (1995). Fat was determined using the Folch method (Folch, Lees, & Sloane Stanley, 1957). Fatty acid were converted to methyl esters by transesterification and then analyzed by gas chromatography on an omega wax 320 capillary column; 30 m × 0.32 m. Injector and detector temperatures were of 230 °C and 250 °C, respectively. Temperature increased by 5 °C/min. For each fatty acid, results were expressed as a percentage of the total fatty acids.

2.3. Statistical analyses

The GLM procedure of Statistica (2000) was used. The model included concentrate level (2), slaughter body weight (2) and their interactions (2 × 2) as fixed factors. Individual lamb was considered as the experimental unit. Values were given as means. Residual mean squares were used as error term. Differences among means were determined using the Fisher test and were considered significant when $P \leq 0.05$.

3. Results and discussion

3.1. Growth and feed intake

Oat hay voluntary intake decreased when increasing concentrate level (CL, $P<0.001$). This could be associated with inhibitory effect of concentrate on voluntary intake of forages (Table 2). ADG was 57% higher ($P<0.001$) for the HCL group than the LCL group (Table 2), while feed conversion rate (FCR) was 41% lower ($P<0.001$) for the HCL group. Final weight increase from 35 to 42 kg did not affect ADG. However, it increased ($P<0.001$) oat hay voluntary intake and FCR by 14% and 13%, respectively.

3.2. Carcass and offal proportions

At fixed slaughter weights, hot and cold carcass weights increased ($P<0.05$) by 12 and 11%, dressing percentage increased ($P<0.05$) by 1.5% and commercial dressing percentage increased ($P<0.01$, Table 3) by 2.7% when CL increased. Papi et al. (2011) reported a 4 kg and 4.9% increase in carcass weight and dressing percentage, respectively, when concentrate proportion went from 30 to 50%. Those results confirmed those reported previously in other studies when increasing dietary energy concentration or concentrate level in the ration (Jacques, Berthiaume, & Cinq-Mars, 2011; Mahgoub, Lu, & Early, 2000, Mushi, Safari, Mtenga, Kifaro, & Eik, 2009). Higher percentage of empty gut ($P<0.05$) and liver ($P<0.001$) with HCL resulted in a higher offal percentage ($P<0.05$). The weight of empty gut (3.18 and 2.86 kg for HCl and LCL groups, respectively) was also higher with HCL ($P<0.05$) and could be associated to higher visceral fat. Fluharty and McClure (1997) reported higher gut and visceral fat weight for lambs fed ad libitum than for lambs fed at 85% of the ad libitum. Jacques et al. (2011) showed also an increase of digestive tract weight when concentrate was fed ad libitum than when it represented 40% of DMI. However, Papi et al. (2011) reported no effect of CL on empty gut weight for lambs slaughtered at 60 kg. Moreover, testis and kidney percentage were lower for HCL group ($P<0.001$).

Table 2
Effects of concentrate level and slaughter weight on voluntary hay intake, concentrate intake, ADG and feed conversion rate (FCR) in Barbarine lambs.

	Concentrate level		Slaughter weight			Level of significance		
	LCL	HCL	SW1	SW2	SEM	CL	SW	CL*SW
Initial weight (kg)	23.1	23.1	22.7	23.4	0.45	NS	NS	NS
Final weight (kg)	37.4	39.2	34.8	41.7	1.00	NS	***	NS
Slaughter weight (kg)	36.4	38.2	33.9	40.7	1.00	NS	***	NS
ADG (g)	77.2	121.7	100.2	98.7	5.88	***	NS	NS
Hay intake (kg/d)	0.9	0.6	0.7	0.8	0.03	***	***	NS
Concentrate intake (kg/d)	0.3	0.5	0.3	0.4	0.09	***	***	NS
FCR (g DM/g ADG)	15.8	9.3	10.9	12.3	0.9	***	***	NS
Fattening period (day)	186	124	121	185				

LCL: low concentrate level (200–300 g); HCL: high concentrate level (400–600 g); SW1: slaughter weight of 34 kg; SW2: slaughter weight of 41 kg. CL*SW: interaction between slaughter weight and concentrate level.
***$P<0.001$; NS: $P>0.05$.

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