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Effect of substitution rate of soya bean cake by faba beans (*Vicia faba*) on meat quality of black of Thibar and fat tail Barbary breed lambs

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Abstract. This study aims to compare the effect that different level of faba bean distributed to two local Tunisian lamb breeds on the quality of meat during 5 days *postmortem*. Thirty male black of Thibar and fat tail Barbary lamb breeds were divided into three groups. After weaning the lambs were offered access to one of three different iso-nitrogen and iso-energetic concentrates, where soya beans were substituted at 0%, 10% or 20% by faba beans cake in diets. At the end of the trial (75 days), all lambs were slaughtered. Colour (L, a*, b*), pH and shear force of *longissimus dorsi* and *semitendinosus* muscle were significantly affected by breed and nitrogen source ($p < 0.001$). This study showed that, lambs receiving faba bean had tender meat and better quality scores than meat from lambs receiving only soya bean.

Keywords. Meat quality – Barbary – Black of Thibar breed – Faba bean – pH – Colour – Shear force.

Effet de la substitution du tourteau de soja par la féverole (*Vicia faba*) sur la qualité de la viande des agneaux de races Noire de Thibar et Barbarine

Résumé. Cette étude vise à comparer l'effet de l'incorporation de différents niveaux de féverole distribués à des agneaux de deux races locales tunisiennes sur la qualité de la viande pendant 5 jours *post-mortem*. Trente mâles simples de race Noire de Thibar et de race Barbarine ont été divisés en trois groupes de 10 agneaux chacun. Après le sevrage, les agneaux avaient accès à l'une des trois rations iso-azotées et iso-énergétiques, où le tourteau de soja a été remplacé par 0%, 10% ou 20% de féverole. À la fin de l'essai (75 jours), tous les agneaux ont été abattus. La couleur (L, a*, b*), le pH et la force de cisaillement du *Longissimus dorsi* et du *Semitendinosus* ont été affectés de manière significative par la race et par la source d'azote ($p < 0,001$). Cette étude a montré que les agneaux recevant la féverole avaient une viande tendre et de meilleurs scores de qualité que la viande d'agneaux ne recevant que du soja.

Mots-clés. Qualité de la viande – Barbarine – Noire de Thibar – Féverole – pH – Couleur – Force de cisaillement.

I – Introduction

Soya bean is the most common nitrogen source included in the concentrate for ruminants. However, in recent years an important objective of Mediterranean farmers has been to promote the use of alternative protein sources, preferably from local feedstuff, in animal feeding to try to reduce production costs. 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 *et al.*, 2002) and is a potentially valuable protein and energy supplements for animals. Several studies showed that their use did not negatively affect growth, slaughter performances or meat quality (Hadjipanayiotou, 2002; Lanza *et al.*, 2003b; Lanza et Priolo, 1999; Purroy *et al.*, 1992; Surra *et al.*, 1992).

Faba bean (*Vicia faba*) is a legume seed available in the Mediterranean area and is comparatively cheap despite its relatively high nutritional value. Its crude protein content is high

(30-32% of dry matter) and the aminoacidic profile has a high lysine content (Palander *et al.*, 2006). The use of diets based largely on faba bean for lamb fattening gave similar growth performance and meat characteristics as traditional diets based on soybean meal as the main protein source (Caballero *et al.*, 1992; Lanza *et al.*, 1999). Thus, the objective of the present trial was to evaluate the effect of replacing dietary soybean meal by faba bean in the concentrate fed to lambs breeds on the quality of meat during 5 days *postmortem* (pH, colour, shear force).

II – Materials and methods

1. Experimental design, animals and diets

The experiment was conducted on a farm in North West of Tunisia. The feeding trial was carried out with a total of 15 fat-tailed Barbarine and 15 Black of Thibar male lambs. The thirty lambs were born on the same farm. At 180 days of age, the lambs were divided into 3 groups balanced according to their weights ($34.13 \text{ kg} \pm 2.75 \text{ kg}$), with 10 animals per treatment. Treatments included: Lambs fed with concentrate where soybean meal was the main protein source (SBM group); lambs fed with concentrate where faba bean was the 10% of protein source (FB1 group) and lambs fed with concentrate where faba beans were the 20% of protein source (FB2 group). The lambs, after 15 days of adaptation to the experimental diet, were fed for 60 days. The lambs were raised in stalls and fed a ration based on wheat straw and concentrate. The wheat straw was offered of ad libitum intake. Although, the concentrate was amount 800 g per head.

The animals were slaughtered 240 days of age in a licensed abattoir. After slaughter, the carcasses were cooled to 4°C for 24 h according to the normal working practice in the abattoir. They were then halved carefully, and the left side of each carcass was divided into standardised commercial cuts: leg, shoulder, rib and loin, breast, and neck, and transported to the laboratory in an appropriate refrigerated system. Slices of *Longissimus dorsi* (LD) and *Semitendinosus* (ST) muscles were taken to measure pH, colour and shear force during meat maturation. Legs were frozen at -20°C to carry out the sensory analysis.

2. pH

The initial pH (pH_i) was measured one hour after slaughter on the carcass at the long dorsal and at the leg. The meat pH was measured at 24 h post-mortem, at $4 \pm 2^\circ\text{C}$, in the LD (9th-13th rib level) and in ST with a penetrating electrode connected to a portable pH-meter type Hi 8424 microcomputer (HANNA instruments). Besides, the pH was measured during five days post mortem in the aim to study the evolution of pH.

3. Meat colour

Meat colour was measured at 24 h post-mortem, at $6 \pm 2^\circ\text{C}$ on the surface of the section of the LD (9th-13th rib level). Meat colour was also measured at 5th day of maturation meat. Colour measurements of the muscle surfaces obtained using a Minolta CR-410 colorimeter (Minolta). Before use, the colorimeter was standardized using a white tile with Illuminant D65. The CIELAB colour space was used in colour measurement. The L (lightness), a* (redness), and b* (yellowness) colour co-ordinates were measured three times on the muscle surfaces and averaged for statistical analysis.

4. Texture

Slices of LD and ST were cut rectangular parallelepipeds, around 1*1 cm-thick and 2-3 cm long, were cut parallel to the muscle fibres. Shear force was measured on meat aged 24 h and 5

days post-mortem. Raw meat texture was measured in the longitudinal configuration using a TA-XT plus (Texture analyser, Stable Microsystem, UK).

5. Sensory analysis

In order to evaluate the influence of faba beans level substitution and breed on the sensory characteristics, 30 cooked lamb legs were assessed by a trained panel of 14 members, using classical sensory analysis by attribution of note to each presented sample (from 1 to 10). The day before the event tasting meat samples were thawed in a refrigerator at 4°C. Each lamb leg muscles were cut into slices according to the number of guests tasters. The slices should be of uniform size and thickness. These were placed in aluminum trays covered with aluminum foil identified and put in an oven pre-heated to 240°C for 50 to 55 minutes. They were cooked with the fat cover may be present on the surface. The panel was held at 12 a.m. the attributes were immediately served on glass plates. A glass of about 100 ml of water was provided for each assessor between samples. All sessions were done in eight booth sensory panel room. Panelists have given a score the meat samples. Each attribute was scored on a scale of 10 cm for each characteristic: color, tenderness, flavor, juiciness, and odor. The attributes were ranged from the lowest intensity of each trait to the highest.

6. Statistical analysis

All statistical analyses were performed using SAS 9.1. Data were analysed using the GLM procedure to determine the significance of effects (breed, faba bean level) on pH, colour and instrumental texture and their interactions. In addition, the muscle effect difference was analysed. Duncan's test was used to measure differences among means. Differences were considered significant at the $p \leq 0.05$ level.

III – Results and discussion

1. pH

The effects of breed and faba beans level in concentrate on pH are summarized in Table 1. The pH values 24 h after slaughter ranged from 5.6 to 5.7 in *Longissimus dorsi* muscle, indicating that the animals were not stressed at the time of slaughter. Furthermore, the pH at 24 h ranged from 5.7 to 5.9 in *Semiteminosus* muscle, is higher than the pH 24h in LD muscle. The results are in accordance with those previously reported by Velasco *et al.*, 2004. This result is probably due to the nature of the muscle (skeletal muscle) and its glycolytic, oxidative and oxidoglycolytic fibers content (Hocquette *et al.*, 1998) and/or its glycogen content (Bendall, 1962). In general, there were no differences in pH measurements among breeds or feed, although there were individual differences according to Duncan's test.

Breed did not significantly influence pH values in either LD or ST muscles. This effect has been widely studied. Compared with the Barbarine lambs, Black of Thibar lambs presented lower pH values at 24 h ($P < 0.001$) in the m. ST. Most studies have reported no significant difference between breeds. Thus, Dransfield *et al.* (1979), using English breeds (Texel, Dorset Down, Suffolk, Oxford, Cotswold, and Southdown); found no difference in pH 24h. Sañudo *et al.* (1996) obtained the same results with Spanish breeds. However, Beriain *et al.* (2000) found differences in ultimate pH of about 0.2 at LD muscle between Aragonesa lambs and those of Lacha breed.

Faba beans level in concentrate did not significantly influence pH values in either LD or ST muscles. The ultimate pH in LD and ST muscle were similar. The pH in LD or ST muscle aged 5 days of Barbarine lambs are significantly different by feed group ($p < 0.05$). The pH (LD) of FB1 Barbarine lambs was higher than those of SBM and FB2 groups. Besides, the pH (ST) of SBM Barbarine lambs was lower than FB1 and FB2 groups. Furthermore, other workers did not find any effect of concentrate in rate on pH in lambs (Carson *et al.*, 2001; Lanza *et al.*, 2003), and

are thus consistent with the results of the present study. However, Solomon and Lynch (1988) showed that male lambs of 45 kg fed by different diets have pH values at 3 and 5 h post-mortem were higher but they became weaker after 48 h post-mortem in the case of lambs fed diets richer compared to those fed the diet poorest. After 1 h post-mortem, glycogen content was higher and lactic acid was the lowest for lambs richer fed diets compared to other. Furthermore, Díaz *et al.* (2002) reported non-significant differences in ultimate meat pH among feeding systems were also available.

Table1. The pH of *Longissimus dorsi* (LD) and *Semitendinosus* (ST) muscles from lambs of different feed groups and different breeds

	Fat-tailed Barbarine			Black of Thibar			P		
	SBM	FB1	FB2	SBM	FB1	FB2	Feed	Breed	Interaction
<i>Longissimus dorsi</i>									
pH _i	6.43	6.35	6.35	6.23	6.30	6.30	ns	ns	ns
pH _{24h}	5.69 ^d	5.74 ^d	5.74 ^d	5.72	5.71	5.67 ^d	ns	ns	ns
pH(5 day aged)	5.53 ^{ac}	5.71 ^{bd}	5.52 ^{ad}	5.7	5.58	5.63	ns	ns	**
<i>Semitendinosus</i>									
pH _i	6.59	6.49	6.55	6.44	6.45	6.52	ns	ns	ns
pH _{24h}	5.96 ^c	5.93 ^c	5.98 ^c	5.78	5.8	5.9 ^c	ns	***	*
pH(5 day aged)	5.65 ^{bc}	5.9 ^{ac}	5.91 ^{ac}	5.77	5.7	5.7	ns	ns	*

ns = Not significant differences; (*) p<0.05 ; (**) p< 0.01 ; (***) p< 0.001; a,b: Different superscripts represent significant differences among feeds (within breed) (p<0.05); c,d: Different superscripts represent significant differences among muscles (p<0.05).

2. Meat colour

Meat colour was influenced by both effects breed and faba beans level in concentrate, but the effect of breed was greater than that of feed group (Table 2). Only the lightness L_{24h} and yellowness b* (5 day aged) at LD muscle, also, L_{24h} and redness index (a* 24h) at ST muscle, didn't affected by breed. The redness index (a*24h) measured at LD muscle for Barbarine lambs was higher than Black of Thibar (16.58 vs 14.42). The LD muscle at 24h was more yellow in Barbarine lambs. After 5 days post-mortem, the LD for Black of Thibar was more lighter (54.80 vs 53.56). However, the ST muscle for Black of Thibar was more yellow than Barbarine lambs (8.39 vs 7.75) at 24 h after slaughter. In addition, after 5 days post-mortem, the ST muscle for Black of Thibar was lighter, redder and more yellow than those for Barbarine lambs (58.82, 22.97, 12.65 and 52.04, 20.45, 9.22 for L, a* and b* parameters for Black of Thibar and Barbarine lambs, respectively). Martínez-Cerezo *et al.* (2005) did find an effect of breed on colour meat and are thus consistent with the results of the present study.

Feed groups affected significantly the L_{24h}, a*_{24h} (p<0.01) and L (5 day aged) (p<0.05) at LD muscle. The LD for FB1 and FB2 groups had the highest redness index (a*) comparatively at those for SBM group. The L_{24h} for SBM group at LD muscle was lighter (55.24) than FB2 (53.48). After 5 days post-mortem, redness index at LD muscle decreased.

The ST muscle for SBM group was less light (54.17) and less red (18.62) than lambs received faba beans in concentrate. The yellow index b* was higher at ST muscle 5 day aged for SBM group (11.85). The incorporation of faba beans increased the redness and yellowness index of LD and ST muscle for Barbarine lambs. Lanza *et al.* (2003b) were reported that lightness (L), redness (a*) and yellowness (b*) values of LD muscle were identical between treatments, lambs received peas and those did not.

Table 2. The colour of *Longissimus dorsi* (LD) and *Semitendinosus* (ST) muscles form lambs of different groups and different breeds

	Fat-tailed Barbarine			Black of Thibar			P		
	SBM	FB1	FB2	SBM	FB1	FB2	Feed	Breed	Interaction
<i>Longissimus dorsi</i>									
L 24h	54.95	54.54	52.82	55.53	54.44	54.13	*	ns	ns
a*24h	15.98	16.40	17.32	13.40	14.8	15.06	*	****	****
b*24h	9.20	9.83	9.42	5.96	6.80	6.92	ns	****	****
L (5 day aged)	54.58	53.87	52.28	54.97	53.55	53.88	**	**	***
a* (5 day aged)	13.81	14.14	14.93	14.99	14.13	15.05	ns	ns	ns
b* (5 day aged)	9.34	8.93	8.71	7.37	7.41	8.25	ns	****	****
<i>Semitendinosus</i>									
L 24h	54.51	51.15	52.69	53.83	53.61	53.34	**	ns	****
a*24h	17.73	20.07	19.59	19.50	19.03	18.74	*	ns	****
b*24h	7.96	7.67	7.60	8.44	8.47	8.27	ns	**	*
L (5 day aged)	52.91	51.30	51.77	60.50	58.70	58.10	ns	****	****
a* (5 day aged)	20.15	20.90	20.40	23.69	22.25	22.96	ns	****	****
b* (5 day aged)	10.73	8.44	8.34	12.96	12.51	12.47	*	****	****

ns = Not significant differences; (*) p<0.05 ; (**) p< 0.01 ; (***) p< 0.001; (****)p<0.0001.

3. Meat tenderness

Mean values of meat shear force are presented in Table 3. The faba beans level did not affect the mean shear force levels at 24h and 5th day post mortem measured in *Longissimus dorsi* and *Semitendinosus* muscles (p>0.05), only the shear force of ST at day 5 post-mortem (p<0.05). The lambs received 20% of faba beans in concentrate had the tenderest ST at day 5 post-mortem (37.47N) than those of SBM and FB1 groups (52.18, 41.50 for SBM and FB1group, respectively). Lanza *et al.* (2003b) reporting non-significant differences in shear force among feeding systems.

Table 3. Shear force of *Longissimus dorsi* (LD) and *Semitendinosus* (ST) muscles form lambs of different groups and different breeds

	Fat-tailed Barbarine			Black of Thibar			P		
	SBM	FB1	FB2	SBM	FB1	FB2	Feed	Breed	Interaction
<i>Longissimus dorsi</i>									
Shear force 24h (N)	40.62	47.83	43.76	46.55	48.59	48.56	ns	ns	ns
Shear force 5 day aged (N)	37.92 ^b	38.04 ^b	40.44 ^a	53.33 ^a	54.86 ^a	43.72 ^b	ns	****	**
<i>Semitendinosus</i>									
Shear force 24h (N)	59.06	41.08	43.43	51.80	51.03	63.01	ns	ns	**
Shear force 5 day aged (N)	51.46 ^a	29.73 ^b	29.48 ^b	52.95 ^a	42.64 ^b	56.53 ^a	*	**	***

ns = Not significant differences; (*) p<0.05 ; (**) p< 0.01 ; (***) p< 0.001; (****)p<0.0001. a, b: Within a column, means without a common superscript letter differ (p<0.05).

The breed affect the tenderness of LD muscle aged 5 day (p<0.0001) and shear force of ST muscle measured at day 5 post-mortem (p<0.001). Barbarine lambs had the lower shear force for LD muscle aged 5 day comparatively to Black of Thibar lambs (38.90 vs 49.55). Indeed, the

ST muscle from Black of Thibar had a higher shear force measured at day 5 post-mortem (49.55 vs 36.70). Martínez-Cerezo *et al.*, 2005, showed that breed had significant effects on instrumental texture. The effect of breed was greater than that of feed group. Therefore, shear force LD at 5th day post-mortem from Barbarine of SBM had the lower shear force than those of FB2 group ($P < 0.05$). Furthermore, the LD from Black of Thibar of FB2 group was more tender than those of SBM and FB1 groups. Significant differences in shear force among production systems/feeding systems have been attributed to the variation of enzymes activities in muscle during maturation meat. At ST muscle aged 5 days, Barbarine lambs from FB1 and FB2 groups had the lower shear force. Indeed, Black of Thibar lambs whose received 10% of faba beans (FB1) had the tenderest ST muscle. All the results obtained by this present study demonstrating that the using of faba beans in concentrate tends to decrease the myofibrillar toughness.

4. Sensory characteristics

Results of sensory characteristics of meat in different feed groups and breeds are presented in Table 4. Except odour intensity score, feed group didn't have significant influence on sensory characteristics. Odour scores given to meat of FB2 lambs were significantly lower ($p < 0.05$) than that of lambs of other feed groups.

Table 4. Meat sensory characteristics of leg form lambs of different groups and different breeds

	Fat-tailed Barbarine			Black of Thibar			p		
	SBM	FB1	FB2	SBM	FB1	FB2	Feed	Breed	Interaction
Colour intensity	5.59 ^a	6.70 ^a	6.40 ^a	5.58 ^a	4.36 ^b	6.25 ^a	ns	*	*
Tenderness	5.06 ^b	5.55 ^b	4.76 ^b	5.29 ^b	6.22 ^a	6.02 ^b	ns	*	ns
Juiciness	4.01 ^b	4.12 ^b	3.94 ^b	5.40 ^a	5.71 ^a	5.02 ^b	ns	**	*
Odour intensity	6.04 ^b	5.46 ^b	5.83 ^b	6.68 ^a	4.96 ^b	5.87 ^b	*	ns	ns
Flavour intensity	5.04	5.27	5.20	5.94	5.35	5.57	ns	ns	ns

ns = Not significant differences; (*) $p < 0.05$; (**) $p < 0.01$; (***) $p < 0.001$; (****) $p < 0.0001$. a, b: Within a column, means without a common superscript letter differ ($p < 0.05$).

Breed affected significantly the meat colour, tenderness and juiciness scores ($p < 0.05$). The black of Thibar had the higher tenderness and juiciness scores but the lower colour score. This result might be related to the carcass fatness or/and intramuscular fat content in meat of Black of Thibar lambs. Priolo *et al.* (2002) noted that influence of fatness level on meat tenderness could be related to a direct effect of the fat which is softer than lean and/or to an indirect effect of reduced muscle fibre shortening. In the current study, tenderness values were positively correlated with carcass fatness score ($r = 0.366$; $P < 0.05$). There were significant differences among breeds within feed groups. Except the Black of Thibar form FB1 group, the others had similar scores. Acceptance of meat by consumers is influenced by numerous criteria such as meat flavour, tenderness and juiciness (Sañudo *et al.*, 1998). Therefore, Panellists gave had a lower meat colour and odour scores to Black of Thibar from FB1 group. In addition, they had a higher tenderness and juiciness scores. These results were in accordance with reports of Yu *et al.* (2001), whose found that the scores of the overall acceptability of meat from lambs fed the narbon beans diets was comparable to that of the lambs fed the Lucerne diets.

IV – Conclusion

Breed had a significant effect on the physic-chemical characteristics and sensory quality of lamb meat and should be considered in programs to improve meat quality. Using faba beans in

concentrate also affected meat lamb quality. Using faba beans in concentrate increased the different parameters of meat colour. After the maturation meat, the meat from black of Thibar was the lighter, redder and more yellow. The Barbarine lambs from FB1 or FB2 groups had the lower shear force. However, the panelists preferred meat from black of Thibar received 10% of faba beans in concentrate.

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