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Replacement of soybean meal with lupine in Barbarin lamb diet: Effect on intake, digestion, fermentation and growth

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Abstract. This study aims to evaluate the effect of white lupine seeds as a substitute for soybean meal in the diets of lambsTwenty-four 6 and a half month-old Barbarine lambs (average initial weight 23 kg) were divided into three equal groups. Three types of concentrates, the first two of which were iso-nitrogenous, were formulated as follows: CC1 containing 75% barley, 22.5% soybean meal and 2.5%mineral and vitamin supplement (CMV); CC2 containing lupin as a substitute for soybeans; and CC3 containing only barley and CMV (this is the concentrated 1 devoid of soybean meal). In addition to the hay that was distributed at libitum, animals assigned to the first and the second group received daily, 500 g of concentrate 1 and 500g of concentrate 2, respectively. Those assigned to the third one received alternately concentrate 2 (day1) and concentrate 3 (day2). Experiment period was divided in a growth period (80 days) followed by a digestible period (10days). Diet had no significant effect on total dry matter and water intakes, average daily gain, diet digestibility and microbial synthesis ($P > 0.05$). For the nitrogen balance, the animals showed different retained nitrogen level ($P < 0.05$). Fermentation parameters were not affected by protein source. However, only the number of protozoa was influenced by the day of fluid collection ($P < 0.05$). It can be concluded that lupine grains can substitute safely soybean meal in diets of Barbarine lambs.

Key words: Soybean meal – Lupine – Lambs – Intakes – Digestibility – Fermentation – Average daily gain.

Remplacement du tourteau de soja par lupin dans l'alimentation des agneaux barbarins: Effet sur l'ingestion, digestibilité, fermentation et la croissance

Résumé. *L'objectif de cette étude est l'évaluation de l'effet de l'utilisation des graines de lupin blanc dans l'alimentation des agneaux comme un substitut au tourteau de soja. Pour cela, vingt-quatre agneaux de la race Barbarine, ayant un poids moyen de 23 kg et âgés en moyenne de 6 mois et demi divisés en trois lots homogènes. Trois types de concentrés, dont les deux premiers sont iso-azotés, ont été formulés comme suit : CC1 contenant 75 % orge, 22.5 % tourteau de soja et 2.5 % CMV ; CC2 contenant le lupin en remplacement avec le soja ; et CC3 contenant seulement de l'orge et de CMV. En plus du foin distribué à volonté, les animaux des deux premiers groupes ont reçu quotidiennement 500 g du concentré 1 (et 500 g du concentré 2, respectivement. Ceux du troisième goupe ont reçu en alternance le concentré 2 (jour1) et le concentré 3 (jour2). Les animaux ont subi une période de croissance (80 j) suivie par une période de digestibilité (6j). Les résultats obtenus ont montré que le régime alimentaire n'avait pas d'effet significatif sur les quantités ingérées, la consommation d'eau, le gain quotidien moyen, la digestibilité du régime et la synthèse microbienne ($P > 0.05$). Le bilan azoté qui était positif a varié significativement entre les trois lots ($P < 0.05$). Le pH, le nombre de protozoaires et le taux d'ammoniac les plus élevés ont été affectés par les régimes. Seulement le nombre de protozoaires qui a été influencé par le jour du prélèvement ($P < 0.05$).*

Mots-clés. *Tourteau de soja – Lupin– Agneau – Ingestion – Digestibilité – Fermentation – Gain quotidien moyen.*

I – Introduction

In Tunisia, particularly in the arid and semi-arid zones, climatic conditions have caused the degradation of rangelands leading to a forage deficit, particularly in sheep and goats. Thus, energy and / or nitrogen supplementation has become essential to maintain these animals and ensure the expected performance. For this reason, Tunisia has resorted to the import of raw materials including soybean meal, barley and corn (Ben Salem, 2011). However, fluctuations in their prices on the world market are negatively affecting animal nutrition industry. Our country imports annually, over 300,000 tons of soybean meal at a price of 1.2dt / kg (Bahri *et al*., 2014). Similarly, these imported raw materials are unstably available on the Tunisian market which can affect the profitability of farms and alter the sustainability of animal production sector. As a result, several attempts to replace these foods, including soybean meal, have been considered by researchers. Protein crops (Lupine, faba beans...) are good alternatives to soybean meal because of their high crude protein content. However, despite their good nutritional quality, their use in animal nutrition is currently limited due to the presence of anti-nutritional factors (Faba bean tannins, lupine alkaloids ...) and their fluctuating availability on the market. Thus, the main objective of this study is the evaluation of the substitution effect of soybean meal by sweet lupine on the ingestion, digestion, growth in Barbarine lambs.

II – Materials and methods

1. Animals

24 six-month-old Barbarine lambs were selected (23 kg±0.32). They were acclimated for 4 days to new housing conditions. Lambs were weighed than divided into three equal groups. All animals received oat hay *ad libitum* and concentrate. the first group received CC1 containing 75% barley, 22.5% soybean meal and 2.5% CMV, where as the second received CC2 containing lupine as a substitute for soybeans in term of CP to be iso-nitrogenous with CC1. The third group received alternately CC2 and CC3 containing only barley and CMV. Experiment period lasted 90days divided in a growth period (80 days) and digestible period (10 days).

2. Sampling

Average daily growth was assessed through weighing animals biweekly. At digestible period, lambs were housed in metabolic cages. A 7-day faecal collection period started on the following day. After weighing the amounts of fresh feed, refusals and faeces, samples of each were taken daily. Part of each sample was used for DM determination and the other part (20% of the weight of the fresh refusals and faeces) was stored at 4 ºC for hay and concentrates or at – 5 ºC for faeces. Urine was collected in plastic recipients containing 100 ml of a 10% sulphuric acid solution (v/v) and frozen (– 20 ºC). Pooled samples of individual feed refusal, and faeces were dried at 50 ºC, ground through 1 mm screen to be analysed. Samples of urine were stored in the freezer (– 20 ºC) until analysed. At the end of the growth period, rumen fluid was taken in two consecutive days to measure pH and ammonia content and to determine protozoa number.

3. Analyses

Feed, refusals and faeces samples were analysed for dry matter (DM), ash and crude protein (AOAC, 1984). They were analysed for (NDF, ADF and ADL) (Van Soest *et al*., 1991). Urine was analysed for Kjeldahl nitrogen (AOAC, 1984) and allantoin concentrations(Chen and Gomes, 1992). Rumen fluid samples were were analyzed for NH3-N (Weatherburn, 1967).

III – Results and discussion

Table 1 reports nutrient contents of feeds. soybean meal is greater in CP than lupine, while the opposite trend was observed for NDF, ADF and ADL.

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

	Oat hay	Soybean meal	Lupin	Barley
DM	929	903	903	896
OM	915	932	967	974
CP	77.6	480	329	110
NDF	673	172	270	489
ADF	404.3	52.9	151.6	102.2
ADL	62.5	3.75	8.63	25.9

Diets intake and digestibility are shown in Table 2. Results revealed that additional protein source did not affect intake, which corroborates with results reported by El Maadoudi (2004) and Ephrem *et al*. (2015). This could be explained by the importance of the nutritional quality of protein sources. Nevertheless, our results are contradictory to those reported by Lestingi *et al*. (2015) by testing the replacement of peas. In addition, proteins source did not reveal a significant effect on digestibility. DCPi amount was significantly affected (P< 0.01). Purroy *et al.* (1989) observed significant differences in diet digestibility by replacing soybean meal with lupine in lambs. Lupine incorporation improved diet digestibility (Ephrem *et al*., 2015). Lupine had no significant effect on the average daily gain (ADG). This result agrees with those of trials carried out on the replacement of protein seeds by lupine (El Maadoudi and El Housni, 2013, El Otmani *et al*., 2011). Moreover, Facciolongo *et al*. (2014) found that supplementation with soybean meal and lupine induced similar ADG, while Lestingi *et al*. (2015) showed low weight gain in animals fed lupine. Although the 3rd group received half of the quantity of lupine consumed by the 2nd one, the corresponding lambs were able to have similar and even better ADG than the others. This leads us to think about the concept of food efficiency. It seems that these animals were able to optimize their efficiency to transform food resources into meat.

Table 2. Effect of of lupine on intake, diets digestibility and daily gain in lambs

	Diets			ESM	P-value
	1	2	3		
DM intake (g/kg BW$^{0.75}$)					
Hay	50.9	50.5	53.0	2.56	0.7639
Diet	84.1	85.0	82.3	2.73	0.7695
Digestibility (%)					
DM	68.9	68.4	68.8	1.02	0.9294
OM	71.0	70.4	70.9	0.98	0.8896
CP	70.5	70.7	68.9	1.11	0.4831
NDF	67.2	65.5	65.2	1.19	0.4592
Intake (g/kg BW$^{0.75}$)					
DOM	55.6	55.7	54.0	1.68	0.7227
DCP	7.96^{a}	8.23^{a}	6.84^{b}	0.20	0.0003
Average daily gain. g/day	99.91	82.14	101.3	6.39	0.0835

^{a,b} Means in the same line with different superscripts are significantly different (P < 0.05).

Nitrogen balance and microbial synthesis are shown in Table 3 . It appears that all animals had positive balances. However, a significant variation in the amount of nitrogen intake and retention was observed in the 3rd group in comparison with the two others. This difference is explained by the variation of the ingested quantity of the concentrate. By correcting the retained nitrogen to the nitrogen intake, the nitrogen balance was similar for all diets, which confirms that animals had the same nitrogen use efficiency. Moreover, similar CP digestibility reinforces this finding.

Total amounts of purine and microbial nitrogen were not influenced by supplemented proteins (P> 0.05), which is consistent with the lack of effect on the CP digestibility. In accordance with our results, Yu *et al*. (2002) found no significant differences between purine and microbial nitrogen in lambs supplemented or not with blue lupine or faba beans.

Table 3. Effect of supplementation of lupine on nitrogen balance and microbial N supply in lambs

	Diets			ESM	P-value
	1	2	3		
Nitrogen intake (Ni), g/day	23.1[a]	23.0[a]	20.3[b]	0.42	0.0001
Fecal N, g/d	7.43	7.37	6.99	0.39	0.6875
Urinary N, g/d	4.18	4.16	3.71	0.49	0.7475
Retained N, g/d	11.5[a]	11.5[a]	9.6[b]	0.49	0.0176
Retained N, % Ni	49.7	49.9	47.6	2.41	0.7636
Total purine (mmol/d)	13.3	13.2	14.0	0.69	0.6668
Microbial N, g/d	9.70	9.57	10.2	0.50	0.6660

[a,b] Means in the same line with different superscripts are significantly different (P < 0.05).

Table 4 presents fermentation parameters. Average pH was affected by the diet (P < 0.05). pH corresponding to the 2nd group exceeded significantly that of the 1st group, but no significant difference was detected between that of the 3rd group and the others. Brand *et al*. (1999) reported pH values ranged between 6.4 and 6.3 in castrated rams fed a lupine diet. Ammonia level was affected only by diet (P > 0.05). The highest concentration was observed in daily lupine fed lambs. White *et al*. (2002) found that ammonia concentration were higher with lupine incorporation rate of 70% than with 35%, which corroborates the high ammonia level in animals receiving lupine daily and the low one in animals receiving lupine alternately. Protozoa numeration revealed a significant difference between diets. Animals belonging to the 2nd group had the highest number whereas those of the 3rd group had the lowest one. This could be explained by the corresponding ammonia concentrations since a large protozoa population is generally associated with a high ammonia concentration (Thivend *et al*., 1985).

Table 4. Effects of lupine on pH, ammonia nitrogen (mg/dl) and protozoa number (×10^5/ml)

	Day		Diets[1]			S E M		P-value		
	1	2	1	2	3	Day	Diet	Day	Diet	day*diet
pH	6.1	6.2	6.1[a]	6.2[b]	6.1[ab]	0.02	0.03	0.114	0.001	0.660
Protozoa	12.4	15.1	14.4[ab]	15.3[a]	11.7[b]	0.67	0.82	0.005	0.008	0.955
NH_3-N	20.5	19.9	19.9[a]	23.9[b]	16.8[a]	0.79	0.97	0.587	<.001	0.114

[a,b] Means in the same line with different superscripts are significantly different (Pr < 0.05).
SEM: Standard error of the mean.

IV – Conclusions

It can be concluded that lupine grains can substitute safely soybean meal in diets of Barbarine lambs.

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