

# Rumen fermentation pattern and blood metabolites of lambs from three breeds reared on pasture or feedlot

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**Abstract.** This study compares the rumen facies and blood metabolites of sheep reared on natural grassland in north-west of Tunisia or on feedlot. For this, 36 lambs (26 kg live weight, in average) from Barbarine (BB), Queue Fine de l'Ouest (QFO) and Noire de Thibar (NT), were equally divided in stall-fed (S) and pasture (P) group. In each feeding system, there were 6 lambs from each breed. After 60 days, fasting plasma was collected as well as the rumen liquid at 0, 2, 5 and 8 hours after feeding. The glucose, magnesium and iron contents in blood were higher for the S system ( $P = 0.001$ ); while cholesterol and urea contents were more elevated for the P system. The protozoa population in rumen fluid was globally similar for P and S systems. The N ammonia was not affected by the feeding system. Before feeding the acetic acid was higher for P group (43.44 vs. 40.37%;  $P = 0.03$ ). The propionic acid had the highest percentage 8 hours after feeding (28.98%). The butyric acid was not affected by both factors. The BB lambs present the highest glycaemia and rumen N ammonia contents, while those from NT breed present the highest creatinine concentration. The effects of both breed and feeding system were more spectacular in blood metabolites than in rumen fermentation pattern, this is in relation with the stability of the in the microenvironment.

**Keywords.** Blood metabolite – Pasture – Stall-fed – Rumen facies.

## **Profils fermentaires dans le rumen et paramètres sanguins chez des agneaux de trois races élevés au pâturage ou en « feedlot »**

**Résumé.** Cette étude compare le faciès fermentaire et les métabolites sanguins de moutons élevés sur les prairies naturelles du nord-ouest de la Tunisie ou en bergerie. Pour cela, 36 agneaux (26 kg de poids vif, en moyenne) de races Barbarine (BB), Queue fine de l'Ouest (QFO) et Noire de Thibar (NT), ont été répartis dans le groupe de bergerie (S) et le groupe de pâturage (P). Chaque groupe contenait six agneaux de chaque race. Après 60 jours, des échantillons de sang ont été collectés à jeun, ainsi que le jus de rumen à 0, 2, 5 et 8 heures après le repas. Les concentrations de glucose, de magnésium et de fer dans le sang étaient plus élevés pour le groupe S ( $P = 0,001$ ), tandis que le cholestérol et l'urée étaient plus élevés pour le groupe P. La population de protozoaires dans le fluide du rumen était globalement similaire pour les deux groupes. La teneur en ammoniac n'a pas été affectée par le système d'alimentation. A jeun la teneur en acide acétique été plus élevée chez le groupe P (43.44 vs. 40.37%;  $P = 0.03$ ). La teneur en acide propionique avait le pourcentage le plus élevé 8 heures après le repas (28.98%). La teneur en acide butyrique n'a pas été affectée par les deux facteurs. Les agneaux BB avaient les concentrations de glucose et d'ammoniac les plus élevées. Les agneaux NT avaient le taux de créatinine la plus élevée. Les effets de la race et du régime étaient plus spectaculaire en métabolites sanguins que dans les paramètres de fermentation dans le rumen, ce n'est en relation avec la stabilité de la dans le microenvironnement.

**Mots-clés.** Métabolites sanguins – Pâturage – Stabulation – Faciès fermentaire.

## I – Introduction

Rustic sheep breeds are better able to conserve fat during feed restriction than less adapted breeds, possibly because of differing responses to homeostatic signals (Chilliard *et al.*, 2000). However, domestication and breeding for better productivity, such as muscle, wool, or milk, may impact some of the adaptive mechanisms regulating energy metabolism in relation with rumen facies and blood metabolites. The aim of the present study was to examine the influence of breed and diet quality and the interaction between both factors on some blood metabolites and rumen fermentation pattern.

## II – Material and methods

Thirty-six lambs (26 kg live weight) from two rustic breeds; Barbarine (BB), Queue Fine de l'Ouest (QFO) and one meat breed, Noire de Thibar (NT), were equally divided into two groups, stall-fed (S) (500 g of concentrate and 500 g of oat hay; 11% of crude protein) and pasture fed (P). In each feeding system, there were 6 lambs from each breed. The grazed land covered 1600 m<sup>2</sup> and the land pasture was composed by 45% grass, 14% legumes and 41% other species (10% of crude protein). The trial lasted 60 days. At the end of the trial, fasting blood samples were taken in heparinized tubes of 10 ml and immediately centrifuged at 3000 rpm for 15 mn and the plasma was kept in plastic tubes of 2.5 ml at -20°C. A 400 µl aliquot of plasma was taken for assaying some plasma metabolites (glucose, cholesterol, triglyceride, urea, creatinine, calcium, phosphore, magnisium and iron). The rumen liquid was collected at 0, 2, 5 and 8 hours after feeding. Samples of rumen liquid used for NH<sub>3</sub>, AGV analyses were filtered for all times. The rumen liquid samples used to count protozoa were collected only at 2, 5 and 8 hours. Statistical analysis of blood metabolites were performed by analysis of variance using the GLM procedure of SAS (1999). A 2x2 factorial design was adopted to test the diet and breed effects. Rumen fermentation pattern variables were analyzed using the MIXED procedure for repeated measures. The factors included were diet or breed as between-subject fixed effects, time as within-subject effect and animal as subject (experimental unit).

## III – Results and discussion

### 1. Blood metabolites

The QFO breed had the highest glucose concentration. The stall fed diet based on concentrate leads to highest glucose concentration in blood (Table 1). In fact stall-fed diet is essentially composed by concentrate rich in starch which is a polymer of glucose. The interaction between both factors was significant for this parameter ( $P = 0.03$ ). In fact this parameter measure the energetic valorization of the diet by different breeds; in pasture the NT breeds had the same concentration as in stall (3.11 mmol/l) however the QFO breed had the highest concentration (3.38 mmol/l) and the BB breed had the lowest concentration (2.92 mmol/l). In Stall QFO and BB breeds had higher concentration of glucose (3.75 and 3.65 mmol/l respectively) and remain more adapted then NT breed to this type of diet. The breed had no effect on the cholesterol level, however the diet had a significant effect on the cholesterol concentration which was more important for animals conducted in pasture (Table 1). Studies with calves, humans, monkeys, chicks, and pigs have also found elevated cholesterol levels resulting from low protein diets (Mann, 1960; Beveridge *et al.*, 1963). Triglyceride concentration was not affected by both factors. This result shows that both diets and all breeds lead to the same amount of lipids (Table 1).

The urea concentration was higher in pasture-fed group. In fact, high concentrations of plant N (> 30 g of N/kg of DM) result in production of excess ruminal ammonia N, which is absorbed into

the bloodstream and excreted as urinary urea N (Dellow *et al.*, 1988). Thomas *et al.* (1988) reported that serum albumin and blood urea nitrogen reflected the dietary protein intake which explains the lower concentration of urea N in stall-fed group (Table 1). The creatinine is influenced by the breed and the NT breed had the most elevated level of creatinine. The rate of blood creatinine may be considered as an index of endogenous protein catabolism (Patrick *et al.*, 1998). This can be justified by the fact that the NT breed produced more muscle (Hajji *et al.*, 2013), thus this breed had higher protein degradation. The diet had no effect on the creatinine concentration this is in relation to the ingested protein level which is similar in both diets. In comparison to the present, Patrick *et al.* (1998) found that Lambs fed low CP diet tended to have greater levels of serum protein and had greater creatinine levels than lambs fed the high CP diet.

Calcium and phosphore were not affected by both breed and diet. However magnesium and iron were significantly higher in stall fed group then in pasture group (Table 1).

**Table 1. Effects of breed and diet on some blood metabolites**

	Breed			Diet			Statistic		
	BB	QFO	NT	S	P	SME	Breed	Diet	Breed* Diet
Glucose <sup>†</sup>	3.33	3.60	3.11	3.53	3.12	0.05	**	**	**
Cholesterol <sup>†</sup>	1.39	1.30	1.50	1.28	1.54	0.03	NS	**	NS
Triglyceride <sup>†</sup>	0.24	0.23	0.19	0.222	0.22	0.01	NS	NS	NS
Urea <sup>†</sup>	5.47	5.02	4.91	4.70	5.63	0.17	NS	**	NS
Creatinine <sup>μ</sup>	61.36	60.20	66.63	62.00	63.73	0.84	**	NS	NS
Calcium <sup>†</sup>	2.23	2.34	2.27	2.37	2.16	0.08	NS	NS	NS
Phosphore <sup>†</sup>	2.10	2.29	2.18	2.29	2.07	0.06	NS	NS	NS
Magnisium <sup>†</sup>	0.78	0.84	0.69	0.82	0.70	0.02	NS	*	NS
Iron <sup>μ</sup>	23.17	21.98	18.27	24.61	17.12	1.40	NS	*	NS

<sup>†</sup> mmol/l; <sup>μ</sup>: μmol/l; NS: insignificant; \*\*: P < 0.01; \*: P < 0.05.

## 2. Rumen fermentation pattern

The time of sampling had a significant effect on the ammonia production (P = 0.0001). Before feeding and 5 hours after the ammonia production was not affected by both diet and breed and the interaction between the factors was not significant. Two hours after feeding only the diet had an effect on the ammonia production and the stall-fed animals had the highest concentration and the interaction between diet and breed was significant (P = 0.05). Knowing that the urea concentration was higher in pasture-fed group, we can conclude that the ammonia transformation to urea in kidney is more efficient in pasture-fed group. Eight hours after feeding the interaction between both factors was significant (P = 0.0001), this may correspond with the time of rumination, which may be of different speed between breeds. The breed had a significant effect on the ammonia production (P = 0.0001) and the NT breed had the lowest value. The NT lambs had the highest level of creatinine so the highest protein catabolism which explains the lowest ammonia amount.

The most important protozoa population was counted at the fifth hour (P = 0.01). Two hours after feeding, the protozoa population was not affected by both factors. At the fifth hour the protozoa was affected by both diet and breed and the interaction was significant between the factors. Generally, the size of the microbial population increases with the pasture and decreases with the diet rich in starch. The present results can not clearly express the effect of the diet or the breed.

The acetic acid production was globally affected by both diet and breed ( $P = 0.001$  and  $P = 0.001$  respectively). The time of sampling had no effect on the acetic acid production. The interaction between factors was significant at 2, 5 and 8 hours post feeding. Before feeding the percentage of acetic acid was affected only by diet and the highest percentage was recorded in P group (43.44 vs. 42.80% respectively) this is in accordance with the finding of Cuvelier *et al.* (2005) who announced that acetic acid production is promoted by diets rich in fibers. The propionic acid percentage was influenced only by the time of sampling and the highest percentage was 8 hours after feeding (28.98%). The butyric acid percentage was not affected by any factor and it averaged 22.89%.

## IV – Conclusion

The effects of both breed and feeding system were more spectacular in blood metabolites than in rumen fermentation pattern. The NT breed has the same energetic valorization of both diets. The QFO breed was the best adapted in both production systems. In stall, the BB lambs were better adapted than the NT ones and this result was inverted in pasture system. Also the interaction between both factors was more widespread in rumen fermentation pattern than in the blood metabolites, this is in relation with the stability of the in the microenvironment.

## References

- Beveridge J.M.R., Connell W.F. and Robinson C., 1963.** Effect of the level of dietary protein with and without added cholesterol on plasma cholesterol levels in man. In: *Journal of nutrition*, 79, p. 289-293.
- Chilliard Y., Ferlay A., Faulconnier Y., Bonnet M., Rouel J. and Bocquier F., 2000.** Adipose tissue metabolism and its role in adaptations to undernutrition in ruminants. In: *Proceedings of the nutrition society*, 59, p. 127-34.
- Cuvelier C., Cabaraux J.-F., Dufrasne I., Istasse L. and Hornick J.-L., 2005.** Production, digestion et absorption des acides gras chez le ruminant. In: *Annales de médecine vétérinaires*, 149, p. 49-59.
- Dellow D.W., Obara Y., Kelly K.E. and Sinclair B.R., 1988.** Improving the efficiency of utilization of pasture protein by sheep. In: *New Zealand Society of animal production*, 48, p. 253.
- Hajji H., Atti N. and mahouachi M., 2013.** Effect of faba bean intake on growth and carcass characteristics of lambs from three breeds. In: *Options Méditerranéennes A*, 107, 2013.
- Mann G.V., 1960.** A method for measurement of cholesterol in blood serum. In: *Clinical chemistry*, 7, p. 275-277.
- Patrick G.H., Hopkins J.A., Ramsey W.S. and Gilmore A., 1998.** Effects of level of protein and type of molasses on digesta kinetics and blood metabolites in sheep. In: *Small Ruminant Research*, 28, p. 161-170.
- SAS, 1999.** *SAS User's Guide: Statistics*. Statistical Analysis Systems Inc., Cary, N.C.
- Thomas V.M., McInerney M.J. and Kott R.W., 1988.** Influence of body condition and lasolocid during late gestation on blood metabolites, lamb birth weight and colostrum composition and production in Finn-cross ewes. In: *Journal of animal science*, 66, p. 783-791.