RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES
PRINT ISSN 2221-1896, ONLINE ISSN 2223-0343
www.roavs.com

Nutritional preliminary characterization of some indigenous raw materials used in formulation of concentrate

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Abstract

Cereal grains and proteins are varied and numerous in Tunisia. The use of these local resources remains limited because of a shift towards relying on imports and state subsidies. This has caused disruption of the national economic strategy and the sustainability of farming systems. Thus, in recent years, research for alternative feed resources readily available within the country borders has accelerated. Among these indigenous resources, barley, triticale, white sorghum, and faba beans who have nutritional values potentially similar to those of corn and soybean meal were incorporated into the formulation of feed concentrate to supplement dairy sheep rations based on encouraging preliminary results on nutritive values (number and types of ciliates, total gas) and on quantity and quality of produced milk in sheep.

Key words: Barley, Faba beans, Production, Resources, Triticale, Tunisia, White sorghum

Introduction

In Tunisia, self-sufficiency in milk and red meat has become one of the main objectives in national development plans (Rouissi et al., 2008). Currently, cultivated forage cover only 300,000 ha each year. Cultivars are dominated essentially oats, while the legume family represents only 5% of total surface used for forage growing (DGPA, 2009). Diets of farm animals are often based on roughages of low nutritional values, especially hay or silage of oats, which are exclusively supplemented with concentrates based on energetic cereal grains (Rouissi et al., 2008). Urea and soybean meal, rich in nitrogen and protein non_nitrogen are imported at great costs given the worldwide current economic conditions which may affect the durability and productivity of farm operations and consequently dairy and meat industries. That is, relying on imports may constitute a limiting factor for high production performances to meet high growing demands (Poncet et al., 2003). The development of forage legume family production as green roughages and grains is one of the votes needed to overcome deficiency of local markets in proteins.

The current environment is favorable to promote alternatives to soybean meal and maize. Indeed, the use of cereals and protein crops produced on the farm (barley, triticale, white sorghum, faba bean, etc.) is now a common practice in livestock production (Delmote and Rampanelli, 2006; Selmi et al., 2010) and the limits of their incorporation are determined by the constraints of the ration energy to protein balance and not by inherent limitations related to anti-nutritional factors (Michalet-Doreau et al., 1987). Table 1 shows the evolution of surfaces cultivated and performances of some studied local food resources.

Table 1: Area (ha) and production of grains for animal feed*

Years	Species	Area (ha)	Production (qx)
2007		20 000	308 000
2008	Faba	23 700	297 500
2009		22 700	342 500
2007		496 000	5 351 000
2008	Barley	541 000	2 539 000
2009		576 000	8 549 000
2007		4 000	105 000
2008	Triticale	7 000	152 000
2009		12 000	250 000

* It should be noticed that the white sorghum is grown by smallholders on reduced areas in the Sejnane region in the north of Tunisia.

The evaluation of the chemical composition and nutritional value of indigenous raw materials and their effects on microbial activity and milk production used in animal feed for ruminants was based on several trials. Measures ranged from simple chemical analyses to the study of the "*in vivo*" and "*in vitro*" digestibility of grains of various species, used in concentrates that meet the requirements of livestock, essentially requirements of dairy sheep.

The aim of this study was to list nutritional characteristics and the effects of these local ingredients on rumen fermentation parameters and their impact on performances of dairy sheep, essentially the Sicilo-Sarde breed.

Nutritional quality of local resources

The chemical composition of local raw materials which were used in the formulation of local concentrate feeds is given in Table 2.

Table 2: Chemical composition (% DM) of barley, triticale, white sorghum and faba bean

Local Resources Nutrients	Barley	Triticale	White sorghum	Faba bean
Dry Matter	86.7	90.6	89.4	87.4
Mineral Matter	2.2	2.3	1.8	3.6
Organic Matter	97.8	97.7	98.2	96.4
Crude cellulose	4.6	2.5	1.5	11.2
Fats	1.8	2.2	3.1	1.4
Crude protein	10.1	9.9	9.8	27.3

Carbohydrates of barley grains represent about 80% of the dry seeds and starch are essentially localized at the caryopsis (Ben Abdejlil, 1999), the average content of starch in barley is 53.5% (De Blas et al., 1995) contrary to what is found by Sauvant et al. (2002) (40.5%). The fiber content of barley seeds varies on average from 5 to 8% dry matter. It is mainly concentrated in the husks (50-60%), envelopes, and cell walls. Hemicelluloses cover a range of non-cellulosic polysaccharides (Godon, 1991). They have a strong power of water retention. Digestibility varies according to grain origins and animal species. Lignin is in the form of polymers of phenol propane-bond carbon-carbon and is found mostly in the seed coats. Barley has a fat content lower than that of maize, sorghum or oats. Observed mean levels vary from 1.5 to 2.5%.

The proteins of barley are of amino acid profile better suited to the needs of animals than corn or wheat. The protein content is estimated at 10.3% dry matter (Bettaieb, 1989). While these levels of calcium and sodium is slightly higher than corn. Barley grain is still a relatively poor in these elements, the major mineral element content in cereal grains is phosphorus (0.4% in barley) (Newman and Newman, 1992).

The seeds of triticale have total nitrogen content lower than that of barley, wheat, and oats; crude fiber content of 3.3% DM, low in fat compared to oats (1.7 vs. 6.7). The energy value of triticale is comparable to that of barley and wheat (1.21, 1.16 and 1.19 UFL) and greater than that of oats (INRA, 1988).

According to Sauvant et al. (2002), the energy value of sorghum grains is high because of the starch they contain; it is substantially equal to that of corn in a ration of ruminants. Peyraud (1993) reported that the addition of concentrate to forage made of complex carbohydrates such as corn and sorghum causes a deviation to acetic acid at the expense of propionic and butyric acids. Jarrige (1988) found that the raw energy of sorghum grain is 4509 kcal / kg DM or 1.21 and 1.22 UFL UFV. Protein levels found in sorghum grains do not usually exceed 8 -9%.

According to Devun et al. (2004), the composition of the seed of faba beans is similar to that of peas. Its protein content is 29% and occupies an intermediate position among the proteins of other seeds (Jarrige, 1988). The content of faba beans is low in fat (<2%) as all resources rich in proteins with the exception of lupins where fat content reached 10% (Doreau et al., 1997); these lipids are rich in linoleic acid. The starch holds a prominent place in the reserves of faba bean seeds, about 40 to 50%. Carrouée et al. (2003) reported that faba beans are characterized by their richness in both protein and energy with 40 to 50% DM starch, 24 to 32% DM protein, 5 to 10% of DM cellulose, and 1-3% DM fat, compared to proteins in Soya beans. It is also rich in oils and low in starch (Herman, 2002).

The energy value of faba beans is comparable to that of peas and lupins (Grosjean et al., 2001) and is closer, among other seeds, to grains with a good level of starch ranging from 38 to 45% (INRA, 2002). The wall content in faba beans, which can interact with the nitrogen use, ranges from 12 to 18% (INRA, 1988).

Anti-nutritional factors of local resources

The main anti-nutritional factors are of barley beta-glucan. The molecule is linear and composed of high molecular weight polymers because of the presence of the b1-3 and 1-4 bonds. However, introducing in the molecule promotes the formation of viscous gels by increasing their digestibility. According to Bourdon et al. (1989), these soluble polysaccharides are mainly located in cell-walls of endosperm of barley seeds; they represent a layer of the endosperm cell -walls between the bark and the center of grain that would be 75% of the endosperm cell. The mean level of beta-glucan was 3.5% ranging from 1.9 to 5.3% DM in all grains.

The grains of triticale inhibitors have reduced their digestibility (Larbier and Lerclercq, 1992). Indeed, these grains are characterized by a chemical imbalance caused by a deficiency in calcium and phosphates (Jarrige, 1988). Moreover, much of the phosphorus (45-75%) is in the form of acid or phytic acid inositolhexaphosphorique (Feil and Fossati, 1997), phosphorus can be absorbed by the body to the extent where it is hydrolyzed inositol and phosphoric acid (Grela, 1996). On the other hand, whole triticale contains trypsin inhibitors minimizing their digestibility compared to other cereals (Jondreville et al., 1994) and tannins (Grela, 1996).

Some nutritional inhibitors and toxic substances are present in the seeds of sorghum (Dhankher and Chauhan, 1987). Gualtieri and Rapaccini (1990) reported that these anti-nutritional factors can be classified into two categories: those that exist naturally in the seeds and those caused by contamination that may be a fungal or land-related or caused by other environmental factors. The types of sorghum grains which are devoid of pigmented walls (white sorghum) do not contain condensed tannins and are nutritionally equivalent to that of maize (Nyachoti et al., 1997). The peculiarity of these antinutritional factors is to bind to proteins and precipitate them, even within the seed and then, especially in light of the digestive tract, forming complexes resistant to enzymatic attack.

Faba bean seeds are characterized by their rich tannins located at their integument. The content varies from 0.8 to 24 g/kg DM depending on the variety (Kaysi and Melcion, 1992). Carrouée et al. (2003) reported that faba bean seeds like peas contain anti-trypsin (vicine and convicine) of about 4 IU/mg and the same content as that of soybean meal. The main inhibiting factor in faba beans is made up of condensed tannins. Some tannin reduces the nutrient retention, particularly of nitrogen fraction and energy which causes a reduction in feed efficiency. Finally, the seeds of faba beans, despite their high starch content, lead to the risk of acidosis less frequent than that caused by cereals. On the other hand, this protein source was characterized "*in vitro*" by low digestibility of starch and high solubility (Michalet-Doreau et al., 1987) and "*in situ*" degradability of nitrogen (N) (Cros et al., 1991).

Formulation of concentrate from local resources

The composition of the different centesimal local (SF, TF and OF) and commercial concentrates is shown in Table 3. The proportion of ingredients in each food concentration is defined so as to have iso -energy and iso -protein aliments.

Effect on rumen ciliates protozoa counts

Selmi et al. (2011a) reported that replacing corn and soybean meal for barley and faba significantly increases the total number of protozoa, complex white sorghum-faba maintains the same population and same mass while the Triticale - faba mixture decreases the total number of protozoa without apparent differences among protozoa geniuses as shown in Table 4.

Effect on total gas production

Digestion of various dietary ingredients is accompanied by gas production from food, to carbon dioxide (CO2) removed by eructation by direct diffusion through the wall of the rumen and methane (CH 4) whose route of elimination is exclusively belching. This production depends mainly on the degradation rate and the nature of starch and carbohydrates cell -wall characteristics of the diet. Selmi et al. (2009) showed that the use of faba beans in sheep rations keeps the gas production similar to that found for soybean meal ($P<0.05$). While the use of cereals and white sorghum instead of corn can change the total gas production (Selmi et al., 2011b). These same authors reported that the potential gas production represented in the model of Orskov and MacDonald (1979) by the constant "b" is high ($P<0.05$) for the regimen corn - soybean (58.7) while the regimen barley–faba bean displays the lowest value (34.5). The statistical difference between the different regimens can be explained by the nature of raw materials. Indeed, the complex corn-soybean has the protein and energy the most important and most digestible in the rumen. In comparing the two corn-soy and white sorghum - Faba concentrates, whose energy sources are botanically similar, the replacement of soybean meal by faba beans did not affect the potential of gas production (Figure 1). While for the two concentrates from cereals and faba beans which have anti-nutritional factors like tannins and beta-glucan (Larbier and Lerclercq,1992), this production is evolving in the rumen with the same speed ($P<0.05$), therefore the substitution and replacement of imported raw materials with local raw materials had no distinct effects.

Table 3: Centesimal composition and nutritive value of feed concentrate and local control concentrate

Concentrates Ingredients (%)	MS	SF	TF	OF
Corn	43.3	-	-	-
Wheat bran	25	-	-	-
Barley	10			71.5
white sorghum	-	66	-	-
Triticale			71	
Faba bean meal	-	30	18	17.5
Soybean meal	17.7	-	7	7
VMC	4	4	4	4
UFL	0.98	0.99	0.98	1.1
PDIE	104.9	95	103	103
PDIN	99	96	102	100

Effect on the quantity and quality of produced milk

The level of milk production was 0.4 ± 0.03 l for the SF and 0.42 ± 0.05 l for the MS supplement concentrates. As for the qualitative aspect, Rouissi et al. (2008) showed that replacement of a commercial concentrate based on corn and soybean meal by a concentrate-based on local of barley and faba beans led to a chemical composition (FAT, CP, solids-not)

Table 4: Influence of nature of supplementation on the total number (10^5/ml) and genre of protozoa (%)

Regimen	Population (10^5/ml)	Genre of ciliates (%)			
		Entodinium	Isotricha	Ophryoscolex	Polyplastron
MS	6.08 ^{b} (0.23)	55.64 ^{a} (6.21)	27.31 ^{a} (6.46)	10.95 ^{a} (1.32)	7.82 ^{a} (2.82)
SF	6.06 ^{b} (0.22)	54.86 ^{a} (15)	29.7 ^{a} (15.29)	8.06 ^{b} (2.62)	5.73 ^{a} (3.93)
TF	5.66 ^{c} (0.09)	50.97 ^{a} (3.10)	30,48 ^{a} (1.57)	11.24 ^{a} (2.35)	6.55 ^{a} (1.35)
OF	6.40 ^{a} ± 0.15	56 ^{a} (4.09)	30.37 ^{a} (3.92)	8.32 ^{b} (1.83)	5.29 ^{a} (1.83)
ESM	0.075	3.47	3.49	0.88	1.09

MS: Corn - soybean, SF: White sorghum-faba bean; TF: Triticale – faba bean; OF: Barley – faba bean *a, b and c*: averages in the same column with different letters are significantly different (P<0.05).

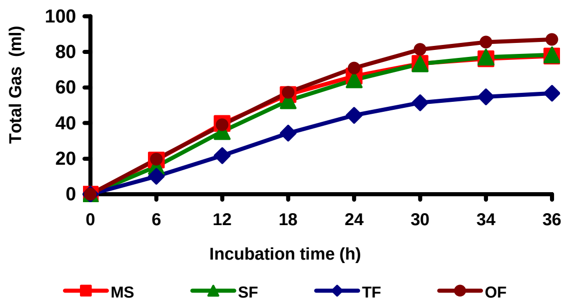

Fig. 1: Kinetics of gas production in the syringe (0.5 g hay) depending on the nature of the supplement concentrate

statistically similar (P>0.05). While Selmi et al. (2011c) who worked on two concentrates: one based on corn and soybean meal and the other based on white sorghum and faba beans, reported that the protein content of sheep milk depends mainly on the energy balance which stimulates the synthesis of microbial protein in the rumen (Bocquier and Caja, 2001). This protein content was significantly higher (P<0.05) for the lot-based white sorghum and faba beans compared to the batch of sheep receiving corn and soybean meal (6.04 vs. 5.8%) (Table 5).

Table 5: Quality of milk produced by ewes fed MS and SF Concentrates

	MS	SF	Effect régime	R^2
FAT (%)	7.21 (0.4)	7.58 (0.6)	NS	0.61
CP (%)	5.86 (0.54)	6.04 (0.57)	*	0.78
SNF (%)	11.04 (0.18)	11.37 (0.2)	*	0.7
Lactose (%)	4.15 (0.5)	4.27 (0.43)	*	0.82
Density	1.036 (0.0006)	1.037 (0.005)	*	0.54
Freezing point (°C)	- 0.58 (0.04)	- 0.6 (0.05)	NS	0.72
pH	6.57 (0.04)	6.61 (0.04)	NS	0.69

NS: not significant, *: means are different at α = 5%
a, b: Means in the same lines with different superscripts are significantly different (p<0.05)

This further explains the positive correlation between the energy balance of the ration and milk protein content. For the lactose content, the highest value is displayed in milk from sheep of the group that received faba and white sorghum (4.27 vs. 4.15%). This is due to the richness of the faba beans in starch easily degradable and cellulose, especially at the seed coat of field bean compared to soybean meal (Pottier, 2002), which leads to digestion and microbial fermentation of cellulose more pronounced in ewes receiving the white sorghum and faba beans.

Conclusion

In the current economic context in which the production cost is the primary concern, the use of indigenous readily available raw materials is imperative. Indeed, many experiences on this topic have led to satisfactory results. Finally, to cope with dependence (import of corn and soybean meal), we can diversify local resources with relatively satisfactory nutritive values. Thus, a research program conducted by specialists in animal production and crop production in collaboration with farmers, based on the existing genetic variability of roughages and shrub resources is needed. Thus, conventional breeding may open horizons for the improvement in terms of seed production, evaluation of nutritional value and requirements of animals in energy and proteins.

References

Ben Abdejlil, K. 1999. Valorisation des orges en aviculture in transfert de technologie en agriculture. *Bulletin de liaison et d'information* PNTTA n° 55.

Bettaieb, L. 1989. Etude des protéines et des acides aminés des orges (Hordum vulgare L) tunisiennes. Thèse doctorat 3ème cycle. Faculté des Sciences de Tunis, P: 127.

Bocquier, F et Caja, G. 2001. Production et composition du lait de brebis: effets de l'alimentation. *INRAT Production Animale,* 14 (2): 129- 140.

Bourdon, D., Février, C., Leclercq, B., Perez, J.M et Lessine, M. 1989. Alimentation des animaux monogastriques. INRA, première édition – paris, pp: 11, 12, 170,171 et 281.

Carrouée. B., Crepon, K et Peyronnet, C. 2003. Les protéagineux: intérêt dans les systèmes de production fourragers français et européens. *Revue Fourrages,* 174:163-182.

Cros, P., Benchaar, C., Bayourthe, C., Vernay, M and Moncoulon, R. 1991. In situ evaluation of the ruminal and intestinal degradability of extruded whole lupin seed nitrogen. *Reproduction Nutrition and Development,* 31: 575-583.

De Blas, C., Mateos, G.G and Rebollar, P.G. 1995. Normas fedna para la formulación de piensos compuetos. *Proceedings o fan international symposium*, pp: 12-13.

Delmotte, C et Rampanelli, P. 2006. Utilisation de mélanges fermiers à base d'orge et de féverole pour la finition d'agneaux d'herbe. *Rencontre Recherche Ruminants,* 13.

Devun, J., Haurez, P., Kentzel, M et Gruet, A. 2004. Autonomie protéique des exploitations Bovins viande. Institut de l'Elevage, P: 75.

DGPA, 2009. Enquête sur les structures des exploitations agricoles, Tunisie. P: 100.

Dhankher, N and Chauhan, B.M. 1987. Effect of temperature and fermentation time on phytic acid and polyphenol content of rabaadi - a fermented pearl millet food. *Journal Food Science,* 52: 828-829.

Doreau, M., Demeyer, D. I and Van Nevel, C.J. 1997. Transformation and effects of unsaturated fatty acids in the rumen. Consequences on milk at secretion, *Milk composition, production and biotechnology*, R. A. S". Welch, D. J. M. Burns, S. R. Davis, A. I. Popay, C. G. Prosser (eds). CAB International, New- York, Pp: 73-92.

Feil, B and Fossati, D. 1997. Phytic acid in triticale grains as affected by cultivar and environment. *Crop Science,* 37(3): 916-921.

Godon, B. 1991. Biotransformation des produits céréaliers. Technique et documentation. Lavoisier INRA- ARPIA, p: 120.

Grela, E.A. 1996.Nutrient composition and content of antinutritional factors in spelt (triticum spelta L) cultivars. *Journal of the Science of Food and Agriculture,* 71(3): 399-404.

Grosjean, M., van Leeuwen, J.F.N., van der Knaap, W.O., Geyh, M.A., Ammann, B., Tanner, W., Messerli, B., Núñez, L.A., Valero-Garcés, B.L and Veit, H. 2001. A 22,000 14C year BP sediment and pollen record of climate change from Laguna Miscanti (23°S), northern Chile. *Global and Planetary Change,* 28 : 35-51.

Gualtieri, M and Rapaccini, S. 1990 Sorghum grain in poultry feeding. *World's Poultry Science Journal,* 46 (3): 246-254

Herman, A. 2002. Accroître l'autonomie en protéines des exploitations du Calvados, Chambre d'Agriculture du Calvados.

INRA – AFZ, 2002. Tables de composition et de valeur nutritive des matières premières destinées aux animaux d'élevage. Coord., INRA Eds, Paris, 291 p.

INRA, 1988. Alimentation des bovins, ovins et caprins. Enseignement agricole Formation professionnelle. Les éditions Foucher Paris 1988.

Jarrige, R. 1988. Alimentation des bovins, ovins et caprins INRA, Paris, P: 471.

Jondreville, C., Van Den Broecke, J., Delpech, A., Gatel, F., Bertin, J.M., Beaux, M.F et Grosjean, F. 1994. Facteurs de variations de la digestibilité iléale des acides aminés des céréales chez le porc charcutier. *Journées Recherche Porcine en France*, 26: 251 – 258.

Kaysi, Y et Melcion, J.P. 1992. Traitements technologiques des protéagineux pour le monogastrique : exemples d'application à la graine de féverole. *INRA Production Animale,* 5 (1): 3 – 17.

Larbier, M et Lerclercq, B. 1992. Nutrition et alimentation des volailles, 2ème édition: 255 – 302.

Michalet-Doreau, B., Geay, Y., Doreau, M., Poncet, C. 1987. Interaction entre espèce animale et nature de l'aliment concentré sur la digestibilité de la ration chez le ruminant. *Reproduction Nutrition Development*, 27 (1 B): 277-278.

Newman, C.W and Newman, R.K. 1992. Characteristic of the ideal barley for feed. In: Barley genetics Vol I: Barley research reviews 1986 – 1991. Session and workshop summaries Proceedings of the Sixth International Barley Genetics symposium. Helsingborg, Sweden, Pp: 925- 939.

Nyachoti, C.M., Atkinson, J.L and Leeson, S. 1997. Sorghum tannins: A review *World's Poultry Science Journal,* 53 (1): 5-21.

Orskov, E.R and Macdonald, I. 1979. The estimations of protein degradability in the rumen from incubation measurements weighted according to rate passage. *Journal of Agriculture Science Cambridge,* 92: 499-502.

Peyraud, J.L. 1993. Comparaison de la digestion du trèfle blanc et des graminées prairiales chez la vache laitière. *Revue Fourrages,* 135: 465-473.

Poncet, C., Rémond, D., Lepage, E et Doreau, M. 2003. Comment mieux valoriser les protéagineux et les oléagineuxs en alimentation des ruminants. *Revue Fourrages,* 174: 205- 229

Pottier, E. 2002. Utilisation des protéagineux en élevage. Synthèse réalisée par l'institut de l'élevage dans le cadre du programme régional, pp: 1-8

Rouissi, H., Rekik, B., Selmi, H., Hammami, M et Ben Gara, A. 2008. Performances laitières de la brebis Sicilo-Sarde Tunisienne complémentée par un concentré local. *Livestock Research for Rural Development,* 20 (7).

Sauvant, D., Perez, J.M et Tran, G. 2002. Table de composition et de valeur nutritive des matières premières destinées aux animaux d'élevage (INRA édit.) Paris, pp 82-83 et pp 190-191.

Selmi, H., Rekik, B and Rouissi H. 2011a. Effect of the nature of energy and nitrogen sources on the population of ciliates in the rumen of sheep. *Research Opinion in Animal and Veterinary Science,* 1 (1): 48-50.

Selmi, H., Ben Gara, A., Rekik, B et Rouissi, H. 2011b. Influence de la nature de l'aliment concentré sur la production de gaz "*in vitro*" et de Méthane chez les béliers de race Sicilo –Sarde. *American- Euroasian Journal of Agricultural and Environment Science,* 10 (3): 346-350.

Selmi, H., Bouzourrâa, I., Tibaoui, G., Alaoua, H., Rekik, B et Rouissi, H. 2011c. Effet du remplacement de Maïs et Tourteau de Soja par le Sorgho blanc et la fèverole sur la production et la qualité de lait de la brebis Sicilo-Sarde. *Livestock Research for Rural Development,* 23 (2).

Selmi, H., Gasmi-Boubaker, A., Mosquera Losada, R., Abdouli, H., Rekik, B., Rouissi, H., Hassen, H and Rigueiro-Rodriguez, A. 2010. Natural Vetch economic alternative to soybean meal in Tunisia. *Options Mediterranéennes,* 92: 63 – 66.

Selmi, H., Hammami, M., Rekik, B., Ben Gara, A et Rouissi, H. 2009. Effet du remplacement du soja par la féverole sur la production du gaz "in vitro" chez les béliers de race Sicilo- Sarde. *Livestock Research for Rural Development*, 21 (7).