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Effect of total replacement of soybean meal and corn on the *in vivo* digestibility and nitrogen balance of Sicilo-Sarde rams

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ABSTRACT

The objective of the study was to evaluate the effect of replacing corn and soybean meal by triticale, faba bean and field pea on apparent digestibility of nutrient and nitrogen balance of Sicilo Sarde rams. Six rams were fed in a Latin Square design with 1.8 kg DM/day of oat hay + 500 g DM/d of one of three concentrates: soybean meal mainly composed by soybean meal and corn; faba bean composed by triticale and faba bean; and field pea concentrate composed by triticale and field pea. Rams were maintained into metabolic cages for 10 days adaptation, followed by five sampling days. Feed intake was recorded daily. Total feces and urine were collected and measured. The dry matter, organic matter and nitrogen intake were not influenced by the total replacement of soybean meal and corn. Apparent digestibility of dry and organic matter was significantly improved with field pea concentrate than with other concentrates. Nitrogen apparent digestibility and faecal nitrogen remained statistically non-significant. The rejected nitrogen in urine was significantly higher for faba bean concentrate than field pea and soybean meal concentrates, with averages about 9.68, 8.83, 8.86 g/d respectively. While, lower nitrogen balance was observed in faba bean concentrate (4.70 g/d) than the field pea (6.33 g/d) and soybean meal (6.47 g/d) concentrates respectively. These data indicated that the substitution of soybean meal and corn by triticale, faba bean and field pea can improve nutrient digestibility and nitrogen balance parameters in Sicilo-Sarde rams.

Key words: Corn, Feed intake, Nitrogen, Nutrient digestibility, Nutritional value, Sicilo-Sarde rams, Soybean meal

For a sustainable and viable animal husbandry, feeding of quality rations to animals is highly essential. The main food of sheep breeding are natural pasture, crop residues, hay, stubble and silage. These resources have usually low nutritional values that depend on scarce and irregular rainfall, that make them inadequate to cover the animal energy and protein requirements. To cover animal need, these resources are complemented by concentrate feed mainly composed by soybean and corn, which are an imported raw material. Their costs of importation are still rising in the last few years, which constitute a major financial burden for sheep production sustainability. Further, it is difficult to find soybean and corn that are not genetically modified (Rouissi *et al*. 2008, Nabradi and Popp 2011, Selmi *et al.* 2013, Bonanno *et al.* 2016). Therefore, most research studies have focused on introducing alternative seeds in order to reduce costs and maintain optimum performance of animals.

Legume grains are cultivable and sustainable to different agronomic conditions, which makes them an interesting alternative for soybean. In fact, they are characterized by their high content in crude protein, starch, lipids (Dixon and Hosking 1992) and their good nutritional value of their crop residues that can be used by grazing animals. Besides, their introduction on crop rotation system has an important agronomic benefit in soil structure and fertility (Sinclair and Vadez 2012). The total or the partial replacement of soybean meal and corn in concentrate, resulted not only in comparable fermentation conditions in the rumen (Selmi *et al.* 2013), but also improved growth performance of sheep and maintained similar milk yields and quality (Khan *et al.* 2011, Bonanno *et al.* 2016). Few studies are focusing on the effect of using alternatives to soybean meal on digestibility and nitrogen balance of sheep. Most of studies focused on the effect of different rates of protein or on the mix between silage and concentrate or the use of by-products on apparent digestibility and nitrogen balance (Khan *et al.* 2011, White *et al.* 2015, Best *et al.* 2017).

In particular, there have been a lack of studies on the impact of replacing soybean and corn by legume grains with the same amount of protein and energy on *in vivo* digestibility. Since digestibility is one of the key factors affecting feeding value of feed, there is a critical need to conduct studies relative to digestibility and nitrogen balance of these alternative proteins sources, which would guarantee the recommendation of their best use in the feeding of sheep

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and others ruminants. Therefore, the objective of this study was to evaluate the effect of different concentrate feed composed by faba bean (*Vicia faba*), field pea (*Pisum sativum*) and triticale (*Triticum secale*) as alternative to soybean and corn on the digestibility and the nitrogen balance of Sicilo-Sarde rams.

MATERIALS AND METHODS

Ethical approval: The experimental procedures of the current study followed the international guidelines for animal welfare and were approved by the local animal ethics and welfare committee of the Higher School of Agriculture of Mateur and the regional center of research in field crops in Béja, Tunisia.

Location of the study: The experiment was carried out at the animal experimental station "Lafareg" (36.69°N, 9.15°E) of the experimental animal station of the regional center of research in field crops in Béja, in the northeast of Tunisia during 45 days.

Experimental design and dietary treatment: Six male Sicilo-Sarde rams with an initial average weight of 54.95±2.80 kg were allocated in a 3×3 Latin square design with three diets and three periods, each period lasted 15 days (10 days of adaptation and 5 days of data collection). Rams were individually housed in metabolic cages with free access to clean water daily. Animals received 1.8 kg of dry matter of oat hay (*Avena sativa*) and 500 g of one of three concentrates presented in Table 1. Offered feed was separated into two equal offerings per day at 08:00 h and 15:00 h.

In vivo digestibility and nitrogen balance of animals were measured by the total collecting method of all faeces and urine from days 10–15 of the sample collection period. The amounts distributed and refusals feeds were individually weighed daily before morning feeding and samples were taken for chemical analyses. The intake trial carried out to estimate voluntary dry matter intake followed by digestibility trial during five days to estimate apparent digestibility of dry matter, organic matter, nitrogen and ash. Faeces were weighed individually daily, and a sample per day per animal was frozen (–20°C) for later analysis. Urine was collected in plastic bucket containing 100 ml of sulfuric acid (10%). Total urine volume was daily measured and samples were kept frozen (–20°C). Dry matter organic matter and ash were determined according to procedure described by AOAC (2000). Feed, faeces and urine samples were analyzed for nitrogen content using the Kjeldahl method (AOAC 2000).

Table 1. Ingredient of the experimental diets

Ingredient (%)	Soybean meal	Faba bean	Field pea
Barley	10	0	0
Wheat bran	25	0	0
Maize	43.3	0	0
Triticale	0	72	70
Soybean meal	17.7	0	0
Faba bean	0	24	0
Field pea	0	0	26
VMC	4	4	4
Total	100	100	100

VMC, Vitamin mineral mixture.

Table 2. Chemical composition and nutritional value of oat hay and feed concentrates

Parameter	Oat hay	Soybean meal	Faba bean	Field pea
Dry matter (%)	90.01	89.2	91.1	91.5
Mineral matter (%)	8	4.7	3.3	5.3
Organic matter (%)	92	95.3	96.7	94.7
Crude protein (%)	4.7	14.3	14.5	13.9
Crude fibre (%)	31	4.6	5.4	5.9
PDIE (g/kg DM)	35	103	102	100
PDIN (g/kg DM)	32	96	88	84
UFL (kg DM)	0.54	0.97	1.12	1.1

Statistical analyses: Statistical analyses were performed with SAS v9.0. Data were statistically analyzed according to the 3×3 Latin square design using the PROC Mixed model analysis. The Least square means and the associated standard errors were determined using the LSMEANS for the concentrates types, and differences of least square means were determined using the PDIFF statement, according to the following model:

$$Y_{ijk} = \mu + A_i + P_j + T_k + e_{ijk}$$

where, Y_{ijk}, observed variable; μ, the overall mean; A_i, effect of animal; P_j, effect of period; T_k, effect of type of concentrate; e_{ijk}, random error.

RESULTS AND DISCUSSION

Chemical compositions of the experimental diets and oat hay are presented in Table 2. Both concentrates feed had comparable composition and nutritional values.

Similar dry matter and organic matter intake and their apparent digestibility were observed among the three concentrate ($P>0.05$). However, ash intake and digestibility were lower in the faba bean concentrate compared to others concentrates ($P<0.05$). The similarity between concentrate feed may be attributed to the similar ruminal conditions that are favourable to the microorganism population of harbouring this ecosystem.

Such observations substantiated the work of Bello and Stado (2013) studying the effect of graded levels of dry matter of the basal diet on feed intake and nutrient digestibility of rams, with averages of dry matter intake ranging between 808.08 and 1661.12 g/day for diets having different percentage of dry matter (84.20 and 92.80%) respectively. According to Khan *et al.* (2011), supplementation of concentrate feed to the basal diet resulted in high dry matter intake, this may be due to the nature of complementation that impact the feed intake. This result was in agreement with the study of White *et al.* (2015) who reported that the substitution of soybean meal by faba

Table 3. Nutrient intake, apparent digestibility and nitrogen balance parameters of experimental diets of Sicilo-Sarde rams.

	Soybean Meal	Faba Bean	Field Pea
Dry matter Intake (g/d)	1459.06[a]	1401.26[a]	1457.06[a]
ash Intake (g/d)	102.007[ab]	96.659[b]	104.212[a]
Organic matter Intake (g/d)	1357.05[a]	1310.57[a]	1352.84[a]
Dry matter digestibility (%)	60.35[b]	59.43[b]	64.04[a]
ash digestibility (%)	47.27[a]	35.90[b]	42.82[ab]
Organic matter digestibility (%)	61.12[b]	61.92[b]	65.67[a]
Nitrogen Intake (g/d)	17.853[a]	17.699[a]	17.721[a]
Faecal nitrogen (g/d)	3.0295[a]	3.3103[a]	2.6412[a]
Urine nitrogen (g/d)	8.8627[b]	9.6876[a]	8.8352[b]
Apparent Digestibility (%)	82.31[a]	81.15[a]	84.85[a]
Nitrogen balance (g/d)	6.4775[a]	4.7010[b]	6.3339[a]

a,b, Means in the same line with different letter superscripts were significantly different (P<0.05).

bean with different rate of tannins does not result in differences in these parameters. The organic matter digestibility in the present study was slightly greater than the values reported by Nigus *et al*. (2015) when wheat bran and hull was used as supplemented diets. Previous study, reported that the supplementation of concentrate to natural grass hay compared to natural grass hay only resulted in lower organic matter digestibility for goats (Getinet and Yoseph 2014). Best *et al.* (2017), who worked *in vivo*, similarly to the present study, did not find effect of replacement of soybean meal with foliage of fodder trees in sheep diet on dry matter, organic matter and ash digestibility.

Intake, fecal and apparent digestibility of nitrogen were not influenced by the total substitution of soybean meal (P>0.05) (Table 3). However, faba bean concentrate resulted in higher urine nitrogen excretion and lower nitrogen balance compared to field pea and soybean meal concentrates (P<0.05).

The values of total intake, faeces and urine nitrogen were similar to those observed by Best *et al.* (2017) in sheep fed with foliage of fodder trees as substitution for soybean meal; however, the value of nitrogen digestibility was higher than that observed in the current study. This is consistent with the study of Getinet and Yoseph (2014) who concluded that the supplementation of concentrate feed on goats diets resulted in lower digestibility of crude protein compared to natural grass only.

The rejected nitrogen in feces is little dependent on the content of N in the diet (Demarquilly *et al.* 1995) and varies especially with the total quantities of dry matter ingested. The urinary nitrogen results from the catabolism of proteins and the excess of nitrogen brought by the ration (Calsamiglia *et al.* 2010). The richness of faba bean seeds in highly degradable protein and amino acids, mainly methionine and lysine may explain the present result (Schmidely and Sauvant 2001, Rouissi *et al.* 2008). This finding was in agreement with previous study concluding that the excreted nitrogen had nutritional origin, or an excess of degradable nitrogen not valued by microbes in the rumen, or an excess of amino acids valued by the animal in the intestine (Peyraud *et al.* 1995, Calsamiglia *et al.* 2010). Gatel *et al.* (1993) asserted that pea introduced in diets of growing pigs as substitution of soybean meals with the same amount of crude protein led to close amounts of nitrogen excreted, that compare with the present results. The lower nitrogen balance with faba bean concentrate may be due to the higher content of condensed tannins (0.8–2.4 mg/g) in faba bean seeds compared to field pea, that have low content of anti-nutritional factors may explain the results (Gate and Grosjean 1990; Wang and Uberschar 1990). This was in agreement with Jetana *et al.* (2010), who reported that a diet containing condensed tannins improved the nitrogen balance. Further, researchers proved that a proportion of condensed tannins at about 2–5% of total dry matter intake in the diet may reduce the fermentation of the forage protein to ammonia in the rumen, increase the quantity of protein digested in the small intestine and decrease urinary N excretion (Mlambo *et al.* 2004). The lack of effect between the field pea and soybean meal concentrates on nitrogen balance was in harmony with funding of White *et al.* (2015) who reported that the total substitution of soybean by faba bean and pea had effect on nitrogen balance of growing and finishing pigs. The current study values were in agreement with reported nitrogen balance values elsewhere (Best *et al.* 2017) and provides important information with regard to nitrogen balance in sheep when fed balanced diets replacing soybean meal.

It can be concluded that corn and soybean meal may be substituted totally in rams concentrate with improvement in the performances of animals.

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