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Effects of the Partial Substitution of Soybean with Faba Bean (*Vicia faba*) in the Concentrate on Beef Cattle Performances

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Abstract: The aim of this study was to study the effect of the partial substitution of soybean with faba bean in fattening concentrate for beef cattle. Fifteen Pie-Noire × Holstein breed beef cattle (average age and initial liveweight: 5 months and 170 kg, respectively) were used and divided into 3 equal groups receiving a basal diet composed of oat-vetch hay. Animals were supplemented with 3 types of fattening concentrate composed of barley, wheat barn, corn, minerals and vitamins supplements and including, respectively 0 (D1), 16 (D16) and 23% (D3) of faba bean, substituting partially soybean. The three types of concentrate (C0, C16, C23) are almost iso-energetic and iso-nitrogenous. The trial lasted 6 months and animals were weighted twice a month. Intake was determined at 4 times at equal intervals, among all the experimental period. Chemical composition of feeds and characteristics of their *in vitro* fermentation using cumulative gas production technique, dry matter intake (DMI), live weight gain (LWG) and feed conversion ratio (FCR) were determined. The obtained results showed no significant differences in *in vitro* gaz production Parameters, *in vitro* organic matter digestibility (IVOMD) and metabolisable energy (ME) between C0, C16 and C23. The incorporation of faba bean in the fattening concentrate of beef cattle did not induce a significant variation in daily LWG (averaged 1400 g day^{-1}). The differences in DMI were not significant between the three groups and DMI of hay varied from 3.3-5.5 kg day^{-1}. The same trend was noted for FCR (averaged 5.5). It was concluded that substituting soybean with faba bean until a rate of 23% of fattening concentrate allowed the obtaining of the same performances as the conventional concentrate based on soybean representing the main protein source. The economical interest of this substitution may depend on the comparative cost of faba bean.

Key words: Substitution, faba bean, soybean, beef, cattle

INTRODUCTION

The growing demand in animal products through out the word, mainly in emerging countries resulted in an increased use of protein sources in animal feeding. Soybean continues to be the most preferred protein raw material used by farmers and concentrate producers, because of his high proteins and essential amino acids content. However the continue increase of soybean prices in international markets in addition to the prohibition of the use of animal meals obliged the protagonists to find alternatives, mainly the substitution of soybean with nutritionally similar or equivalent row materials (Haurez, 2003; Branshwig and Lamy, 2002). The use of proteaginous in substitution of soybean constitutes one of the most investigated alternatives and several new varieties have been created to allow a better utilization of faba in the animal feeds (Harzik and Emile, 1996; Institute of Breeding, 2003). The use of faba bean to substitute soybean in meet production could be envisaged in Tunisia, whereas faba bean is traditionally used by farmers in fattening beef cattle. In contrast, only small amounts are introduced by concentrate producers, mainly in small factories integrated in farms. The development of the use of this raw material in animal feeds is possible, but is depending on the level of control of its production cost and the improvements of output and produced amounts. The quantitative and qualitative regularity of the provisioning is necessary to optimise the use of this row material by concentrate producers. In the current study we aimed to analyse the technical possibilities of soybean substitution with faba bean in beef cattle feeding.

MATERIALS AND METHODS

Animals: The experiment was carried out in the farm FRITISSA in the north of Tunisa. Fifteen Pie-Noire × Holstein breed beef cattle (initial average age

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and liveweight: 5 months and 170 kg, respectively) were used. They were divided into 3 equal groups and housed in blocked stalling, with linear mangers and automatic troughs.

Feeds and diets: All the animals received a basal Diet (D) composed of oat-vetch hay (70 and 30% at seedling) *ad libitum,* produced in 2005. Animals were supplemented with 3 types of fattening concentrates composed of barley, wheat barn, corn, minerals and vitamin supplements and including , respectively 0 (C0: D1), 16 (C16: D2) and 23% (C23: D3) of faba bean substituting partially soybean. Concentrates were formulated on the basis of nutritive value tables (INRA, 2004) using LIBRA software and manufactured in the factory of Chawat. Concentrate composition is presented in Table 1.

Table 1: Composition of experimental concentrates (%)

Raw materiel	C0	C16	C23
Barely	45	36.5	29.5
Wheat bran	17.5	14	23
Corn	20	20	15
Soybean	13	9	5
Faba bean	-	16	23
Sal	1	1	1
$CaCO_3$	1.25	1.25	1.25
Di-calcium phosphate	1.75	1.75	1.75
Premix	0.5	0.5	0.5
Cost (DT/Tone)	326.480	365.700	371.000

DT: Tunisian Dinar (0.75$)

Table 2: Planning of feeding during the experimental period

	Distributed feeds kg day^{-1}	
Liveweight (kg)	Hay	Concentrate
150	4.5	3.5
200	5.5	4.7
250	6.5	5.3
300	7.5	5.6
350	8.5	6

Measurements and calculation

***In vitro* measurements:** The *in vitro* gas production technique as described by Menke and Steingass (1988) was used to determine gas production parameters from the 3 experimental concentrates. Rumen liquor was collected from 2 adult Barbarine breed sheep fitted with rumen cannula (average live weight: 45 kg). Sheep were housed in individual pens and received in 2 equal meals (8 and 16 h) 70 g kg^{-1} LW$^{0.75}$ of a ration composed of 70% of oat-vetch hay and 30% of commercial concentrate on Dry Matter (DM) basis twice per day. Triplicate samples of 300 mg DM from each experimental concentrate were introduced into pre-warmed (40°C) calibrated 100 mL glass syringes, before injection of 30 mL of rumen liquor: Buffer mixture (1:2 v/v) into each syringe. Syringes where incubated in a warm bath (39°C) and gently shaken every 30 min during the first 10 h of incubation. Gas production was recorded after 2, 4, 6, 12, 24, 36, 48, 72 and 96 h periods. For each concentrate, measurements were carried out during 3 successive periods. Gas volumes were fitted using the exponential model of Ørskov and McDonald (1979): $GP = A + B(1\text{-}e^{-Ct})$, where: GP is the gas production at time t; A is the immediate gas production; B is the fraction with slower gas production; C is the rate of gas production and A + B is the total gas production. Parameters were calculated using Non Linear procedure (SAS, 1985). *In vitro* organic matter digestibility (IVOMD) and metabolisable energy (ME) were calculated according to Menke and Steingass (1988) as:

IVOMD (g kg^{-1}DM) = [14.88 + 0.889IVGP24 (mL 300 mg^{-1} DM) + 0.45CP (%DM)] × 10.

ME(MJ kg^{-1}DM) = 0.15 + 0.1557 IVOMD (%) + 0.0130 CP (%DM), converted to kcal kg^{-1}DM

Performance trial: The trial was started in mars 2006 and lasted 180 days. Diets were distributed in two equal meals (8 and 15 h). Assuming that concentrate was fully consumed, hay DMI was determined during 5 successive days in 4 times at equal intervals, covering all the experimental period, by difference between distributed and refused quantities. Body liveweight of animals were recorded for tow successive days every 2 weeks. The planning of feeding was adjusted according to real intake (Table 2). Daily and total live weight gain (LWG) and feed conversion ratio (FCR) as kg of DMI per kg of LWG were calculated.

Chemical analysis: Feeds and concentrates (1mm screen) were analyzed for DM by drying samples to constant weight at 105°C in a forced air oven and OM calculated as weight lost during ashing at 550°C for 6h. Nitrogen concentration was determined by the Khjeldahl method (AOAC, 1984). Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) exclusive of residual ash, (respectively NDFom, ADFom) were analyzed as described by Goering and Van Soest (1970).

Statistical analysis: The General Linear Model procedure (GLM) of SAS (1985) was used to analyze data in both *in vitro* and growth trial. Duncan multiple range test was used to compare treatment means.

RESULTS AND DISCUSSION

Chemical composition: Chemical composition of feeds and concentrate is presented in Table 3. Hay was low in ash and CP, (respectively, 41 and 52 g kg^{-1} DM) and high in fibers (373 and 234 g kg^{-1} DM, respectively, for NDF

Table 3: Chemical composition of feeds and concentrate (g kg^{-1} DM)

Item	Hay	Faba bean	Soybean	Barley	Wheat bran	Corn	C0	C16	C23
DM (%)	81.6	878	89	87	87	87.5	87.3	87.8	86.9
Ash	41	37	51	25	5	18	59	64	63
CP	52	292	467	98	157	8	169	163	161
NDFom[b]	373	19	13	191	451	113	90	100	110
ADFom	234	9	4.5	57	108	3	62	68	72

C0, C16, C23: Concentrate including, respectively 0, 16 and 23 % of faba bean

and ADF). These results are typical for the usual Tunisian Oat-vech hay which is generally of low nutritive value (Kraiem *et al*., 1997). Row materiel composition is in line with of the values presented by INRA (2004). Particularly for faba bean, it's important to note that N is of a high solubility (Fontaine *et al*., 2003). The 3 types of concentrate presented approximatively similar content of Ash, CP, NDF and ADF (average means: 62, 64, 100 and 67 g kg^{-1} DM, respectively).

***In vitro* fermentation of concentrates:** Data on *in vitro* gas production of concentrates and hay are reported in Table 4. Total cumulative gas production (A + B) was lowest in oat-vetch hay (p<0.01), comparatively with the 3 types of concentrate which were similar (averaged: 86.35%). The rate of gas production (C) was highest in the 3 concentrates, which were similar (averaged 0.1% h^{-1}) and lowest in hay (0.049% h^{-1}). The same trend was observed with IVOMD (67.6% and 49.2, respectively for concentrates and hay) and *in vitro* determined ME (2526.3 and 1551 kcal kg^{-1} DM). These results showed that including faba bean in concentrate at the rates of 16 and 23% did not result in any significant effect on fermental parameters. This may indicate that the 3 concentrates are almost nutritionally similar and is in line with the approximatively similar values of chemical composition.

Intake: Results concerning DM hay intake are presented in Table 5. They indicated that soybean substitution by faba bean until a rate of 23% affected neither DM intake nor food conversion ratio (mean values: 4.3 kg and 5.55, respectively). This finding confirmed those reported by Seegers (2002). It seems that including faba bean until a rate of 23% of concentrate did not result in significant modifications of fermental trends and likely microbial synthesis in the rumen and amino acid absorbed in the gut. According to Fontaine *et al*. (2003), young beef cattle Are able to consume 2-3 kg of faba bean without any risk. The found trends are in line with those of the *in vitro* trial using the method of cumulative gas production technique (Menke and Steingass, 1988) which demonstrated that gas production parameters, IVOMD and calculated ME content are statistically similar in the 3 types of concentrate.

Table 4. *In vitro* gas production characteristics of concentrates

	Feeds					
Parameters	C0	C16	C23	Hay	SEM	p- value
A (mL)	-1.2	-1.8	-2	-2.1	0.019	NS
B (mL)	89,8a	87.9a	87.3	6a63b	1.7	<0.01
C (h^{-1})	0.12a	0.10a	0.10a	0.049b	0.001	<0.01
A+B (mL)	87.6a	86.1a	85.36a	61.9b	1.6	<0.01
IVOMD (%)	68.9a	67.6a	66.3a	49.2b	2.3	<0.01
ME (kcal kg^{-1}DM)	2569a	2520a	2490a	1551b	58	<0.01

C0, C16, C23: Concentrate including, respectively 0, 16 and 23 % of faba bean. A, b value with different letters in the same line are significantly different. A, B and C are constants in the equation: $GP = A + B(1-e^{-Ct})$, where GP is the gas production at time t, A is the immediate gas production, B is the fraction of the slowly gas production, C is the rate of gas production and (A + B) is the total gas production. NS: Not significant.

Table 5: Effect of partial substitution of soybean with faba bean on intake, live weight gain and food conversion ration

Diets	D1	D2	D3	SEM	p- value
Initial LW (kg)	147	145.4	145.7	4.9	NS
Final LW (kg)	4.23.2	404.4	415.2	12.4	NS
LWG (kgday^{-1})	1.47	1.37	1.39	0.3	NS
Total gain (kg)	91.6	93.8	95	3.8	NS
Hay DMI (kg)	4.24	4.25	4.41	0.35	NS
Feed conversion ration	5.29	5.67	5.7	0.46	NS
Feeding cost of gain (Dtkg^{-1})	1.21	1.31	1.31		

D1, D2 and D3: diets with concentrate including, respectively 0, 16 and 23% of faba bean. NS: Not significant, SEM: Standard error of the mean. DT: Tunisian Dinar (0.75 US$)

Animals performances: The main results relative to growth trial are summarized in Table 5, while evolution of LW and LWG are illustrated, respectively by Fig. 1 and 2. Liveweight value variation (Fig. 1) showed a good homogeneity of the mean weight of beef cattle in the 3 groups, during all the experimental period. The deviations of weight inside the same group varied from 25-45 kg and remained unchanged during the experiment. The mean weights in the end of the experiment were 429, 421 and 431 kg, respectively for D1, D2 and D3. No significant differences were observed between the three treatments. Values of total LW gain were comparable during all the periods of the trial (Fig. 1). For mean observed value, the difference between the 3 diets was not significant (averaged 93.4 kg).

The daily LW gain ranged from 0.88-2.19 kg day^{-1} and observed values were the highest for periods between 1 and 6 and then they decreased during the end of the fattening period (Fig. 2). This result is in line with those reported by Haurez (2003) when substituting partially soybean with faba bean. In the same trend, according to Girard (1990), the substitution of soybean with faba bean on the basis of CP content, (2 kg of faba bean instead of 1.1 kg of soybean) resulted in similar protein content, but a small surplus in energy, while concentrate is well balanced and allows similar performances. In our trial, important decreases in LWG were observed mainly during

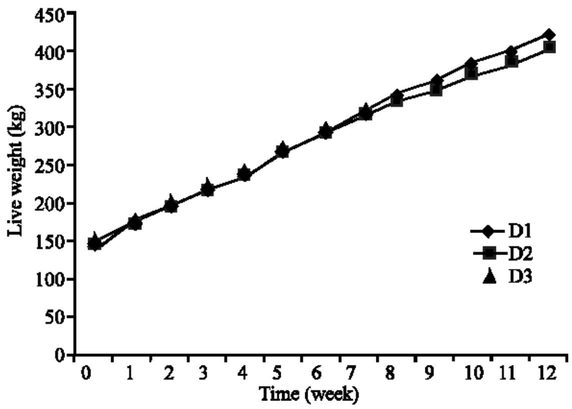

Fig. 1: Live weight variation (D1, D2 and D3: diets with concentrate including, respectively 0, 16 and 23% of faba bean)

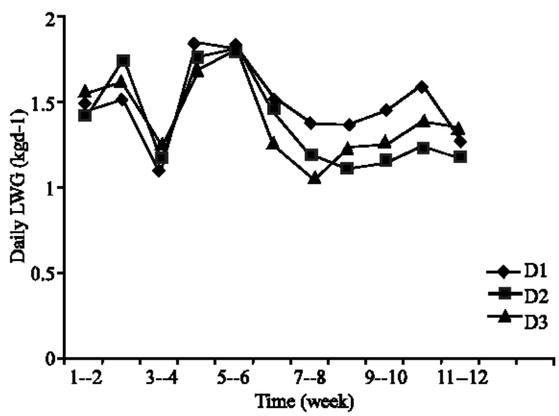

Fig. 2: Daily Liveweight gain variation as measured by week. D1, D2 and D3: diets with concentrate including, respectively 0, 16 and 23% of faba bean

periods 3-4 and 7-9. These periods were of high temperature (t° exceeded 35°C) combined to high relative moisture, causing thermal resulting in increased intake. The mean LWG value during all the trial was 1.4 kg day^{-1} (Table 5). This value is relatively high compared to usual results observed in beef cattle from dairy breeds in Tunisia. In deed, lower values ranging from 583 and 900 g day^{-1} were found by Akbar and Gupta (1990) or noted in some unpublished data from previous studies carried out in institute. Our relatively high values could be attributed, by one hand to the low number of animals and their young age and by another hand to the individual control of feeding, which may result in higher efficiency.

Consequently it seemed that it's possible to substitute up to 60% soybean by faba bean, while preserving the same level of performances of the animals. Economically, substituting soybean with faba bean did not affect considerably the feeding cost of liveweight. In deed, the incidence of the substitution on the feeding cost was very low. Feeding cost was increased by only 0.1 DT kg^{-1} in both D2 and D3.

CONCLUSION

It was concluded that partial substitution of soybean with faba bean up to 16 and 23 % in concentrate resulted in comparable performances and didn't affect significantly growth of beef cattle comparatively to soybean diet. This incorporation may depend on the cost of this raw material. Consequently, in the particular case of Tunisia, increasing yield and reducing cost of faba bean culture is quite necessary to develop its utilization mainly in beef cattle feeding.

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