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Nutritive value of faba bean hulls for ruminants

D. Minakowski, Halina Skórko-Sajko and Aniela Falkowska

Institute of Animal Nutrition and Feed Management,
Olsztyn University of Agriculture and Technology
Oczapowskiego 5, 10-718 Olsztyn, Poland

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ABSTRACT

Faba bean hulls (var. Nadwiślański) contain approximately, %: CP 14.1, CF 39.6, NDF 54.3, ADF 53.0 and 6.75 mg kg^{-1} DM condensed tannins. UFL and UFU level was 0.71 vs 0.62; PDIN and PDIE 91g vs 100g kg^{-1} DM, respectively. The effective ruminal degradability (ERD) of DM, OM, CP and NDF amounted to 25, 29, 52 and 7%, respectively.

Faba bean hulls fed at the rate of 18.3% DM of the diet decreased crude protein digestibility ($P<0.01$) and increased N-retention (3.8 g vs 5.5 g) in growing sheep. Significantly higher glucose level and decreased urea content in blood serum has been found within experimental animals.

KEY WORDS: faba bean, hulls, nutritive value, degradability, digestibility, N retention, sheep

INTRODUCTION

Faba beans contain some anti-nutritive factors (eg. tannins, trypsin inhibitors, glycosides determined as glycopyranosides) which limit digestibility of other components, especially of crude protein (Newton and Hill, 1983; Barry and Mangan, 1984; Mangan, 1988; Zduńczyk et al., 1992; Vaithiyamathan and Kumar, 1993). Due to this, attention is being paid to the procedures which would decrease levels or inactivate these substances. There is a variety of technological procedures improving nutritive value of faba beans; one of them consist of removing the hulls. Since majority of the tannins as structural carbohydrates as well as part of trypsin inhibitors are contained in the hull, bean dehulling is fully justified in some cases. The beans obtained with this procedure are characterised by 10% higher protein content. Content of crude fibre and so level of tannins decreased by 70-90% and 60%, respectively (Zduńczyk et al., 1992). The by-product consisting of the hulls constitutes from 12 to 16% of faba bean weight. Newton and Hill (1983) indicate that these hulls can be used as a feed for ruminants, which will also modify metabolism of nutritients in the rumen. However, data characterizing value of this product as ruminant feed are lacking.

This study was undertaken to determine nutritive value of faba bean var. Nadwiślański (*Vicia faba manor*) hulls for ruminants.

MATERIAL AND METHODS

Faba been hulls

Faba bean hulls (var. Nadwiślański) was obtained by mechanical separation of the hulls and seed leaves with a huller ($\pm$1.5 mm screen).

Animal management

Cows– Two cows with rumen fistula were housed individually in box stalls with free access to water and fed twice daily (8 and 16 h) a ration consisted of 5 kg good quality meadow hay, 2 kg ground barley and 100 g commercial mineral-vitamin mixture (Biostar, Belgium). Cows has been adapted to the ration for 3 weeks prior to the incubation procedure for bean hulls degradability.

Rams – Nine growing rams (10-11 months of age, $\pm$40 kg body weight) divided into 3 groups, were used in balance trial. The animals were housed in individual metabolism cages and fed a ration consisted of concentrate mixture CJ*, dried sugar beet pulp and chopped meadow hay with free access to water (Table 2). Part of hay in groups II and III was substituted by crushed faba bean hulls. Daily ration was divided into two portion given at 8 and 16h.

Degradability of bean hulls

The effective ruminal degradability (ERD) of DM, crude protein (CP), organic matter (OM) and NDF was calculated according to Ørskov and McDonald (1979) based on the rate of passage $k = 0.06$. Incubation was carried out for 0, 3, 6, 12, 18, 24, 48 and 72 h. After incubation in the rumen, the bags were washed three times for 5 min and dried in an forced ventilation at 45^{0}C.

* CJ – concentrate mixture for calves and lambs with 14.7% CP and 1.43 Mcal net energy

Balance experiment

Faeces and urine were collected for 6 days, after 10-days adapatation period. Collected samples were maintained at 2 to 4^{0}C to retard microbial activity. Subsamples of total urine (10%) and faeces (5%) were taken for analysis. Urine samples were preserved with sulphuric acid.

Chemical analysis and calculations

Chemical composition of the hulls and feeds was determined with conventional methods, plant cell wall components (NDF, ADF, ADL) according to Van Soest and Wine (1967). Minerals content of hulls (Ca, Na, Fe, Cu, Zn) was estimated with atomic spectophotometry and flame photometry, condensed tannin concentration according to Mejbaun-Kazenellonbogen and Kudrewicz-Kubicka (1966), degradability of CP, OM, DM and NDF by nylon bag techniques *in sacco* (Ørskov and McDonald, 1979).

The PDIN and PDIE contents were calculated based on ruminal protein degradability and INRA (1989) coefficients.

Nitrogen in feeds, fresh faeces and urine was determined by Kjeldahl method; other nutrients were determined in dried faeces by conventional methods. Sample of urine were analysed for allantoin content according to Harnarsky and Müller (1980).

In samples of blood serum, taken from jugular vein, glucose and urea were estimated according to Krawczyński and Osiński (1967).

The results were subjected to statistical analysis using single factor variance analysis (Ruszczyc, 1978).

RESULTS AND DISCUSSION

Faba bean hulls contain 14.3% crude protein and high level of crude fibre 39.6% in DM (Table 1). Crude protein content is almost twice higher than the data given by other authors (Newton and Hill, 1983; Zduńczyk et al., 1992). This suggests that the product used contained not only the hulls, but also some seed leaves. The content of some crude fibre fractions, especially of cellulose and ADF, were high (50.25 and 53.04% in DM, respectively). Content of condensed tannins amounted to 6.75 mg/kg DM of the hulls. High level of crude fibre (Table 1) suggests that this product may be used as a feed only for ruminants.

The dynamics of ruminal degradation of total N, OM, DM and NDF in the rumen are presented in Figure 1. In the initial period of the incubation (0-3 h) soluble fractions and those more digestible were degraded. In this period

TABLE 1

Chemical composition and nutritional value of faba bean hulls

Specification	Content in DM
In percent	
dry matter	100
crude ash	3.51
crude protein	14.13
ether extract	1.06
crude fibre	39.59
N-free extractives	41.69
NDF	54.27
ADF	53.04
ADL	2.79
cellulose	50.25
hemicellulose	1.23
Minerals	
Ca, g/kg	5.35
Na, g/kg	0.4
Fe, mg/kg	64.6
Zn, mg/kg	52.15
Cu, mg/kg	6.43
Condensed tannins, mg/kg	6.754
Condensed tannins, %	0.68
Energy, Mcal/kg[1]	
gross energy	4.5
digestible energy	2.65
metabolizable energy	2.11
NE, UFL	0.71
NE, UFM	0.62
Protein value, g/kg[2]	
PDIA	52
PDIN	91
PDIE	100

[1] NE (UFL,UFM) – net energy in feed units for milk/meat production; calculated according to INRA system (1989)

[2] Protein value; calculated on the basis of INRA system (1989)

digestion of crude protein was relatively low (about 47%), similarly as of organic matter and dry matter (22 and 18%, respectively). Degradability of NDF was negligible. Longer incubation of the samples resulted in increased rumen degradability for all nutrients.

Coefficients of protein degradation reached 58% after 34-h incubation. Decisively lower values were noted with respect to the degradation of DM, and

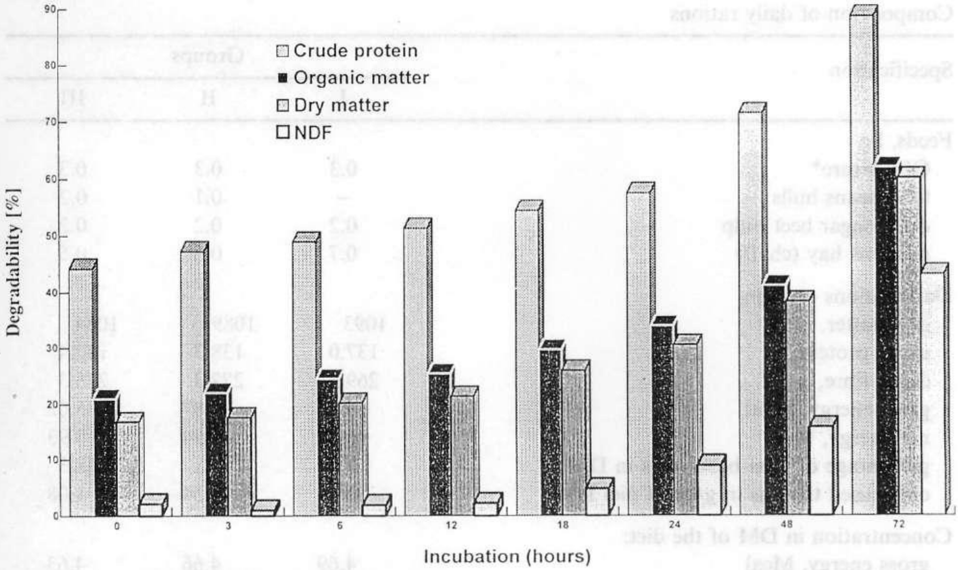

Figure 1. Degradability of crude protein, organic matter, dry matter and NDF of faba bean hulls in the rumen

especially of the structural components. Digestion dynamics of DM and OM (Figure 1) reveals that digestibility of the nutrients of faba bean hulls in the rumen increased after prolonged incubation of the samples, most of all after 48 and 78 h. Hence, it may be concluded that faba bean hulls, similarly as some other feeds (ground soyabean, fish meal or maize grain), are characterized by low digestibility in the initial phase of ruminal incubation, but their degradability increases with incubation period. This is confirmed also by low degradation coefficient for water soluble fractions contained in faba bean hulls (Figure 1).

The effective ruminal degradability (ERD) of DM, OM, CP and NDF, calculated at ruminal passage rate of 6% h^{-1} and basing on the loss during incubation for the given time, amounted to 25, 29, 52 and 7%, respectively. Lower digestion of DM and OM compared to crude protein was observed irrespective of the duration of sample incubation. This means that faba bean hulls contain some excess of nitrogen substances degrading in the rumen compared to the amount of available energetic components. Energetic value of faba bean hulls (Table 1) proved to be slightly lower than French standards by INRA, (1989) for all types of energy, at the same coefficient $q = 0.47$. Lower value of PDIA was undoubtedly due to 13% lower content of crude protein in 1 kg DM compared to the standards (162 g vs 141 g). Energetic value expressed as gross energy was similar in all diets (Table 2). Contents of crude protein in DM

TABLE 2

Composition of daily rations

Specification	Groups		
	I	II	III
Feeds, kg			
CJ mixture*	0.3	0.3	0.3
faba beans hulls	–	0.1	0.2
dried sugar beet pulp	0.2	0.2	0.2
meadow hay (chaff)	0.7	0.6	0.5
Daily rations contain			
dry matter, g	1093	1089	1084
crude protein, g	137.0	138.7	140.4
crude fibre, g	269.3	272.3	275.3
gross energy, Mcal	5.13	5.07	5.02
net energy, Mcal	0.99	0.94	0.93
percentage of faba bean hulls in DM	0	9.1	18.3
condensed tannins in g/kg of diet DM	0	0.54	1.08
Concentration in DM of the diet:			
gross energy, Mcal	4.69	4.66	4.63
net energy, Mcal	0.90	0.86	0.86
crude protein, %	12.5	12.7	12.9
crude fibre, %	24.6	25.0	25.4
NDF, %	35.1	36.1	37.1
ADF, %	28.1	29.1	30.2
ADL, %	3.81	3.80	3.78
cellulose, %	24.2	25.3	26.4
hemicellulose, %	7.1	7.0	6.9

* concentrate mixture for calves and lambs with 14.7% CP and 1.43 Mcal NE/kg

ranged from 12.35 (I) to 12.95 % (III). Higher differentiation of the energetic values as net energy was observed for diets containing faba bean hulls (groups II and III). Diets in groups II and III were contained higher NDF, ADF and cellulose content at relatively similar level of crude fibre.

Introduction of faba bean hulls into the diet decreased crude protein digestibility (Table 3). This was especially noticeable in the case of the diet with the highest content of faba bean hulls (0.2 kg-group III); the difference was significant ($P < 0.01$) compared to the control group I. Lowering of crude protein digestibility might have been caused, among others, by increased content of structural carbohydrates and tannins in the hulls (Table 1). Also Osbourne et al. (1971) observed that tannins decreased crude protein digestibility. Barry (1985) tested sheep diets containing *Lotus pedunculatus* which also contained considerable level of condensed tannins (76-90 gkg^{-1} DM) and found that weight gains of the animals and wool yield decreased. The reduction of apparent CP

TABLE 3

Nutrients digestibility, N-retention and level of glucose and urea in blood serum

Specification	Groups		
	I	II	III
DM intake			
g/day/head	1029	1063	1059
g/kg $BW^{0.75}$	63.5	68.1	66.6
Nutrients digestibility, %			
crude protein	$65.5^{A} \pm 1.07$	$61.8^{AB} \pm 1.93$	$57.3^{B} \pm 3.23$
ether extract	53.0 ± 4.42	55.2 ± 5.50	59.1 ± 0.65
crude fibre	53.1 ± 3.91	53.5 ± 2.59	52.4 ± 2.49
N-free extractives	66.7 ± 1.77	65.7 ± 1.66	65.1 ± 0.85
organic matter	62.8 ± 1.85	61.8 ± 1.83	60.6 ± 1.21
Nitrogen balance, g/day			
N intake	20.81 ± 1.91	21.87 ± 0.30	22.14 ± 0.56
N excretion			
in faeces	$7.17^{a} \pm 0.87$	$8.35^{ab} \pm 0.32$	$9.44^{b} \pm 0.90$
in urine	$9.84^{a} \pm 0.51$	$8.78^{ab} \pm 0.06$	$7.16^{b} \pm 1.67$
N-retention	3.79 ± 0.55	4.75 ± 0.59	5.54 ± 1.22
N-retention/N-intake, %	18.2	21.70	25.01
In blood serum, mmol/l			
glucose	$3.31^{Aa} \pm 0.40$	$3.81^{b} \pm 0.08$	$4.16^{B} \pm 0.13$
urea	4.91 ± 0.49	4.95 ± 4.95	3.86 ± 0.47

A,B $P \leqslant 0.01$
a,b $P \leqslant 0.05$
$\pm$ standard deviation

digestibility observed in this trial, is similar to the results with canola hulls for ruminants (McKinnon et al., 1995). The apparent CP digestibility (Table 3) indicates that high proportion of the faba bean hulls protein in the diet is also unavailable to the ruminants. Increased N excretion in the faeces of the animals fed faba bean hulls suggests possible formation of hardly assimilable fraction of nitrogen substances in the digestive tract, bound in complex with hulls tannins. Earlier studies by Nuñez-Hernandez et al.(1991) also suggested such possibility. The digestibility of other nutrients revealed no noticeable differences; crude fat being the only exception. Digestibility of crude fat increased in diets containing faba bean hulls (group II and III), however, the difference was statistically insignificant.

Sheep receiving faba bean hulls in the diets (group II and III) had higher N retention (Table 3) compared to the control animals (group I). However, it could be noted that higher excretion of N in the faeces of sheep in group III was accompanied by its lower excretion in urine ($P < 0.05$). This resulted in an improved ratio of N-retained to N-intake in sheep fed diets containing faba bean hulls, but N retention, expressed as per cent of N-retained to N-intake, was low in all animals (group I-III).

The use of faba bean hulls in growing ram diets increased the concentration of glucose (3.3 vs 3.8, 4.2 mmol/l) in blood serum and reduced the serum urea content (4.9 vs 3.0 mmol/l; Table 3). Increased of condensed tannins in diets decreased of urea serum concentration and was also reported by Nuñez-Hernandez et al. (1991). Some reports (Waghorn et al., 1994 a, b) show that condensed tannins can have detrimental effect on nutritive value of feeds for ruminants.

Typical effects of condensed tannins in the ruminant feeds include a low DM intake and N digestion. Urea allantoin-N ranged from 516 to 494 and 459 mg/head/day in I, II and III group, respectively. This trend may suggest the reduction in the rate of rumen microbial biomass due to condensed tannins.

CONCLUSION

Faba bean hulls contain hardly assimilable structural fraction of NDF fibre. This results in lower rate of nutrients degradation in the rumen. Noticeable increase of dry matter and organic matter digestion was found in the rumen of cow only after 72-h incubation. Crude protein contained in the hulls was the component most rapidly degraded in the rumen (ERD = 52%) in comparison to the degradability of organic matter, dry matter and NDF.

High content of NDF and ADF fibre (50% DM) and especially of cellulose (about 50% DM) and high concentration of tannins in faba bean hulls suggests that use of this product is limited in ruminant feeding. Its content should not exceed 20% DM of the diet for growing and fattening sheep.

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STRESZCZENIE

Wartość pokarmowa i wykorzystanie łupiny nasiennej bobiku w żywieniu przeżuwaczy

Łupina nasienna bobiku (odm. Nadwiślański) zawiera w suchej masie 14.13% białka ogólnego, 54,3% włókna surowego, 2,8% ADL oraz 6,75 mg kg^{-1} skondensowanych tanin. Zawartość UFL oraz UFM wynosi odpowiednio 0,71 i 0,62, PDIN oraz PDIE stanowi 91 g i 100 g kg^{-1} SM. Efektywna degradacja w żwaczu (ERD) suchej masy, substancji organicznej, białka ogólnego oraz NDF oznaczona metodą *in sacco* wynosiła odpowiednio 25, 29, 52 i 7%.

Udział łupiny nasiennej bobiku w ilości 18,3% SM dawki pokarmowej dla rosnących tryczków wpłynął na obniżenie strawności pozornej białka ogólnego ($P<0,01$) i wzrost retencji azotu (3,8 g vs. 5,5 g). Wprowadzenie do dawki pokarmowej łuski z nasion bobiku wpłynęło na obniżenie poziomu mocznika oraz istotne podwyższenie zawartości glukozy w surowicy krwi.