Evaluation of dehulled faba bean (*Vicia faba* cv. Fiord) as a protein source for laying hens

S.F. Magoda & R.M. Gous#
Animal and Poultry Science, University of KwaZulu-Natal, P/B X01, Scottsville 3209,
Pietermaritzburg, South Africa

Abstract

Dehulled faba beans were evaluated as an alternative to soybeans as a protein source for laying hens using 240 individually caged birds, 50 weeks of age. Two basal feeds were formulated to the same nutrient specifications but with one containing no faba beans and the other containing 200 g dehulled faba bean meal/kg. The experiment was divided into two parts: a dilution series, and a choice feeding treatment. The dilution series consisted of increasing concentrations of faba beans, the five levels in the series being 0, 50, 100, 150 and 200 g/kg of food. The sixth treatment was a choice between the two basal feeds. Although food intake increased linearly with faba bean inclusion, reflecting a need by the hens to consume more in an attempt to obtain sufficient of some unidentified limiting nutrient, laying performance was the same on all feeds in the dilution series. Hens consumed the same amount of each basal feed when given a choice between the two, suggesting that no anti-nutritional factors were present in the faba beans used in this trial. It can be concluded, from a nutritional point of view, that dehulled faba bean meal may be used successfully as an alternative to soybeans as a source of amino acids for laying hens as long as the levels of anti-nutritional factors present are very low, as was the case in this trial, and as long as accurate estimates of the AME and the digestible amino acid contents of the ingredient are used when formulating feeds containing faba beans. If faba beans can be grown and then used locally in areas unsuitable for soybean production, the reduced transport cost could make this an attractive alternative to soybeans.

Keywords: Anti-nutritional factors, protein sources, choice feeding
Corresponding author: gous@ukzn.ac.za

Introduction

As the world population continues to increase, so does the demand for protein. Farrell (1997) predicted that traditional sources of protein for livestock will become increasingly scarce because of the need to feed a progressively larger human population that will compete with an expanding intensive livestock industry that is being forced to exclude animal protein sources in animal feeds. As a result, a considerable effort has been made to explore the use of plant proteins that can be grown in areas where soybeans are not agronomically successful.

Vicia faba is an important crop in those areas of the world where cereal monoculture is practised and soybeans cannot be produced economically (Evans *et al*., 1972) as it requires a cool season for best development. In temperate and subtropical areas, it is grown as a winter annual. Hardier cultivars in the Mediterranean region tolerate winter temperatures of –10 °C without adverse effects whereas the European cultivars, which are the hardiest, tolerate temperatures as low as –15 °C (Elzebroek & Wind, 2008). The total world production of faba beans in 2005 was 6 million metric tons, produced on 3.3 m hectares. The countries producing most of the faba beans in the world are China (1.5 million ha), Ethiopia (0.6 million ha), Australia (0.18 million ha), and Morocco, Egypt and France, the latter together allocating 3.6 million ha for its production (H. Agenbag, personal communication, Protein Research Foundation, P.O. Box 1564, Rivonia 2128, South Africa). The majority of the beans produced are consumed by humans.

Initially, faba beans were shown to have a harmful effect on rats (Schonie *et al*., 1958) and this led to extensive studies with poultry some of which suggested that faba beans could be used with no harmful

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effects on performance (e.g. Carpenter & Johnson, 1968; Waring, 1969; Waring & Shannon, 1969). However, other reports suggested that high inclusion rates of faba bean resulted in poor growth, feathering and pigmentation of feathers which could be rectified by the inclusion of good quality protein (Bletner *et al.*, 1963; Kardirvel & Clandinin, 1974).

The effects of faba bean inclusion in feeds for laying hens have been studied for many years, with conflicting results. When faba beans were added at a rate of 100 g/kg in layer feeds supplemented with methionine and cysteine no adverse effect was observed (Vogt, 1972; Guillaume *et al*., 1973), whereas at a rate of 200 g/kg both feed conversion efficiency and egg weight were reduced (Vogt, 1972). Wilson & Teague (1974) reported that this latter rate of inclusion had no effect on laying performance or food intake, but resulted in a severe decrease in egg weight. Davidson (1973) suggested the inclusion level should be no more than 150 g/kg until more knowledge is attained of the factors that hamper production when higher levels were used. More recent research, performed by Perez-Maldonado *et al*. (1999), showed that the optimum level of inclusion of faba bean in laying hen diets was about 250 g/kg. It has also been shown that yolk colour, albumen quality and Haugh Unit Scores are not affected by concentrations as high as 300 g faba bean/kg feed (Guillaume & Bellec, 1977).

The contradictory results reported in the literature may be attributed to the variation in the composition of different cultivars of faba beans and hence differences in their nutritive value (Clarke, 1970). Some varieties of faba bean have been shown to include high concentrations of condensed tannins, and the nutritive value of these varieties is likely to improve by removal or inactivation of these tannins (V an der Poel *et al*., 1992). Marquardt *et al.* (1973) reported that most of the anti-nutritional factors found in the beans are located in the dehulled cotyledon, which led them to recommend dehulling and heat-treating the bean for optimum efficiency of faba bean utilization.

The study reported here formed part of a series, sponsored by the Protein Research Foundation, in which faba beans were evaluated as a protein source in feeds for broilers, laying hens and pigs, the objective being to determine to what extent this protein source would be acceptable to poultry and pigs thereby making available to the balanced feed industry a protein source other than soybeans.

Materials and Methods

Two hundred and forty 50-week old HyLine Silver laying hens, reared at Ukulinga Research farm, Pietermaritzburg, South Afica were used in this experiment. They had been fed a commercial layer mash *ad libitum* before they were used for the experiment. The experiment, which lasted 12 weeks, was conducted in an open-sided house. Hens were housed in individual cages, with food and water being supplied *ad libitum*. They were subjected to 16 h of light each day, artificial lighting being supplied by fluorescent lamps.

The experiment was divided into two parts: a dilution series, and a choice feeding treatment. The dilution series consisted of increasing concentrations of dehulled faba beans, the five levels in the series being 0, 50, 100, 150 and 200 g/kg of food. The sixth treatment was a choice between the two basal feeds. Each treatment was applied to 40 hens in blocks of six treatments in eight rows of cages (five blocks per row).

Dehulled faba bean were sourced from a local supplier. These were the same variety as those used by Brand *et al*. (1995), who determined the contents of anti-nutritional factors contained in this variety of faba beans. Two basal feeds were formulated using the WinFeed 2 feed formulation programme (EFG Software, 2005), one high and the other low in faba bean content (Table 1) but containing equal contents of AME_n and major minerals. Lower bounds of the essential amino acids were specified for the basal foods, specifications being those used by Animal and Poultry Science, University of KwaZulu-Natal (Table 1). Both feeds were formulated at least cost, to reflect commercial practice.

The two basal feeds were mixed thoroughly using a horizontal food mixer on the Ukulinga Research Farm. The intermediate feeds were then blended using appropriate proportions of the two basal feeds (Table 2). The two basal feeds were sampled after mixing and these samples were analysed for apparent metabolisable energy (AME) and digestible amino acid contents (Table 1).

All birds had *ad libitum* access to food. A self-feeding trough with a capacity of 1 kg was allocated to each pen. These troughs were filled with food and weighed at the beginning of the experiment. At the end of each week each trough was weighed to determine the amount of food consumed. These troughs were then refilled and the weight recorded before once again being placed in front of the hen. This process was repeated weekly for the duration of the experiment.

Table 1 Ingredient composition of the two basal foods used (kg, air dry basis)

Ingredient	Faba bean basal	Soybean basal
Dehulled faba bean	200	
Yellow maize	580	582
Wheat bran	0	67.1
Soybean full fat	15.1	209
Soybean (480 g crude protein/kg)	68.7	
L-lysine HCl		0.03
DL- methionine	1.7	1.3
L-tryptophan	0.2	
Vit + min premix	1.5	1.5
Limestone	90.9	90.6
Salt	0.7	
Monocalcium phosphate	20.5	20.2
Sodium bicarbonate	6.2	7.3
Choline chloride 60%	14.5	21.3
Nutrient composition	Calculated values	
AME (MJ/kg)	11.3	11.3
Crude protein	141	139
Lysine	60	60
Methionine	30	30
TSAA	62	62
Crude fibre	34	31
Crude fat	25	55
Calcium	35	35
Avail. phosphorus	60	60
Sodium	20	20
Potassium	60	60
	Analysed values	
AME (MJ/kg)	11.5	11.3
Crude Protein	136	133

Table 2 Proportions of the two basal feeds used to produce the series of five feeds

Treatment	Faba basal	Soya basal
1	100	0
2	67	33
3	50	50
4	33	67
5	0	100

Hens on the choice treatment were provided with two feed troughs, each being half the width of the trough used by the other hens on the experiment. These troughs were clearly marked with the basal feed to be added, and the amounts of feed added and remaining at the end of the week were recorded separately. At no time was either of the two feed troughs allowed to empty, i.e. there was always feed in each trough to ensure that the hen always had the option of choosing one or the other.

Eggs were collected and recorded each day. Weekly mean rate of lay per hen was calculated by dividing the number of eggs produced by each bird by seven. Eggs collected on Monday, Wednesday and Friday of each week were weighed immediately after collection, and weekly mean egg weight was calculated as the average of the eggs collected. Each bird was weighed at the beginning, after six weeks, and at the end of the experiment.

Means of the 40 replications of each treatment, and estimates of error for each variable were obtained using analysis of variance (GenStat, 2005). Linear regression (GenStat, 2005) was used to ascertain whether the rate of inclusion of faba beans resulted in any significant trends in the variables measured, and a t-test was used to determine whether the choice made by the hens differed significantly from the null hypothesis that equal amounts of the two basals would be consumed. The rationale for using this approach to evaluate faba beans as a protein source is described in Gous (2011).

Results

Brand *et al*. (1995) measured the alkaloid content of the variety of faba beans used in this trial to be 0.0, and Emiola & Gous (2011) measured the condensed tannin content of the dehulled beans to be <0.5% catechin equivalents.

The mean responses over all six treatments, in rate of lay, egg weight, egg output and food intake over the 12-week experiment period, are given in Table 3. Egg production (rate of lay and egg weight) was unaffected by the level of faba bean included in the feed, but food intake increased linearly (Table 3) with faba bean content. The change in body weight over the 12-week period was so small (mean -0.0003 g/d) that the mean values for each treatment are not given: these did not vary between treatments. In no case was the quadratic term in the regression analysis significant indicating that the responses to faba bean inclusion were not curvilinear in nature.

Table 3 Mean rate of lay (%), egg weight (g), egg output (g/bird d) and food intake (g/bird d) of laying hens given feeds of increasing faba bean content and those given a choice of two basal feeds, and linear regression coefficients of these variables on faba bean content (g/kg)

Faba bean content (g/kg)	Rate of lay (%)	Egg weight (g)	Egg output (g/bird d)	Food intake (g/bird d)
0	84.8	63.5	55.5	110
50	85.5	63.1	56.0	110
100	85.2	62.2	54.8	111
150	84.7	63.1	54.9	113
200	84.6	63.2	55.1	113
Choice	83.3	62.4	52.0	114
Mean	84.9	63.0	55.2	111
SE	1.39	0.72	1.04	0.55
Linear regression coefficient	-0.0026 ± 0.0088	-0.0009 ± 0.0045	-0.0041 ± 0.0067	0.017 ± 0.0035
t-value	0.77	0.84	0.54	< 0.001

For the choice feeding treatment a regression was fitted to the mean weekly amount of faba bean basal consumed as a proportion of the total food consumed over the length of the experimental period, to determine whether the laying hens on this treatment either exhibited a preference for one or the other basal, or changed their preference over the 12-week period. The non-significant linear coefficient (0.64 ± 0.45) indicates that their choice of basal feed did not change with time. The constant term of 48.5 ± 3.27, which does not differ from 50, indicates that the hens did not prefer one basal feed over the other, eating virtually the same proportion of each.

Discussion

The objective of this experiment was to determine whether dehulled faba beans would adversely affect the performance of laying hens. Because rate of lay and egg weight remained constant throughout the range of inclusion levels of this protein source it may be assumed that the faba beans used in this study contained no anti-nutritional factors and that the nutrient contents used for faba beans when formulating the basal feed were a reasonably accurate reflection of the true nutrient contents. These results are in agreement with the studies conducted by Wilson & Teague (1974) and by Perez-Maldonado *et al*. (1999), but contrary to those of several studies in which rate of lay was found to decrease with faba bean content (Vogt, 1972; Davidson, 1973; Guillaume & Bellec, 1977; Robblee *et al*., 1977). Egg weight was also found to decrease in some studies when faba bean content was increased (Guillaume & Bellec, 1977; Robblee *et al*., 1977; Mateos & Puchal, 1982; Perez-Maldonado *et al*., 1999).

In the present trial food intake increased linearly with faba bean inclusion, suggesting that the birds needed to consume more of this basal to meet their nutrient requirements, as hens are known to eat to satisfy their requirement for the first limiting nutrient in the feed (Gous *et al.*, 1987). They were successful in doing so, as egg production remained the same on all feeds. In the studies of Robblee *et al*. (1977) and Mateos & Puchal (1982) food intake was unaffected by faba bean inclusion rate whereas laying performance decreased at the higher faba bean inclusion levels in their trials.

The purpose of the choice feeding treatment was to determine whether the birds could detect the presence of toxins, but in this case it seems that there were none to detect. Had toxins been present, it would have been unlikely that the laying hens would have consumed the same amounts of the two basal feeds. Similarly, food intake is unlikely to increase with faba bean content, as it did in this trial, if there is a toxin present in the faba beans. In a similar trial conducted a year earlier at the University of KwaZulu-Natal, with pigs, the faba beans were found to contain <0.5 % catechin equivalents (Emiola & Gous, 2011), this being a measure of the condensed tannin content of ingredients. Levels as high as 3.5% catechin equivalents may be found in some varieties of faba bean (Jansman *et al*., 1994) and in these the apparent ileal digestibility of crude protein is lower than in varieties containing lower catechin equivalents.

The trial was designed differently from other trials in which faba beans have been evaluated as an energy and protein source. Firstly, by including the test ingredient at increasing rates in the feed the trend in performance can be determined. In some cases the response might be curvilinear, where there is some initial synergy between the two basal feeds but as the rate of inclusion increases so performance decreases; in other cases the response might be linear upwards or downwards. These responses are useful in determining whether there is an optimum level of inclusion (in the case of a curvilinear response) or whether the test ingredient is superior or inferior to the control treatment. Where performance remains constant, as it did in this case, the conclusion is that there is nothing intrinsically wrong with the test ingredient, and this is borne out by the absence of choice made by the hens on the choice feeding treatment, which reinforces this view.

Conclusion

The results obtained from this trial suggest that, from a nutritional point of view, dehulled faba beans may be used successfully as an alternative to soybeans as a source of amino acids for laying hens as long as the levels of anti-nutritional factors present are very low, as was the case in this trial, and as long as accurate estimates of the AME and the digestible amino acid contents of the ingredient are used when formulating feeds containing faba beans. Of course, these conclusions apply to all ingredients used in poultry feeding. A further consideration in the use of this protein source is its cost and availability relative to that of soybean. If faba beans can be grown and then used locally in areas unsuitable for soybean production, the reduced transport cost could make this an attractive alternative to soybeans.

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