# Faba bean (*Vicia faba* var. *minor*) as a protein source for organic chickens: performance and carcass characteristics

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*Paper received March 11, 2009; accepted April 22, 2009*

## ABSTRACT

The ban on transgenic feed and synthetic amino acids in e organic chicken diets has made it necessary to find protein-rich feedstuffs which do not alter productive performance. The effect of the faba bean (*Vicia faba* var. *minor*) as a partial substitute for soybean on the performance and carcass traits of slow-growing chickens of both sexes reared under the organic method was assessed. The experiment was carried out in the spring and autumn; one thousand birds per season were split into 8 groups (4 groups of males and 4 groups of females, each duplicated) and fed a double phase diet: a common starter diet for 20 days and two different growing-finisher diets containing either soybean (24%; S) or faba bean (16%; F) till the end of the rearing period (120 d). Average values of final live weight, feed intake and daily weight gain were significantly affected by sex, being higher in males than in females; the diets affected performance only in the 21-60 days of age period when the F group grew less and had poorer feed efficiency compared to the S group. Successively, the compensatory growth eliminated differences in slaughter weight. Regarding carcass traits, the diet affected only the ready- to-cook carcass percentage and the carena length, both of which were higher in S birds. Faba beans could be a valuable protein source in the diet of organic chickens when used after the critical starter period.

Key words: *Faba bean, Organic system, Performance, Carcass.*

## RIASSUNTO

UTILIZZO DEL FAVINO (VICIA FABA VAR. MINOR) COME FONTE PROTEICA PER POLLI BIOLOGICI: PRESTAZIONI PRODUTTIVE E CARATTERISTICHE DELLA CARCASSA

*Considerato il divieto di utilizzo di alimenti transgenici e di aminoacidi sintetici nell'avicoltura biologica lo scopo della presente ricerca è stato quello di studiare l'effetto della parziale sostituzione della soia con* *favino (Vicia faba var. minor) sulle prestazioni produttive e sulle caratteristiche della carcassa di polli biologici. L'esperimento è stato ripetuto in due stagioni: Primavera e Autunno. Mille polli per stagione sono stati suddivisi in 8 gruppi (4 gruppi di maschi e 4 di femmine, ognuno replicato) ed alimentati con una dieta bi-fase: dieta starter per 20 giorni e due differenti diete di finissaggio contenenti soia (24%; S) o favino (16%; F) fino alla fine del periodo di allevamento (120 giorni). I pesi finali, il consumo di alimento e gli accrescimenti medi giornalieri sono stati influenzati solo dal sesso, mentre la dieta ha prodotto effetti significativi solo nel periodo 21-60 giorni, quando gli animali alimentati con la dieta F sono cresciuti meno ed hanno mostrato peggiori indici di conversione. Alla macellazione i pesi dei gruppi erano gli stessi per effetto di una crescita compensativa. Riguardo al caratteristiche della carcassa, solo la resa in busto e la lunghezza della carena sono risultate superiori negli animali del gruppo S. In conclusione si può affermare che il favino può essere considerato una valida fonte proteica per l'alimentazione di polli biologici a patto che venga utilizzato dopo il primo periodo critico di accrescimento.*

Parole chiave: *Favino, Polli biologici, Prestazioni produttive, Carcassa.*

## Introduction

The organic livestock system is governed by EU-Regulation 1804/1999 which provides specifications for housing conditions, rearing and animal care, disease prevention, veterinary treatment and nutrition. Since the synthetic forms of amino acids and GMO ingredients are banned from organic diets, the possible alternatives for poultry producers include the use of slow-growing genotypes which have lower protein and amino acids requirements (especially during the starter phase) (Leclercq *et al.*, 1993; Pesti *et al.*, 1994; Rosa *et al.*, 2001) and feed formulations utilizing lesser amount of soybean which has a high risk of GMO contamination (Hanson *et al.*, 2004). Slow-growing birds are recommended for better adaptation to the outdoor environment and to a longer rearing period (Castellini *et al.*, 2002; Fanatico *et al.*, 2005); moreover they are healthier birds with fewer heart, leg and metabolic problems (Julian, 1998).

One of the most studied legumes as an alternative to soybean is the faba bean (*Vicia faba* var. *minor*), which has received considerable interest as an indigenous source of protein for Mediterranean countries since it can grow easily in dry areas. Unfortunately, there have been reports (Sterling *et al.*, 2002; Attia *et al.*, 2005) of low growth rates and food intake of broilers fed diets containing high levels of faba bean. The presence of toxic constituents and the low sulphur amino acid content of faba bean proteins have been claimed to be the main reasons for its low nutritional value (Rubio *et al.*, 1990). Van Leeuwen *et al.* (2000) showed that the faba bean has the lowest digestibility of the essential amino acids (mainly methionine) among several plant sources (maize, wheat, lupin, soybean), rendering the total substitution of soybean with faba bean not feasible.

However, heat treatment can improve the nutritional quality of faba beans by removing or destroying other thermo labile antinutritive factors responsible for reduced chick weight, feed efficiency and retention of dry matter, protein and crude fibre (Marquardt *et al.*, 1976; Ward *et al.*, 1977; Diaz *et al.*, 2006).

The aim of this study was to verify the effects of the faba bean (*Vicia faba* var. *minor*) as a partial substitute for soybean in growing-finisher diets on the performance of slow-growing chickens reared under the organic system.

## Material and methods

*Animals and experimental design*

The experiment was carried out at the Agricultural farm of the University of Perugia. The effect of the partial substitution of soybean with faba bean was tested in poultry diets when administered after a common starter diet. The trials were repeated in two different seasons (autumn and spring).

All the animals were reared according to EU Regulation 1804/99 and Italian directives (Italian Republic, 1992) on animal welfare for experimental and other scientific purposes.

For each season, one thousand day-old slow-growing chicks (Gaina, Avicola Berlanda, Padua, Italy) were divided into 8 experimental groups of 125 birds each (4 groups of males and 4 groups of females, each duplicated). They were fed the same starter soybean-based diet from 1 to 20 days of life. From day 21 until slaughter (120 d), they were fed 2 different growing-finisher diets: soybean based growing diet (S) or partially replaced with extruded faba bean (F). Diets were formulated according to NRC (1994) recommendations for slow-growing chickens (Table 1). Feed and water were provided *ad libitum*.

From hatching to 20 days of age all birds were kept in an environmentally controlled poultry house with temperature and relative humidity ranging from 30 to 32°C and from 65 to 70%, respectively. At 21 days of age they were transferred to a straw bedded poultry house (0.10 $m^2$/bird), equipped with feeders and drinkers and with free access to open air runs (4 $m^2$/bird).

The chicks were vaccinated against Marek and New Castle disease and coccidiosis (Paracox®).

Individual body weight (20% of the animals in each group were sampled) was recorded every 10 days and daily weight gain (DWG) and feed efficiency (FE) were calculated accordingly. Feed intake (FI) and bird mortality was recorded daily. At 120 days, the birds in all the experimental groups were slaughtered.

*Analytical determinations of diets*

The analyses of the chemical composition of the diets were carried out according to AOAC methods (1995) and the metabolizable energy was estimated according to the method described by Carrè and Rozo (1990).

The extraction and purification of vicine and convicine of diets were carried out by the reference method HPLC adapted according to Quemener (1988). Faba bean seeds were ground in an IkA-Universal M20 mill for 3 min to a particle size of less than 0.5 mm. A 500 mg quantity of sample was weighed in a centrifuge tube and 15 mL of aqueous uridine solution (0.4 mg $mL^{-1}$) was added. The tube contents were homogenized for 2 min with a Polytron homogenizer equipped with 10S Model axis and centrifuged at 25000 g for 5 min. Portions of 10 mL of supernatant were transferred to another centrifuge tube and 60 µL of 1 N HCl was added in order to precipitate most of the proteins at their isoelectric pH (pHi~4.2). The mixture was shaken and centrifuged at 2,500 g for 5 min. An aliquot of 100 µL of supernatant was diluted six times with ultra-pure water and maintained at 4°C until glycoside HPLC analysis.

The HPLC system consisted of an HP series 1100, Rheodyne Loot injector, Supelcosil LC PAH (15 cm x 4.6 mm) Column. Ultra-pure water was eluent at flow rate of 1 mL $min^{-1}$; the volume of injection was 20 µL. Concentration of vicine and convicine was quantified by relative UV response factors to uridine 0.803 and 0.601, respectively, measured at wavelength of 273 nm.

*Carcass dissection*

At 120 days, a representative sample of 10 birds per sex and diet for both seasons (weight ranging ±10% of the mean weight of all the birds) were slaughtered 12 hours after feed withdrawal. Chickens were electrically stunned (110 V; 350 Hz) before killing.

Table 1. Formulation (%), chemical composition (% DM except dry matter), energetic value (MJ kg-1), amino acids, vicine and convicine (%) of the starter and finisher diets.

| | | Starter | Growing/Finisher | |
|---|---|---|---|---|
| | | | S | F |
| Ingredients: | | | | |
| Maize | | 31.00 | 46.00 | 42.00 |
| Wheat | | 13.50 | 13.50 | 13.50 |
| Extruded soybean flakes | | 36.00 | 24.00 | 13.50 |
| Pea | | 7.00 | 7.00 | 7.00 |
| Extruded Faba bean | | - | - | 16.00 |
| Gluten feed | | 9.00 | - | - |
| Wheat bran | | - | 6.00 | 4.00 |
| Soybean oil | | | | 0.50 |
| Salt | | 0.20 | 0.20 | 0.20 |
| Calcium phosphate | | 1.10 | 1.10 | 1.10 |
| Calcium carbonate | | 1.60 | 1.60 | 1.60 |
| Minerals and vitamins* | | 0.60 | 0.60 | 0.60 |
| Chemical composition: | | | | |
| Dry matter | % | 88.49 | 88.00 | 88.07 |
| Crude protein | | 20.47 | 16.25 | 16.03 |
| Ether extract | | 8.22 | 6.65 | 5.39 |
| Crude fibre | | 4.54 | 4.20 | 4.62 |
| Ash | | 6.18 | 5.65 | 5.35 |
| Metabolizable Energy** | | 13.14 | 12.66 | 12.50 |
| Lysine *** | | 1.15 | 0.87 | 0.86 |
| Methionine + cystine *** | | 0.72 | 0.58 | 0.54 |
| Threonine | | 0.80 | 0.62 | 0.52 |
| Tryptophan | | 0.24 | 0.19 | 0.16 |
| Antinutritional factors: | | | | |
| Vicine | | nd | nd | 0.18 |
| Convicine | | nd | nd | 0.09 |

*S: soybean; F: faba bean.*

**Amounts per kg: Vit. A 11,000 U; Vit. $D_3$ 2000 U; Vit. $B_1$ 2.5 mg; Vit. $B_2$ 4 mg; Vit. $B_6$ 1.25 mg; Vit. $B_{12}$ 0.01 mg; α-tocopheryl acetate 30 mg; Biotin 0.06 mg; Vit. K 2.5 mg; Niacin 15 mg; Folic acid 0.30 mg; Panthotenic acid 10 mg; Choline chloride 600 mg; Mn 60 mg; Fe 50 mg; Zn 15 mg; I 0.5 mg; Co 0.5 mg.*

***Estimated by Carrè and Rozo (1990).*

****Calculated values.*

*nd=not detected.*

The carcasses were plucked, eviscerated (non-edible viscera: intestines, paraventriculus, gall bladder, spleen, oesophagus and full crop) and individually weighed before and after refrigeration for 24 hours at +4°C. The carcass weight losses occurring during refrigeration were calculated as the difference in weight before and after refrigeration.

Full and empty gastrointestinal tracts were also individually weighed and the weight of the *ingesta* was calculated by difference.

The head, neck, legs, edible viscera (heart, liver, gizzard) and fat (perivisceral, perineal and abdominal) were removed and weighed; the ready-to-cook carcasses (RCC) were then weighed. Biometric measurements were carried out following the procedure described by ASPA (1996). The breasts and drumsticks were also removed from the carcasses and weighed, and their yields were calculated as a percentage of the RCC.

*Statistical analyses*

Data were analysed with a 3-way linear model including the effects of dietary regimen, sex and season. The effect of season and the interactions were not significant and were thus omitted.

The significance of differences was evaluated by the t-test (SAS, 1999). Mortality was analysed with CHISQ proc. (Pearson's chi-square).

The effect of diet on feed intake, feed efficiency and daily weight gain were also tested in the single sub periods.

The growth curve of the birds was also evaluated with the Gomperz equation (Roush *et al.*, 2006).

## Results and discussion

Formulation (%), chemical composition (% d.m.), energetic value (MJ $kg^{-1}$), amino acids, vicine and convicine of the diets (% d.m.) are reported in Table 1.

The amounts of vicine and convicine in the F diet were 0.18 and 0.09% d.m., respectively. These values agree with those observed by Gutierrez *et al.* (2006) who determined their contents in different faba bean cultivars (ranging from 0.02 and 0.01% d.m. to 0.33 and 0.21% d.m. for vicine and convicine, respectively). According to Sixdenier *et al.* (1996), the total amount of vicine and convicine should be considered high when the values are greater than 0.15% d.m., while values lower than 0.05% d.m. are classified as low; in our study the amount was 0.28% and should thus be considered high. These high levels in the diet showed that extrusion was not able to reduce the glucoside content. Although heat treatment inactivates part of the antinutritional factors (Ward *et al.*, 1977; Diaz *et al.*, 2006) contained in the seeds, vicine and convicine are thermostable (El-Sayed *et al.*, 1996; Elkowicz and Sosulski, 1982).

The effects of diet and sex on productive performance are reported in Table 2. The average values of final live weight, feed intake and daily weight gain were significantly affected only by sex, being higher in males than in females; diet did not influence performance traits.

A similar trend was observed in the productive performance in the different sub periods of the rearing cycle (Table 3), except from 21 to 60 days when the F group grew less and had a poorer feed efficiency compared to the S group. Afterwards, these differences between groups disappeared. Trends of DWG, FE and FI are ascribable to a compensatory growth phenomenon. It has been hypothesized that birds have a specific set point for body weight at a certain age and when they are behind their scheduled growth curve, they try to reach this weight in a shorter time (Wilson and Osbourn, 1960; Mosier, 1986). When the early nutri-

Table 2. Productive performance of organic broilers fed with different growing-finisher diets.

| | | Diet | | Sex | | Significance | | Pooled SE /$\chi^2$ |
|---|---|---|---|---|---|---|---|---|
| | | S | F | M | F | Diet | Sex | |
| Final live weight (LW) | g | 2,583 | 2,458 | 2,767 | 2,274 | ns | ** | 264 |
| Feed intake | g/d | 80.0 | 75.6 | 85.6 | 70.0 | ns | ** | 11.0 |
| Daily weight gain | g/d | 21.3 | 20.1 | 22.8 | 18.6 | ns | * | 2.4 |
| Feed efficiency | | 3.76 | 3.76 | 3.75 | 3.76 | ns | ns | 2.2 |
| Mortality | % | 9.6 | 10.4 | 11.0 | 9.0 | ns | ns | 3.1 |

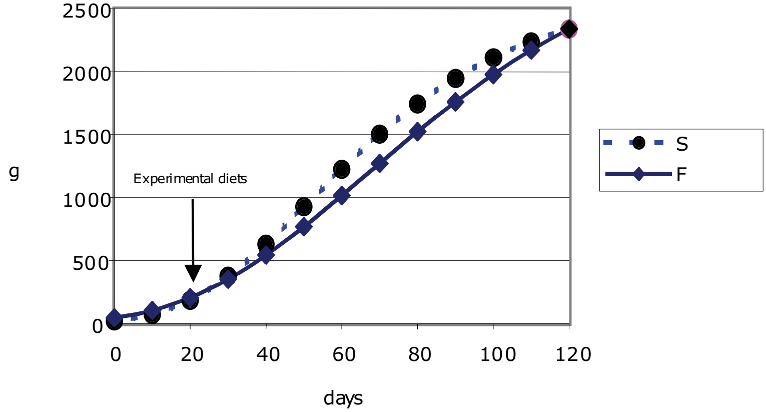
*S: soybean; F: faba bean.*
*n=400;*=P< 0.05; **=P<0.001; ns: not significant.*

Table 3. Influence of protein sources on the feed intake, daily weight gain and feed efficiency of the chickens.

| | | Diet | | Pooled SE |
|---|---|---|---|---|
| | | S | F | |
| Feed intake: | | | | |
| 1-20 d | g/d | 12.5 | 12.2 | 2.0 |
| 21-40 d | " | 48.9 | 45 | 3.2 |
| 41-60 d | " | 85.4 | 79.8 | 7.3 |
| 61-80 d | " | 108.9 | 104 | 14.1 |
| 81-100 d | " | 115.4 | 110.5 | 8.7 |
| 101-120 d | " | 108.9 | 102.3 | 10.2 |
| Daily weight gain: | | | | |
| 1-20 d | g/d | 8.3 | 8.7 | 1.8 |
| 21-40 d | " | 22.1$^{b}$ | 17.9$^{a}$ | 2.5 |
| 41-60 d | " | 29.1$^{b}$ | 24.5$^{a}$ | 1.8 |
| 61-80 d | " | 26.2 | 25.9 | 4.0 |
| 81-100 d | " | 23.4 | 24.0 | 3.2 |
| 101-120 d | " | 18.9 | 19.8 | 2.3 |
| Feed efficiency: | | | | |
| 1-20 d | g/d | 1.5 | 1.4 | 0.2 |
| 21-40 d | " | 2.2$^{a}$ | 2.6$^{b}$ | 0.6 |
| 41-60 d | " | 2.9$^{a}$ | 3.3$^{b}$ | 0.6 |
| 61-80 d | " | 4.2 | 4.0 | 1.1 |
| 81-100 d | " | 4.9 | 4.6 | 1.2 |
| 101-120 d | " | 5.7 | 5.4 | 1.4 |

*S: soybean; F: faba bean.*
*n=400; a,b=P<0.05.*

Figure 1. Growth curve of control and faba bean fed chickens.




*S: soybean diet; F: faba bean diet.*

Table 4. Carcass characteristics of organic broilers fed with different growing-finisher diets.

| | | Diet | | Sex | | Significance | | Pooled SE |
|---|---|---|---|---|---|---|---|---|
| | | S | F | M | F | Diet | Sex | |
| Eviscerated carcass (EC) | g | 2097 | 2018 | 2225 | 1890 | ns | ** | 161 |
| Dressing out | EC/LW | 81.2 | 82.1 | 80.4 | 83.1 | ns | ** | 2.8 |
| Refrigeration losses | % | 0.13 | 0.12 | 0.13 | 0.12 | ns | ns | 0.02 |
| Gastro-intestinal tract | " | 11.52 | 11.58 | 11.60 | 11.50 | ns | ns | 1.81 |
| Gastro-intestinal content | " | 5.84 | 5.85 | 5.90 | 5.79 | ns | ns | 0.15 |
| Abdominal fat | | 1.00 | 1.10 | 1.00 | 1.12 | ns | ns | 0.10 |
| Ready-to-cook carcass (RCC) | g | 1589 | 1531 | 1715 | 1405 | * | ** | 150 |
| Dressing out | RCC/LW | 0.62 | 0.62 | 0.62 | 0.62 | ns | ns | 1.81 |
| Breast yield | % RCC | 16.00 | 16.20 | 15.40 | 16.80 | ns | * | 2.15 |
| Thigh yield | " | 17.20 | 17.20 | 17.70 | 16.70 | ns | * | 0.31 |
| Biometric measurements: | | | | | | | | |
| Tibia length | cm | 14.10 | 14.30 | 14.50 | 13.90 | ns | * | 0.41 |
| Sternum | " | 13.80 | 13.80 | 14.20 | 13.40 | ns | * | 1.11 |
| Carena | " | 11.18 | 10.60 | 11.20 | 10.56 | * | * | 0.36 |
| Rostrum | " | 2.77 | 2.75 | 2.92 | 2.60 | ns | * | 0.22 |
| Breast width | " | 5.90 | 5.90 | 6.00 | 5.80 | ns | ns | 0.84 |
| Breast layer thickness | " | 2.20 | 2.20 | 2.30 | 2.10 | ns | ns | 0.34 |
| Meat-to-bone ratio | | 2.94 | 2.96 | 2.85 | 3.05 | ns | ns | 0.49 |

*S: soybean; F: faba bean.*
*n=160;*=P< 0.05; **=P<0.001; ns: not significant.*

tional requirements of the birds were met by a soybean-based starter diet, the successive compensatory growth, occurring after 81 days of age, was able to reach similar slaughter weights (Figure 1).

Moschini *et al*. (2005) showed that 479 g/kg of raw faba bean did not have any negative effects on DWG and FE during the growing period (1-21) of conventionally reared Ross chickens. It is important to emphasize that in their trial supplementation of synthetic amino acids was carried out, while in our experiment synthetic amino acids were absent since they are not allowed by organic rules.

Regarding carcass traits (Table 4), the diet affected only the RCC percentage and the carena length, both of which were higher in S birds. Sex showed a strong effect on most of the carcass traits, including the eviscerated carcass, dressing out, ready-to-cook carcass, breast and thigh yields as well as the biometric measurements, due to the pronounced sexual dimorphism which in slow-growing birds is more pronounced (Fanatico *et al.*, 2005). In chickens fed 500 g/kg of raw or extruded faba bean (Diaz *et al.*, 2006) observed a higher breast meat percent yield with respect to the standard diet independent of processing.

## Conclusions

Data obtained in this experiment prove the effectiveness of the faba bean (*Vicia faba* var. *minor*) in poultry diets as a protein source as partial substitute for soybean. Chickens fed a growing-finisher diet containing faba beans as a partial substitute for soybean, after a transition period of lower DWG, showed compensatory growth in the later period, reaching a final live weight similar to the S group and reducing the diet-dependent differences in the carcass traits. Thus the F diet without synthetic amino acids, if administered after a starter period, is able to meet the requirement of slow-growing birds.

This study was supported by the E.QU.I.ZOO. BIO project (Efficiency, Quality and Innovation in Organic Livestock).

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