Treated fava bean (*Vicia faba* var. minor) as substitute for soybean meal in diet of early phase laying hens: Egg-laying performance and egg quality

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ABSTRACT The objective of this study was to determine the effect of dietary dehulled-micronized fava bean (*Vicia faba* var. minor) seed on egg production, egg weight, feed conversion ratio, eggshell quality, and egg yolk color. In this trial, 18-wk-old laying hens in the early phase of production (ISA Brown) were randomly assigned to 2 groups and fed durum wheat middlings-based diets containing soybean or micronized-dehulled fava bean meal as the main protein source. Eggs were collected and weighed daily. Laying performance, egg quality, and feed conversion ratio were evaluated for 10 wk. The only significant effect detected was for feed intake ($P < 0.05$), which was lower in hens fed the diet containing fava bean than for hens fed soybean meal, without however any negative effects on feed efficiency. None of the egg quality parameters studied were influenced by dietary treatment, except for yolk color score that was reduced in hens fed the fava bean diet ($P < 0.05$). We conclude that dehulled-micronized fava beans in the diet did not have a negative influence on productive performance or egg quality of young brown hens.

Key words: laying hen, fava bean, egg performance, egg quality

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INTRODUCTION

The use of meat-bone meal and its by-products in diets for livestock was banned in 2001 by the European Commission (EC directive 999/2001) to guarantee consumer safety with consumption of animal products. Soybean is the most commonly used protein source in poultry diets and is usually known for its high quality. Because soybean meal is the major by-product of oil extraction from soybeans, costs and availability of soybean meal are strongly correlated with the price of agricultural commodities on the world market (Vicenti et al., 2009; Jezierny et al., 2010). World market prices are influenced by variations in economic growth and changes in consumer product preferences and on weather conditions (Trostle, 2008; Jezierny et al., 2010). Therefore, price and availability of soybean meal on global markets may change rapidly, thereby stimulating interest in maximizing the use of locally produced feed ingredients including grain legumes (Ravindran and Blair, 1992).

The use of alternative legume sources such as fava bean (*Vicia faba* var. minor) in poultry feed has been hampered due to the presence of secondary plant metabolites particularly in hulls. These include the pyrimidine glcosides vicine and convicine (Vilariño et al., 2009). Due to considerable progress in plant breeding, the level of secondary plant metabolites present in fava bean has been notably decreased, resulting, for example, in the development of zero-tannin fava bean cultivars (Duc et al., 1999).

Furthermore, processing procedures (e.g., dehulling and micronization) have been developed to eliminate or inactivate antinutritive substances from fava bean and alter starch structure to improve the nutritive value of seeds for poultry (Lacassagne et al., 1988; Longstaff and McNab, 1991; Igbasan and Guenter, 1997). Micronization in particular is useful to improve nutrient value and protein utilization in poultry. Microninization is a dry-heat process using short infrared radiation produced by burning propane over ceramic tiles or nichrome wire elements to heat grains (Douglas et al., 1991). Mwangwela et al. (2007) and Laudadio and Tufarelli (2010) recently reported that micronization improved the nutritive value and increased the protein content of legume ingredients for growing broiler chicks. Thus, there is a need to reevaluate currently available cultivars of fava bean to optimize their utilization as a locally produced feed component of high nutritional value in diets for poultry. There is a paucity of available information on the use of micronization to enhance

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Table 1. Composition and chemical analysis of experimental diets

Item	Diet	
	Soybean	Fava bean
Ingredient, g/kg (as-fed basis)		
Durum wheat middlings	705.5	615.0
Soybean meal (48% CP)	150.0	—
Fava bean	—	240.0
Calcium carbonate	90.0	90.0
Soybean oil	20.0	20.0
Dicalcium phosphate	17.0	16.0
Vitamin-mineral premix[1]	5.0	5.0
L-Lys HCl	3.2	4.5
Sodium chloride	2.5	2.5
Sodium bicarbonate	2.5	2.5
DL-Met	1.3	3.5
Choline chloride	1.0	1.0
Yeast	1.0	1.0
Enzyme[2]	1.0	1.0
Chemical analysis, g/kg		
DM	902.5	903.1
CP	178.8	179.2
Crude fiber	28.8	27.9
Crude fat	40.9	40.2
Ash	126.9	128.1
Calculated analysis		
ME, MJ/kg of diet	11.2	11.1
Lys, %	0.90	0.91
Ca, %	4.02	4.04
Met + Cys, %	0.65	0.67
Available P, %	0.37	0.37
Antinutritional factor, %		
Vicine	—	0.01
Convicine	—	0.04
Fatty acid,[3] %		
Σ SFA	30.35	33.53
Σ MUFA	34.39	27.23
Σ PUFA	34.32	38.29
Total n-6	32.63	39.09
Total n-3	1.59	1.10

[1]Provided the following per kilogram of product: 2,500 IU of vitamin A, 300,000 IU of vitamin D_3, 7,500 μg of 25-hydroxycholecalciferol, 6,000 mg of vitamin E, 500 mg of vitamin K_3, 4,000 mg of vitamin PP, 300 mg of vitamin B_1, 1,000 mg of vitamin B_2, 2,000 mg of D-pantothenic acid, 400 mg of vitamin B_6, 3 mg of vitamin B_{12}, 150 mg of folic acid, 20 mg of D-biotin, 10,000 mg of Fe, 1,000 mg of Cu, 30,000 mg of Mn, 40 mg of Co, 15,000 mg of Zn, 200 mg of I, 20 mg of Se, and 50 mg of canthaxanthin.

[2]Provided the following per kilogram of product: endo-1,4-β-glucanase, 800,000 U; endo-1,3(4)-β-glucanase 1,800,000 U; and endo-1,4-β-xylanasem, 2,600,000 U.

[3]SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

the nutritive value of fava beans. Therefore, this study was aimed at investigating the potential enhancement of this raw material for layers.

MATERIALS AND METHODS

Experimental Design and Diets

A total of 100 ISA Brown pullets, 18 wk of age with an initial BW of 1,516 ± 8.3 g, were housed in colony layer cages at 2 birds per cage. The cages were equipped with a nipple drinker and trough feeders. The hen house was provided with programmable lighting and adequate ventilation. The lighting program at the start of the trial was 14 h of light and was increased by 15 min each week to 16 h of light.

The diets were formulated to be isocaloric (11.2 MJ of ME/kg) and isonitrogenous (18% CP) and to meet or exceed NRC (1994) nutrient requirements for laying hens. Ingredient and diet analysis, according to the Association of Official Analytical Chemists (AOAC, 2000) procedure, are reported in Table 1. The extraction and purification of vicine and convicine in diets were carried out by the reference HPLC method adapted according to Duc et al. (1999). Lipid extraction was performed on diets according to Hara and Radin (1978), whereas the transesterification of the fatty acids was carried out according to Christie (1982), with the modifications described by Chouinard et al. (1999).

Soybean treatment (control diet) was a practical wheat middlings-soybean meal laying hen diet, whereas the fava bean diet was formulated to contain 24% of dehulled-micronized fava beans (*Vicia faba* var. minor cv. Prothabat, 36% CP and 2.6 of crude fiber), which replaced soybean meal. Locally grown fava bean seeds used in diet formulation were tempered overnight to the preferred moisture content as recommended by Khattab et al. (2009) using distilled water. Tempered seeds were heated to 130°C using a small experimental benchtop micronizer composed of a tubular quartz infrared lamp (115 V) with a tungsten wire filament enclosed in a ceramic casing (Research Inc., Eden Prairie, MN). Processing times for fava beans were 1.5 min. Dehulling was accomplished with the aid of a roller mill and the hulls were separated from the cotyledons by air separation. Each diet was randomly replicated 5 times with 10 birds per replicate. The diets were presented in pellet form and feed and water were provided ad libitum throughout the experiment. The duration of the experiment was 10 wk (between 18 and 28 wk of age).

Hen and Egg Parameters

Laying hens' BW were obtained at the start and end of the experiment. Eggs were collected daily and egg production was calculated on a hen-day basis. Eggs with any adhering manure were classed as dirty, and the percentage was calculated. Feed intake was recorded weekly by replicate. Feed conversion ratio (**FCR**) was calculated as grams of feed per gram of egg. Mortality was recorded as it occurred.

Eggs produced on the last day of each week of the trial were individually weighed and graded as described by the European Council Directive (2006). The categories recorded for egg size were extra large (>73 g), large (63 to 73 g), medium (53 to 63 g), and small (<53 g). Eggs were examined for interior and exterior quality. The eggs were examined for shell quality by specific gravity. Shell thickness (with shell membrane) of the eggs was measured by micrometer. Shell thickness was a mean value of measurements at 3 locations on the eggs (air cell, equator, and sharp end). Breaking strength of uncracked eggs was measured with a tensile

Table 2. The effect of experimental diets on laying hens' BW, feed conversion ratio, egg production, and egg weight

	Diet			
Item	Soybean	Fava bean	SEM	*P*-value
Initial BW, g	1,502	1,524	9.31	0.601
Final BW, g	1,855	1,869	13.78	0.212
ADFI, g	107.1	105.5	0.71	0.045
Feed conversion ratio, g of feed/g of egg	1.98	2.02	0.03	0.073
Egg production, %	80.67	78.11	0.79	0.097
Egg weight, g	55.7	54.1	0.49	0.112
Mortality,[1] %	3	5	—	0.098

[1]Number of dead laying hens during 10 wk of experimental period.

testing machine (model 1140, Instron Ltd., Bucks, UK). The components of egg (albumen, yolk, and shell) were measured by weekly breakouts on 2 eggs per replicate pen and expressed as percentage of egg weight. Haugh unit was determined and yolk color was evaluated by the Roche yolk color fan (Hoffman-La Roche Ltd., Basel, Switzerland; 15 = dark orange; 1 = light pale).

Statistical Analysis

The ANOVA was performed on the data as a randomized complete block design using the repeated measures analysis (PROC MIXED; SAS Institute, 2000), and means were compared by the Student-Newman-Keuls method when appropriate (SAS Institute, 2000).

RESULTS AND DISCUSSION

In Table 2 is reported the effect of diet containing dehulled-micronized fava bean on the BW, ADFI, FCR, egg production, and egg weights in laying hens. The diet supplemented with fava bean had no significant effects on BW. Inclusion of the alternative protein source at our level of 24% in the diet significantly ($P < 0.05$) influenced feed consumption, without any negative effect on feed efficiency ($P = 0.073$) compared with the control diet.

Previous data regarding the effects of dietary fava bean on BW, feed intake of laying hens, and FCR are inconsistent. In a study, Fru-Nji et al. (2007) showed that dietary fava bean, at different inclusion levels, had no significant effect in feed intake of laying hens, but FCR was significantly increased by fava bean inclusion. However, other studies showed that addition of fava bean seeds into the diet significantly affected BW and feed intakes of the pullets (Brufau et al., 1998; Perez-Maldonado et al., 1999). Because increase in body mass of laying hens was negatively correlated with egg production, stability of body mass in layers fed diets supplemented with fava bean can be considered a favorable factor in increasing egg production as observed by Aydin et al. (2008). The results of the present study showed that supplementation of the diet with fava bean did not negatively influence BW changes of the laying hens and a dehulled-micronized fava bean diet led to a better feed utilization. Such factors include nutrient content, house temperature, production rate, egg size, and BW. The suggested feed consumption rate for the ISA Brown strain of layers under normal field conditions, using an energy-adequate diet, was also met. The determination of feed efficiency is perhaps the single main indicator used in economic assessment of egg production in layers. Feed efficiency values were in accordance with findings obtained in other trials where common vetch (*Vicia sativa*) and blue lupin (*Lupinus angustifolius*) were used as protein supplements in layer diets (Farran et al., 2001; Hammershøj and Steenfeldt, 2005).

Hen production (%) was statistically similar ($P = 0.097$) for all hens on the experimental diets at 80.67 in hens on the soybean diet and 78.11 in hens on the fava bean diet, indicating uniformity in the laying pattern and quantity of eggs laid by the hens fed the alternative protein source. It has been suggested that dietary inclusion of treated fava bean meal increased blood flow to the ovaries, thereby leading to more ovarian follicle formation, which ultimately increased egg production (Fasuyi et al., 2007).

Egg weight was also statistically similar ($P = 0.112$) among experimental hens, at 55.7 or 54.1 g for hens fed a soybean or fava bean diet, respectively. The trend for increased egg weight for hens fed fava bean diets appears to be associated with a significant increased percentage of albumen ($P = 0.039$), which was greater for the fava diet than for the control soybean diet. The average weight of the eggs also compared favorably with values reported for layers in the available literature (Castanon and Perez-Lanzac, 1990; Fru-Nji et al., 2007). The only significant difference observed was for the percentage of large eggs (63 to 73 g) from 18 to 28 wk of age, which was greater for hens fed the soybean control diet than for hens fed the fava bean diet (61.2 vs. 58.1%; $P < 0.05$).

Dietary treatment did not negatively affect any trait related to egg or shell quality (Table 3). The overall values obtained in the present study are optimal for this age of hens (18 to 28 wk) in phase I of production. Conversely, studies in the past, on other legume-based diets fed to hens, have reported that fava bean supplementation can have a negative effect on egg qual-

Table 3. The effect of experimental diets on the egg parameters

Item	Diet		SEM	*P*-value
	Soybean	Fava bean		
Egg component, %				
Yolk	24.2	23.7	0.13	0.115
Albumen	64.9	66.1	0.15	0.039
Shell	10.9	10.2	0.04	0.154
Shell thickness, mm·10^{-2}	0.32	0.32	0.02	0.313
Shell strength, kg/cm^2	1.61	1.64	0.13	0.232
Broken + shell-less eggs, %	0.17	0.18	—	0.365
Dirty eggs, %	0.28	0.30	—	0.156
Yolk color score	12.22	11.78	0.49	0.041
Haugh unit	86.4	85.5	1.21	0.097
Egg grade, %				
>73 g	4.2	3.8	0.98	0.085
63 to 73 g	61.2	58.1	1.11	0.041
53 to 63 g	33.2	36.4	1.23	0.118
<53 g	1.4	1.7	0.41	0.203

ity (Brufau et al., 1998). However, this may be related to the presence of antinutritional factors in fava bean, minimized in the present study by the processing effect of dehulling and micronization, as found also in peas seeds by Laudadio and Tufarelli (2010). In fact, a combination of processing effects has been reported to be effective in reducing the levels of antinutrients in different feeds (Bellido et al., 2006).

The shell thickness and strength also had similar mean values ($P > 0.05$) among dietary treatments, indicating a similar relative density for the eggs. Moreover, the Haugh unit values were similar ($P > 0.05$) for the eggs laid by the experimental laying birds. The average values of this egg quality parameter conformed to data reported for standard commercial egg production guides and other available literature (Ravindran and Blair, 1992). Egg yolk color score was reduced when fava beans were incorporated instead of soybean into the diet of layers (11.78 vs. 12.22, respectively; $P = 0.041$). The influence of legumes on yolk color observed in this study may be related to the quantity of xanthophylls in fava beans, but at present, there is no information on the xanthophyll content of this protein source. Previous work (Igbasan and Guenter, 1997) showed a progressive influence in yolk color as the level of legumes (e.g., peas) in the laying hen diet was increased.

In conclusion, fava beans can be included in standard laying hen diets with neither a significant reduction in production nor the quality of the eggs. Furthermore, these findings indicate that dietary inclusion of dehulled-micronized fava beans may be the most economically effective for egg production.

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