Use of faba beans (*Vicia faba* L.) in diets of laying hens

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The study was conducted to evaluate an appropriate inclusion level of locally produced unprocessed or expander-processed coloured flowered faba bean (FB) (cv. 'Kontu') seeds in diets for laying hens. Egg production and egg quality variables were determined with 560 hens (Lohmann Selected Leghorn, LSL Classic) in a 40-week continued experiment. The hens were fed one of the five diets containing soybean meal as the main protein source. A diet without FB was served as a control diet. Both unprocessed and expander-processed FB was tested either in proportions of 50 g kg^{-1} or 100 g kg^{-1} in the diet. Faba bean inclusion (control vs. FB diets) had no effect on the egg production rate, egg mass production, feed consumption, or feed conversion ratio, but it decreased egg weight (p<0.05). Dietary FB inclusion tended to increase the mortality of the hens (p<0.10). Faba bean processing had no effects on egg production parameters or hen mortality. Daily egg mass production decreased and feed conversion ratio increased when FB proportion increased (from 50 to 100 g kg^{-1}, p<0.05). Faba bean inclusion had no effects on egg exterior quality. It can be concluded that 50 g kg^{-1} of the FB studied (cv. 'Kontu') can be used in the diets of laying hens (LSL Classic) without negative effects on production performance or livability.

Key words: egg production, faba bean, feed processing, health, laying hen

Introduction

Soybean is the most commonly used protein source in poultry diets in Europe (Laudadio and Tufarelli 2010). Because soybean meal (SBM) is a by-product of oil extraction from soybeans, the cost of SBM depends on the price of agricultural commodities on the world market. These prices are influenced by changes in economic growth, consumer product preferences, and weather conditions (Jezierny et al. 2010). Soybean prices are highly volatile, but an upward trend is detectable. Furthermore, the supply of non-genetically modified soybeans is diminishing and thus the relating premiums are increasing. As a result, there is an interest to maximise the use of other- and especially locally produced protein sources. Faba bean (*Vicia faba L.*) (FB) is a protein-rich legume and adapted to most climatic areas of Europe. FB's low fertiliser requirements and its capacity to return nitrogen to the soil make it an ecosystem-serviced crop (Jensen et al. 2010). Faba bean is a good source of lysine, but sulphur containing amino acids methionine and cysteine are present at low levels in the protein of FB (Gatel 1994). In addition, the digestibilities of these amino acids have often been found to be low in FB (Brufay et al. 1998). The use of FB in diets for non-ruminants is restricted due to its content of anti-nutritional factors (ANF) (Crépon et al. 2010). Dehulling and heat treatment are recommended to allow a maximum inclusion level of FB in laying hen diets (Marquardt et al. 1973). Unlike most of the ANF, vicine and convicine (V+C) located in the cotyledons in FB are heat-stable (Crépon et al. 2010), and therefore they cannot be easily removed through technological or chemical processes (Dvořák et al. 2006). Crépon et al. (2010) summarised, that the use of FB with a high V+C content cannot exceed 70 g kg^{-1} of the diet, but it is possible to include FB at up to 200 g kg^{-1} if the cultivar used has a low V+C content. There is a need to evaluate the optimal inclusion levels of locally cultivated FB cultivars in the diets of laying hens.

The objective of this study was to find an appropriate inclusion level of locally produced unprocessed or expander-processed coloured flowered FB seeds (cv. 'Kontu') in diets of laying hens. The study further aimed to examine the effects of FB on the livability of the hens, and the hens' egg quality variables. In addition, the content of V+C present in studied unprocessed or expander-processed FB cultivar was studied.

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Materials and methods

Experimental animals and treatments

A total of 560 39-week-old Leghorn chicken (Lohmann Selected Leghorn, LSL Classic) were assigned to 5 different dietary treatments. A diet based on cereal and SBM served as the control diet (Table 1). Both unprocessed and expander-processed coloured flowered FB seeds (cv. 'Kontu') were tested in proportions of 50 g kg^{-1} and 100 g kg^{-1} of feed. The hens were housed in enriched (furnished) cages (TAPE, Triotec Oy, Koski TL, Finland). The dimensions of cages were 120 cm × 50 cm × 48 cm (width × depth × height) and 8 hens were housed per cage, providing 750 cm^2 of total cage area per hen. Layers were assigned to 35 feeding replicates with 2 cages per replicate (yielding 7 replicates per treatment). The duration of the experiment was 40 weeks and it comprised ten 4-week periods. During the trial, the day length was 14.5 hours and the temperature was kept at 20 °C.

There were two 20-week feeding phases. In the second feeding phase, the diets had more calcium, better suited to the latter half of the laying phase. The diets within the feeding phases were formulated to contain equal amounts of nutrients per MJ of apparent metabolizable energy (AME) and meet the nutrient requirements of LSL Classic hens (Lohmann 2010). The nutrient content of diets were equalised with rapeseed oil, amino acids, monocalcium phosphate and limestone. The energy values (MJ AME per kg) were based on the feed values of feed ingredients published in the Finnish Feed Tables and Nutrient Requirements (MTT 2014). The processed FB seeds were expanded at 90–110 °C (5–20 bar, conditioned at 70–80 °C). All grain ingredients, including FB, were ground in a roller mill (Gehl Company, West Bend, Wisconsin, USA). The feeds were mixed and steam-pelleted (Kahl 33–50, Amandus Kahl GmbH & Co. KG, Hamburg, Germany). The pellet diameter was 4 mm. In the hen house a chain feeder supplied the feed, and nipple drinker lines supplied water. Feed and water were available ad libitum throughout the experiment.

Analytical and experimental procedures

Feed samples were taken from every batch made and then pooled. The pooled samples were passed through a hammer mill fitted with a 1-mm mesh for analysis. The crude fat and ash contents were determined by standard methods (AOAC 1990). The crude fibre content was determined with a modified method (AOAC method 962.09) using glass wool instead of a ceramic fiber filter. The nitrogen content was analysed using a Leco FP 428 nitrogen analyser (Leco Corporation, St. Joseph, MI). The crude protein content was calculated by multiplying the nitrogen content by 6.25. The content of V+C in FB samples was determined using high-performance liquid chromatography (HPLC) according to Quemener (1988).

Egg weight and number were recorded daily, and the mean production variables were calculated for each 4-week period. Mortality was recorded daily. Cumulative mortality was calculated at the end of the experiment. The Finnish Food Safety Authority diagnosed the cause of death and performed autopsies on one hen per replicate euthanized (by cervical dislocation) after experiment. The hens were weighed at the age of 40-, 59-, and 79 weeks.

Egg quality was examined when the birds were 53- and 74 weeks old. The egg quality variables: specific weight, shell strength, Haugh units, and shell thickness were measured in 8 eggs per replicate. The assessment of the specific gravity of eggs was based on Archimedes' principle. The mass of the water (22 °C) displaced by each egg was weighed by placing the egg in a wire basket. The basket was supported from the outside in a water bowl that was on a scale. Specific gravity was calculated as the quotient of the egg mass and the mass of the water displaced by the egg. The shell-breaking force was measured as compressive fracture force using an eggshell tester (OTAL Precision Company Limited, Ottawa, ON, Canada). Albumen height was measured with a digital tripod micrometre (York Electronic Centre, Technical Services and Supplies Limited, York, England) and converted to Haugh units.

Statistical analyses

Production performance data were subjected to repeated-measures ANOVA using the GLM procedure of SAS (SAS Institute Inc., Cary, NC, USA) and the following model: $Y_{ijk} = \mu + t_i + \delta_i + p_j + (p \times t)_{ij} + \varepsilon_{ijk}$, where Y_{ijk} = observation, μ = the general mean, t_i = the effect of the treatment (i = 1, …,5), δ_i = the error term for the effect of the treatment i, p_j = the effect of the period (j= 1,…,10), and ε_{ijk} = the experimental error term. The egg quality variables and live weight were analysed using the following model: $Y_{ij} = \mu + t_i + \varepsilon_{ik}$, where Y_{ij} = observation, μ = the general mean, t_i = the effect of the treatment (i = 1, …,5), and ε_{ijk} = the experimental error term. The treatment effects were separated into four orthogonal contrasts as follows: Effect of FB, control (SBM) treatment vs. FB treatments; Effect of processing (P), unprocessed FB vs. processed FB; Effect of FB inclusion level (L), FB content of 50 g kg^{-1} feed vs. FB content of 100 g kg^{-1} feed; and the interaction of processing and FB inclusion level (P × L). In cases where interactions between processing and FB level were noted ($p<0.10$), the effect were further tested within each four level of the factor (effect of processing at both inclusion level and effect of inclusion level of both FB type). In the current study, $p<0.05$ was considered to be significant and $p<0.10$ tended to be significant.

Results

Table 1 presents composition and calculated and analysed chemical composition of the experimental diets. The crude protein content of expander-processed FB was lower than that of unprocessed FB (Table 2). The crude protein content of SBM was clearly higher than that of unprocessed or expander-processed faba beans. The V+C content in unprocessed and processed FB were similar.

FB inclusion tended to increase the cumulative mortality of hens throughout the entire experiment ($p<0.10$) (Table 3). The mortality of the hens fed unprocessed FB increased with increasing inclusion level ($p<0.05$), whereas the mortality of hens fed expander-processed FB remained the same. During the latter half of the laying phase the mortality was lower in the unprocessed FB treatments compared with the processed FB treatments ($p<0.01$).

Based on the amount of abdominal adipose tissue present, the euthanized (one hen per replicate) sample hens were obese and in a few cases hens had fatty livers indicating that hens may have been received too much energy from the experimental diets. All the sample hens were in lay. There was no evidence that the mortality among hens fed by FB was caused by FB inclusion, and no specific reason for mortality was observed among deceased hens.

During the entire and early part of the trial an increase in unprocessed FB inclusion level (50 g kg^{-1} vs. 100 g kg^{-1} feed) reduced the egg production rate (%), but the same effect was not observed with expander-processed FB (processing × inclusion level, $p<0.10$ and $p<0.10$). The only significant effect of FB supplementation compared to the control diet was in egg weight (g), which was lower in hens fed diets containing FB during the entire and latter part of the trial ($p<0.05$ and $p<0.01$). The increase in FB level reduced egg weight with expander-processed FB but not with unprocessed FB during the entire and early part of the trial (processing × inclusion level, $p<0.05$ and $p<0.05$). FB had no effect on egg mass production and unprocessed FB only tended to reduce egg mass production during the early part of the trial ($p<0.10$). Egg mass production (production, g per hen per d) decreased when the FB inclusion level increased from 50 to 100 g kg^{-1} feed during the entire ($p<0.01$), early ($p<0.01$) and latter ($p<0.10$) part of the trial. Feed consumption rates (g per hen per d) were similar in all the treatments. Feed conversion ratio (FCR) (g of feed per g of egg) was impaired when the FB inclusion level increased (50 g kg^{-1} vs. 100 g kg^{-1} feed) during the entire ($p<0.05$) and early ($p<0.01$) part of the trial. FCR of the hens fed unprocessed FB was lower than that of the hens fed processed FB during the early part of the trial ($p<0.05$). Increase in FB inclusion level (50 g kg^{-1} vs. 100 g kg^{-1} feed) increased FCR with unprocessed FB but not with expander-processed FB during the latter part of the trial (processing × inclusion level, $p<0.10$). The egg quality variables studied (specific weight, shell strength, Haugh units, and shell thickness) were similar in all the treatments (Table 4). Dietary treatments had no effects on hen live weights (data not shown).

Table 2. Analysed chemical composition of soybean meal and unprocessed and expander-processed FB (g kg^{-1} of DM), except DM[1].

	SBM[2]	FB[3], unprocessed	FB[3], expander-processed
DM, g kg [1]	887	890	881
Crude protein	538.0	302	285
Crude fat	26.2	22.7	21.5
Crude fibre	43.8	93.9	95.5
Ash	70.0	37.2	48.3
Nitrogen-free extract	322.0	544.2	549.7
Vicine and convicine	-	10.6	8.9

[1] based on single analysis DM: dry matter
[2]SBM: soybean meal
[3]FB: faba bean

Table 1. Composition (g kg^{-1}) and calculated and analysed chemical composition of the experimental diets (g kg^{-1} DM), except DM and AME.

	Control	Experimental diets (39–59 weeks of age)				Control	Experimental diets (59–79 weeks of age)			
		Unprocessed FB 50 g kg^{-1}	Processed FB 50 g kg^{-1}	Unprocessed FB 100 g kg^{-1}	Processed FB 100 g kg^{-1}		Unprocessed FB 50 g kg^{-1}	Processed FB 50 g kg^{-1}	Unprocessed FB 100 g kg^{-1}	Processed FB 100 g kg^{-1}
Barley	259	248	248	238	238	274	263	263	253	253
Wheat	214	206	206	197	197	227	218	218	210	210
Oats	214	206	206	197	197	227	218	218	210	210
Soybean meal	170	146	145	122	122	140	116	116	92.6	92.6
Faba bean, unprocessed	-	50	-	100	-	-	50	-	100	-
Faba bean, processed	-	-	50	-	100	-	-	50	-	100
Rapeseed oil	24.0	25.5	25.5	26.8	26.8	12.0	13.2	13.2	14.9	14.9
Monocalcium phosphate	14.5	14.5	14.5	14.5	14.5	14.0	14.0	14.0	14.0	14.0
Limestone	93.8	93.8	93.8	93.8	93.8	95.5	95.5	95.5	95.5	95.5
Salt	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Mineral premix[1]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Vitamin premix[2]	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Methionine	1.4	1.5	1.5	1.6	1.6	1.0	1.2	1.2	1.3	1.30
Lysine	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	-	-
Threonine	-	0.1	0.1	0.3	0.3	-	0.1	0.1	0.3	0.3
Calculated composition										
MJ AME per kg	10.7	10.7	10.7	10.7	10.7	10.5	10.5	10.5	10.5	10.5
Crude protein	156	156	156	156	156	149	149	149	149	149
Lysine	7.66	7.65	7.65	7.66	7.66	6.87	6.88	6.88	6.87	6.87
Methionine	3.83	3.82	3.82	3.83	3.83	3.83	3.82	3.82	3.83	3.83
Methionine + cysteine	6.98	6.90	6.90	6.84	6.84	5.83	5.83	5.83	5.83	5.83
Threonine	5.69	5.69	5.69	5.68	5.68	5.31	5.31	5.31	5.31	5.31
Calcium	39.0	39.0	39.0	39.0	39.0	39.5	39.5	39.5	39.5	39.5
Phosphorus (available)	3.58	3.58	3.58	3.59	3.59	3.46	3.47	3.47	3.47	3.47
Analysed composition										
DM, g kg^{-1} 35 – 55 wk	893	905	908	904	904	912	910	912	911	912
Crude protein	177	173	171	174	170	144	145	144	146	148
Crude fat	52.9	61.1	59.5	60.6	61.4	44.5	45.3	45.6	46.1	46.0
Crude fibre	48.3	50.5	44.2	60.4	54.3	48.5	41.1	48.0	51.6	48.9
Ash	135	147	145	145	148	148	133	147	142	143

AME: apparent metabolisable energy, DM: dry matter, FB: faba bean

[1] Providing the following per kg of feed: Ca 0.6 g, Fe 25 mg, Cu 8 mg, Mn 50 mg, Zn 65 mg, I 0.5 mg, Se 0.2 mg

[2] Providing the following per kg of feed: Ca 1.3 g, vitamin A 12.950 IU (retinol), vitamin D_3 2.960 IU, vitamin E 33.3 mg (α-tokopherol 30.3 mg), vitamin K_3 5.7 mg, vitamin B_1 2.6 mg, vitamin B_2 5.7 mg, vitamin B_6 4.0 mg, vitamin B_{12} 0.02 mg, biotin 0.2 mg, folic acid 0.7 mg, niacin 45.5 mg, pantothenic acid 11.4 mg, canthaxanthin 3.1 mg.

Table 3. The effects of faba bean dietary inclusion level on laying hen egg production variables.Values are means of 7 observations per treatment and they represent the means of the values of 5 or 10 periods (4 weeks each).

	Control	Faba bean inclusion Unprocessed FB[1] 50 g kg^{-1}	Processed FB 50 g kg^{-1}	Unprocessed FB 100 g kg^{-1}	Processed FB 100 g kg^{-1}	SEM	Statistical significance (P-values) FB	P[3]	L[4]	P × L[5]
Egg production rate, %										
39–79 week of age	90.0	91.4	90.9	88.0	90.9	0.85	0.796	0.181	0.055	0.051
39–59 week of age	93.6	94.7	94.1	91.1	94.0	0.88	0.856	0.193	0.048	0.059
59–79 week of age	86.4	88.2	87.6	84.9	87.8	1.03	0.562	0.270	0.136	0.104
Egg weight, g										
39–79 week of age	66.1	64.6	65.7	65.1	64.3	0.46	0.028	0.751	0.283	0.049
39–59 week of age	65.3	64.0	65.7	64.4	63.6	0.52	0.148	0.410	0.106	0.026
59–79 week of age	67.0	65.2	65.8	65.8	65.0	0.44	0.004	0.759	0.743	0.132
Egg mass production, g per hen per d										
39–79 week of age	59.5	59.0	59.7	57.2	58.4	0.55	0.160	0.108	0.008	0.640
39–59 week of age	61.1	60.6	61.8	58.6	59.8	0.68	0.237	0.092	0.007	0.979
59–79 week of age	57.8	57.5	57.6	55.8	57.0	0.59	0.200	0.281	0.056	0.364
Feed consumption, g per hen per d										
39–79 week of age	114.5	114.3	116.9	122.4	116.6	3.03	0.370	0.614	0.207	0.176
39–59 week of age	115.8	115.9	114.1	122.2	115.3	2.54	0.716	0.100	0.154	0.317
59–79 week of age	113.1	112.7	119.7	122.6	118.0	3.68	0.223	0.741	0.276	0.125
FCR[2], g of feed per g of egg										
39–79 week of age	1.93	1.94	1.97	2.14	2.00	0.053	0.166	0.312	0.030	0.120
39–59 week of age	1.90	1.91	1.85	2.09	1.93	0.445	0.330	0.021	0.008	0.281
59–79 week of age	1.96	1.96	2.08	2.20	2.08	0.067	0.122	0.991	0.094	0.080
Cumulative mortality, %										
39–79 week of age	2.7	1.8	9.8	9.8	9.8	2.56	*0.094*	0.118	0.164	0.139
39–59 week of age	0.9	0.9	5.4	8.9	3.6	2.28	0.147	0.846	0.181	**0.040**
59–79 week of age	1.8	0.9	4.5	0.9	6.3	1.40	0.400	0.003	0.529	0.529

[1]FB: control (soybean meal) treatment vs. faba bean treatment

[2]FCR: feed conversion ratio

[3]P: unprocessed faba beans vs. processed faba beans

[4]L: faba bean content 50 g kg^{-1} vs. faba bean content 100 g kg^{-1}

[5]P × L: interaction of processing and FB inclusion level

Table 4. The effects of faba bean dietary inclusion level on laying hen egg quality variables. Values are means of 7 observations per treatment (each observation is a mean of 8 eggs per experimental unit) and represent the mean values.

	Control	Faba bean inclusion Unprocessed FB[1] 50 g kg^{-1}	Processed FB 50 g kg^{-1}	Unprocessed FB 100 g kg^{-1}	Processed FB 100 g kg^{-1}	SEM	Statistical significance (P-values) FB	P[2]	L	P × L[3]
Specific weight										
53 week of age	1.09	1.09	1.09	1.09	1.09	0.001	0.629	0.750	0.921	0.961
74 week of age	1.08	1.08	1.08	1.08	1.08	0.001	0.580	0.450	0.329	0.972
Shell strength, kg										
53 week of age	3.77	3.71	3.87	3.78	3.66	0.085	0.892	0.812	0.452	0.110
74 week of age	3.31	3.13	3.05	3.17	3.04	0.151	0.218	0.507	0.907	0.875
Haugh units										
53 week of age	82.0	82.2	82.1	84.1	81.3	0.99	0.703	0.160	0.616	0.188
74 week of age	86.4	87.3	86.1	84.9	86.3	1.30	0.876	0.921	0.409	0.309
Shell thickness, µm										
53 week of age	387	391	394	389	386	3.6	0.459	0.901	0.187	0.417
74 week of age	381	376	382	380	381	3.4	0.830	0.325	0.812	0.513

[1]FB: control (soybean meal) treatment vs. faba bean treatment

[2]P: unprocessed faba beans vs. processed faba beans L: faba bean content 50 g kg^{-1} vs. faba bean content 100 g kg^{-1}

[3]P × L: interaction of processing and FB inclusion level

Discussion

The crude protein content of the batch of FB studied (unprocessed 302 g kg $^{-1}$ and processed 285 g kg $^{-1}$) were similar compared to the table value published in the Finnish Feed Tables and Nutrient Requirements (300 g kg $^{-1}$ for unreported FB cultivar) (MTT 2014). The average rates of starch, crude fibre and crude fat contents (g kg $^{-1}$ DM basis) for unreported FB cultivar are 380, 80 and 20 (respectively) (MTT 2014). Considering the major variations in nutrient content detected between and within FB genotypes (Duc et al. 1999), the nutrient content in studied FB cultivar were typical. The 74 genotypes showed wide variations in their main constituents (g kg $^{-1}$ DM basis) in the study of Duc et al. (1999): with starch from 370 to 505, protein from 247 to 372, cell walls from 127 to 222 and neutral detergent fibre from 134 to 264,sugars from 35 to 63, ash from 30 to 55 and crude fat from 11 to 47. The diets in feeding phases were very similar in their content of crude protein. However, even the mild heat treatment (90−110 °C) during expander-processing may had a positive effect on FB carbohydrate utilization. Lacassagne et al. (1988) have previously reported that heat treatment had a considerable effect on faba bean starch digestibility and energy value.

To our knowledge, no research studies have previously been conducted on the V+C content of the FB cultivar used in this study. The V+C content detected in this study corresponds with the results of Duc et al. (1999) who reported that V+C content in high V+C varieties usually ranges from 6 to 14 g kg^{-1} of mature seed DM. The analysed V+C content imply that studied FB (cv. 'Kontu') was a V+C containing cultivar, considering that in the study of Jezierny et al. (2010) V+C content in low V+C genotype was 0.3 g kg^{-1} DM. In the present study, the difference in V+C content between unprocessed and expander-processed FB was non-existent. This is in line with previous reports that vicine and convicine are heat-stable compounds and not easily removed by technological or chemical processing (Duc et al. 1999, Dvořák et al. 2006, and Vilariño et al. 2009). In the study of Dvořák et al. (2006), different methods of treatment – including exposure to over 100 °C, to organic acids, and to substrate maturation along with subsequent drying, were tested without any significant effects on the V+C content.

In the current study, mortality tended to increase with dietary FB. In the study of Robblee et al. (1977), a FB inclusion level of 200 g kg $^{-1}$ feed had no adverse effect on mortality of white Leghorn pullets, but a level of 300 g kg^{-1} feed increased the mortality rate. It is conceivable that the V+C content of the studied FB (cv. 'Kontu') may had been higher than that of the FB (cv. 'Ackerperle') used by Robblee et al. (1977), but they did not report the V+C content of the cultivar they used. In the study of Fru-Nji et al. (2007) mortality rates were not reported, indicating that FB inclusion had no major problems on the mortality of the hens in their study (half were LSL and the other half Lohmann Brown). In contrast to our study, FB inclusion had no adverse effect on mortality in the studies of Campbell et al. (1980), Perez-Maldonado et al. (1999), and Laudadio and Tufarelli (2010). Campbell et al. (1980) used SCWL laying hens, Hy-line, and FB at 250 g kg $^{-1}$ in the diet. Perez-Maldonado et al. (1999) used SIRO-CB pullets, and FB cv. 'Fiord' at 250 g kg^{-1} in the diet. Laudadio and Tufarelli (2010) used ISA Brown pullets, and FB cv. 'Prothabat' at 240 g kg^{-1} in the diet. According to Crépon et al. (2010) human carriers of a widespread genetic defect, experience FB toxicity: a deficiency of the erythrocyte-located glucose-6-phosphate dehydrogenase (G6PD). To our knowledge, there was no evidence in literature that this genetic defect is also in poultry, but this possibility can't be excluded.

Reduced egg weight related to FB supplementation agrees with the findings of previous studies (Robblee et al. 1977, Campbell et al. 1980, Olaboro et al. 1981). Muduuli et al. (1981) demonstrated that vicine consumption reduced egg weight and increased erythrocyte hemolysis. According to Muduuli et al. (1981) vicine may act in following three ways: reduces the amount of precursor material available to the granulosa cells, by damaging granulose cells and hence their activity, or by destroying the ovum. However, Fru-Nji et al. (2007) reported that increases in dietary FB content seemed to increase albumen fraction and simultaneously reduce the yolk fraction of the eggs. Albumen and yolk weights were not determined in the current study, but the reduction observed in egg weight with dietary FB supplementation might be due to a reduction of the yolk fraction.

Campbell et al. (1980) reported lower egg weight when less methionine was added to FB diets. Davidson et al. (1973) reported that added methionine is beneficial to prevent egg weight loss when FB is used in layer diets. According to Fru-Nji et al. (2007), the reduction in egg mass production during increased dietary FB inclusion may be due to ANF of the FB, and also because of the deficient essential amino acid (methionine and cysteine) content of the FB. In our study, the methionine was supplied to achieve the nutrient requirements of the hens. In the current study the differences in chemical composition of experimental diets or detected feed consumption rates seemed not to be related to egg weight loss or decreased daily egg mass production. Therefore we assumed that the reduction in egg weight observed between the control and the FB diets, and the reduction in daily egg mass production observed between the 50 g FB kg^{-1} feed and the 100 g FB kg^{-1} feed was mainly due to V+C and probably not due to different amounts of dietary methionine content.

In agreement with our results, Robblee et al. (1977), Muduuli et al. (1981), and Fru-Nji et al. (2007) reported no differences in feed consumption between the control and FB diets. In contrast, Laudadio and Tufarelli (2010) reported decreased feed intake, and Magoda and Gous (2011) reported increased feed intake with increased FB inclusion. Magoda and Gous (2011) suggested that the hens needed to consume more feed to meet their nutrient requirements when FB is included in the diet. In agreement with the study of Fru-Nji et al. (2007), in our study FCR increased with dietary FB inclusion. The results of the current study are consistent with those of Laudadio and Tufarelli (2010), and Magoda & Gous (2011) reported that dietary FB inclusion had no negative influence on hen body weight.

Faba bean inclusion had no effects on the egg quality variables studied. This agrees with the results of Fru-Nji et al. (2007) (shell strength), Laudadio and Tufarelli (2010) (Haugh unit and shell thickness), and Robblee et al. (1977) (specific weight). In contrast to the current study, in the study of Robblee et al. (1977) the Haugh unit values increased as the amount of FB in laying hen diets increased.

In conclusion, when the diets are balanced with nutrients 50 g kg^{-1} feed of unprocessed or processed V+C containing FB (cv. ‘Kontu’) can be used in laying hen (LSL Classic) diets based on cereals and SBM, without negative effects on the production performance or livability of laying hens. Expander-processing did not reduce the content of V+C in FB and nor did it had an effect on the production performance of the hens.

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