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ORIGINAL ARTICLE

The effect of low soybean meal diets on broiler performance

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Abstract

Background: This study was performed to evaluate the performance of low soybean meal diets in broiler chicks.

Methods: A total of 330 broiler chicks were divided into three groups. Each group was treated with one type of diet (group 1=control [soybean], group 2=crushed peas, and group 3=faba bean). The proportion of crude protein (CP) for the control group was 20.45% as a starter and 19.75% to 17.66% as a grower and finisher. The CP values for group 2 were 17.45% as a starter and 16.95% to 15.46% as a grower and finisher. While chicks of group 3 received 17.75% CP as a starter and 17.23% to 15.68% CP as grower and finisher. Data obtained were expressed as mean±SEM. The results obtained were analyzed using the ANOVA Test, by Minitab 2015 statistical analysis software. P-value < 0.05 was considered as significant.

Results: Significantly ($p<0.05$) higher weight gain was obtained in the faba bean group (2744.72 g ±217) than control (2430.50 g ±593.8). No significant difference was noticed in the consumption of different diets. The carcass yield of control (70.10%) and faba beans (70.32%) groups were comparable. Concerning the biochemical parameters, we found that the partial change of soybean did not affect the biochemical profile, except for the significant variation of blood sugar, cholesterol, and triglycerides between the control and group 2 ($p<0.05$).

Conclusion: Faba beans as a locally available source of protein could be a potential alternative to substitute soybean meal in the broiler diet.

Keywords: protein crops, soybean meal, pea, faba bean, biochemical profile.

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Introduction

The protein is an important macronutrient r in poultry feed (Gognet *et al.,* 1995). The Poultry production in Algeria is dependent on soyabean supplies, mainly from other countries and about 1.2 million tonnes imported in 2021. Few studies have been conducted to replace soybean meal with other cheap protein sources (Meziane *et al.,* 2013). This protein-rich raw material is good from a nutritional point of view as poultry feed but expensive for the production of poultry meat or eggs. One of the aims should be to find substitutions for protein, especially soybean meal sources using available foods in Algeria such as faba bean and crushed peas to improve the profitability of poultry farms. The important plant protein sources in Algeria are different legumes like faba bean, pea, lupine, vetch and beans. These plant protein sources are rich with lysine and deficient in sulfur containing amino acids. These seeds also contain fat in different proportions, starch and cell wall carbohydrates which are well digested. The energy value of these seeds is also good (Dragoul et *al.,* 2004). So, we performed this study to evaluate the performance of 3 diets of different protein sources (soybean meal, faba bean and crushed peas) in broilers.

Materials and methods

Chick selection and rearing

The study was carried out within PADESCA Laboratory research in the Institute of Veterinary Sciences of Constantine, Algeria, and conforms to international guidelines concerning animal care and use in research and teaching. A total of 330 one day old ISA15 chickens were randomly divided into 3 groups. Strict hygienic practices were followed during the experiment. Anti - stress substance was administered in water for the first three days. Standard management practices of commercial broiler production were applied. Vaccination against gumboro and Newcastle disease were performed at the appropriate ages. Birds were provided standard *ad-libitum* diets, covering the birds' energy and protein requirements during the three phases of production.

Diet formulation

The composition of starter, grower and finisher diets were presented in Table 1, 2 and 3 respectively. The total metabolizable energy and % crude protein of the different rations were also measured (Tables 1, 2, 3).

Diet allocation

The first group acted as control and fed with ration 1. Group 2 and 3 were fed ration 2 and 3 respectively (Tables 1, 2, 3). The duration of the starter, grower and finisher diet were 15, 16-45 and 46-56 days respectively.

Table 01: Composition of starter diet

Starter feed composition	Diet 1 (control)	Diet 2 (Pea)	Diet 3 (faba bean)
Maize	62%	62%	62%
Soya meals	30%	15%	15%
Faba bean	/	/	15%
Pea	/	15%	/
Bran	5%	5%	5%
Dicalcium phosphate	2%	2%	2%
Vitamin mineral premix	1%	1%	1%
Metabolizable energy (Kcal/Kg)	2912	2961	2942
Crude protein (%)	20.45	17.45	17.75

Table 02 : Composition of grower diet

Grower feed composition	Diet 1 (control)	Diet 2 (Pea)	Diet 3 (faba bean)
Maize	64%	64%	64%
Soya meals	28%	14%	14%
Faba bean	/	/	14%
Pea	/	14%	/
Bran	5%	5%	5%
Dicalcium phosphate	2%	2%	2%
Vitamin mineral premix	1%	1%	1%
Metabolizable energy (Kcal/Kg)	2933	2978	2961
Crude protein (%)	19.75	16.95	17.23

Table 03 : Composition of finisher diet

Finisher feed composition	Diet 1 (control)	Diet 2 (Pea)	Diet 3 (faba bean)
Maize	70%	70%	70%
Soya meals	22%	11%	11%
Faba bean	/	/	11%
Pea	/	11%	/
Bran	5%	5%	5%
Dicalcium phosphate	2%	2%	2%
Vitamin mineral premix	1%	1%	1%
Metabolizable energy (Kcal/kg)	2995	3031	3017
Crude protein (%)	17.66	15.46	15.68

Data collection and analysis

Twenty birds were taken for each group and were weighed every five days to determine average daily gain and also to find the difference in weight gain among the three groups. The daily feed intake was measured to calculate the index of consumption. At the end of the experiment, the chickens were weighed individually and sacrificed by bleeding to determine the carcass yield. Subjects were plucked hot, eviscerated, the heads and feet removed. Carcasses, livers, gizzards and abdominal fat were weighed, which allowed us to calculate the average. The mean difference in different parameters among three groups were evaluated by the analysis of variance (ANOVA). All analyzes were performed using MINITAB 15 software.

Results

Production parameters

Slaughter weight and carcass yield

Table 4 shows that the partial incorporation of faba bean in the diet (15 %, 14 % and 11 %) significantly ($P < 0.05$) increase the live weight and carcass weight than control.

Feed intake and feed efficiency

The incorporation of pea to the feed ration affected feed intake (4868.84 g), while the feed intake of the "faba bean" and "control" birds were (5510.79 g) and (5899.41 g), respectively. The feed efficiency rates during all phases of the trials show that the best feed conversion rate was obtained in the pea lot with a value of 2.01, but this group recorded the lowest live weight. The "control" group recorded the highest feed conversion ratio with a value of 2.42, followed by the "faba bean" group with an average of 2.35.

Liver and abdominal fat

Under our experimental conditions, the introduction of faba beans in the diet significantly increased liver weight and abdominal fat compared to "control" and "pea" groups. However, no improvement in liver weight and abdominal fat of chickens was observed following the incorporation of peas in the feed.

Influence of different rations on the biochemical profile

Starter

According to the above results, blood sugar levels were not influenced by the incorporation of protein crops in the starter phase (P>0.05). The blood glucose level of the pea group (1.56 g/l) was lower than those of the faba bean group (1.68 g/l) and the control group (1.99 g/l). Blood urea levels at the end of the first two weeks of age are almost the same for all three batches (0.02 g/l) and without any significant difference. The highest protein level (26 g/l) was reported in the "faba bean" lot followed by the "pea" and "control" lots (21.60 g/l) and (17.80 g/l) respectively, but this difference was not significant. The results showed that the blood of chicks from the "pea" batch contain more cholesterol (1.02 g/l) than the "control" (0.67 g/l) and "faba bean" (0.98 g/l) batches with a non-significant difference. We also recorded similar values for triglycerides (0.56 g/l, 0.68 g/l, 0.59 g/l) of "control", "pea" and "faba bean" respectively, without any significant difference.

Grower

The results we obtained for blood glucose levels during the growth phase were comparable to those obtained during the starter phase without any significant variation. (Tables 7, 8). In the growth phase, the glucose level in “pea” group (1.68 g/l) was significantly (P<0.05) lower than that of “control” group (2.00 g/l). In addition, significant variation (P < 0.05) of cholesterol level between the "control" group and the "pea" group was found (Table 8). The triglyceride levels were also similar to those found in the starter phase. There was almost no significant variation of triglyceride levels (P>005) among three groups.

Finisher

For finishers, the blood glucose content differed significantly between the control and the two experimental batches (pea and faba bean). It should be noted that the highest blood glucose level was reported in the pea batch (2.27 g/l) followed by those of faba bean and soybean , respectively (2.24 g/l and 1.73 g/l). We also did not observe any significant variation of uremia among three groups at the final stage of the experiment.. The results were consistent with those of start-up and growth. The total protein content at finishing showed no significant difference among the three groups (P>0.05). The birds in the "control" lot had an average of 27.80 g/l, compared with 26.50 g/l for the "faba bean" lot and 25.40 g/l for the "pea" lot.

Table 4: Influence of different diets on live weight and carcass yield

	Diet 1 (control)	Diet 2 (Pea)	Diet 3 (faba bean)
Live weight at slaughter (g)	2430.50[a] ±593.8	2070.4[a] ±462.1	2744.72[b] ±217
Eviscerated carcass (g)	1703.56[a] ±454.72	1409.66[a] ±339 .58	1930[b] ±156,84
Carcass yield (%)	69.66%[a] ±2.2	67.97%[a] ±4.4	70,34%[a] ±2,4

[a,b] Values within each row with different superscripts are significantly different (P < 0.05). **a** and **b** lowercase letters indicate significant differences.

Table 5: Effects of three diets on feed intake, weight gain and feed efficiency

	Feed intake (g)		
	Diet 1 (control)	Diet 2 (Pea)	Diet 3 (faba bean)
Starter (day 1 to day 15)	369.70	281.70	330.24
Growing (day 16 to day 45)	3593.70	2901.49	3150.73
Finisher (day 46 to day 56)	1936.01	1685.65	2029.82
Accrued (day 1 to day 56)	5899.41	4868.84	5510.79
	Weight gain (g)		
	Diet 1 (control)	Diet 2 (Pea)	Diet 3 (faba bean)
Day 15	230.80	200.28	252.48
Day 45	1838.80	1483.55	1719.57
Day 56	2430.22	2070.2	2744.72
	Feed efficiency		
	Diet 1 (control)	Diet 2 (Pea)	Diet 3 (faba bean)
Starter (day 1 to day 15)	1.60	1.41	1.31
Growing (day 16 to day 45)	2.23	2.26	2.15
Finisher (day 46 to day 56)	3.27	2.87	1,98
Accrued (day 1 to day 56)	2.42	2.35	2.01

Table 6: Influence of the three diets on the liver and abdominal fat

	Diet 1 (control)	Diet 2 (Pea)	Diet 3 (faba bean)
Liver weight (g)	$47.56^{a} \pm 10.76$	$46.56^{a} \pm 10.24$	$63.48^{b} \pm 11.43$
Abdominal fat (g)	$24.89^{a} \pm 12.73$	$31.66^{a} \pm 13.13$	$53.94^{b} \pm 19.50$

^{a,b} Values within each row with different superscripts are significantly different ($P < 0.05$). **a** and **b** lowercase letters indicate significant differences.

Table 7: Effects of three diets on the biochemical profile in chickens during the starting phase

	Diet 1« control »	Diet 2 « pea »	Diet 3 « faba bean »
Blood sugar (g/l)	$1.98^{a} \pm 0.81$	$1.56^{a} \pm 0.82$	$1.68^{a} \pm 0.70$
Uremia (g/l)	$0.02^{a} \pm 0{,}007$	$0.02^{a} \pm 0.01$	$0.02^{a} \pm 0.01$
Total protein (g/l)	$17.80^{a} \pm 5{,}59$	$21.60^{a} \pm 8.17$	$26.00^{a} \pm 15.19$
Cholesterol (g/l)	$0.67^{a} \pm 0{,}31$	$1.02^{a} \pm 0.37$	$0.98^{a} \pm 0.27$
Triglycerides (g/l)	$0.56^{a} \pm 0{,}48$	$0.68^{a} \pm 0.35$	$0.59^{a} \pm 0.18$

^{a,b} Values within each row with different superscripts are significantly different ($P < 0.05$). **a** and **b** lowercase letters indicate significant differences

Table 8: Effects of three different diets on the biochemical profile in chickens during the growing phase

	Diet 1« control »	Diet 2 « pea »	Diet 3« faba bean »
Blood sugar (g/l)	$3.11^{a} \pm 0.71$	$1.68^{b} \pm 0.42$	$2.00^{b} \pm 0.44$
Uremia (g/l)	$0.02^{a} \pm 0.007$	$0.018^{a} \pm 0.008$	$0.015^{a} \pm 0.01$
Cholesterolemia (g/l)	$1.77^{a} \pm 0.74$	$0.97^{b} \pm 0.27$	$1.21^{a} \pm 0.19$
Triglycerides (g/l)	$0.50^{a} \pm 0.17$	$0.40^{a} \pm 0.10$	$0.39^{a} \pm 0.14$

[a,b] Values within each row with different superscripts are significantly different ($P < 0.05$). **a** and **b** lowercase letters indicate significant differences.

Table 9: Effects of three different diets on the biochemical profile in chickens during the finishing phase

	Diet 1 « control »	Diet 2 « pea »	Diet 3 « faba bean »
Blood sugar (g/l)	$1.73^{a} \pm 0,212$	$2.27^{b} \pm 0.23$	$2.24^{b} \pm 0.15$
Uremia (g/l)	$0.020^{a} \pm 0.007$	$0.010^{a} \pm 0.00001$	$0.012^{a} \pm 0.005$
Total protein (g/l)	$27.80^{a} \pm 2.17$	$25.40^{a} \pm 3.847$	$26.50^{a} \pm 2.380$
Cholesterolemia (g/l)	$0.70^{a} \pm 0.09$	$1.14^{b} \pm 0.244$	$1.1875^{b} \pm 0.251$
Triglycerides (g/l)	$0.45^{a} \pm 0.11$	$0.86^{b} \pm 0.25$	$0.70^{b} \pm 0.07$

[a,b] Values within each row with different superscripts are significantly different ($P < 0.05$). **a** and **b** lowercase letters indicate significant differences.

The results obtained for cholesterol levels at finishing were as follows: (1.19 g/l) for the 'faba bean' group, (1.14 g/l) for the 'pea' lot against (0.70 g/l) for the 'control' lot. The difference was clearly significant between the control, the field bean and the pea group. We recorded similar values of triglyceride level for the "pea" (0.86 g/l) and "faba bean" (0.70 g/l) groups. However, the lowest triglyceride level was recorded in the 'control' group with an average of 0.45 g/l; this decrease was significant between the 'control' and the two groups containing protein crops.

Discussion

We evaluated the performance of partially substituted soybean meal diets on broiler performance. We used crushed peas and faba beans to partially substitute the soybean meals. The performance of the faba beans group was comparable with the standard diet containing soybean meal as protein source. Use of faba beans to partially replace soybean meals will reduce the cost of broiler production and increase farmers' profit in Algeria.

We observed significantly higher carcass yield in the faba beans group that crushed pea group. Similar result was also reported by Perella *et al.* (2009) in Italy. According to the latter, faba beans (16%) could be a valuable source of protein in the diet of organic chickens when used after the initial period. Thus, in the laying hen the introduction of 30% of the peas in the ration remains tolerable to prevent the decrease in egg weight (Mihailović *et al.,* 2005). One of the major problems for pea was the fact that plants sagged before harvest, which made it very difficult for mechanical harvesting. The emergence of varieties ``afila" consisting essentially of twists and allowing an erect plant port, has solved this problem. Production really developed in the mid 80s. The feed producers were also asked about the qualities of the protein and the incorporation rate to apply, taking into account their nutritional value and the possible presence of antinutrients, the amino acid balance, taste, etc. (Froidmont and Leterme, 2005). In laying hens several studies report that faba bean beans reduce the production in particular the weight of the egg. This negative effect is ascribed to the presence of anti - nutritional glucosides: vicine and convicine. According to Lessire *et al.,* (2005), an incorporation rate of 20 % of the mixture or only faba in foods, showed that the intensity of spawning is not modified by the various foods, but that the average weight of the egg is closely related to the content and vicine convicine of food. Nevertheless, it is interesting to note that Parviz and Siavash, (2006) showed that the addition of enzymes in diets containing heat treated pea (20%), positively affect liver weight.

Depending on the bird species, age and sex, this low fat content is very relative and the fat status can also vary depending on many criteria related to the feed. The main purpose of adding fat to the feed is to increase its energy concentration, thus improving production performance. Their impact on carcass fatness is minor when nutritional balances and, in particular, the energy ratio is kept constant. But the nature of the added lipids modifies in a profound way that of the body lipids. Thus, it is possible to adapt the body fatty acid profiles of poultry, and chicken in particular, to the quality requirements of slaughterhouses and the consumer. Excessive fat deposits lead to reduced yields during the evisceration, cutting and product preparation. Finally, from a nutritional point of view, the synthesis and deposition of 1 g of body lipid is more expensive than the synthesis and deposition of 1 g of muscle protein. The consumer does not appreciate fat deposits, but body fat has a positive effect on the organoleptic quality of products.

The distribution of body fat also varies between different species. Thus the proportion of abdominal fat is similar in ducks and chickens (3 to 4% of live weight: 27 g for the male and 35 g for the female), while the carcass of the turkey contains only 1 to 2% of abdominal fat (Leclercq, 1989; Lessire *et al.,* 2005). Our results with faba beans are in line with those of (Perella *et al.,* 2009).

Bouvarel *et al.,* (2001), showed that the introduction of 25% pea did not modify the zootechnical performance of the animals, nor their health status. Thus, the incorporation of pea with a percentage of 25% in the broiler feed has a positive effect on growth (Mihailovic et *al.,* 2005), which contradicts our results where chickens receiving pea in the feed ration presented a relatively low live weight and carcass yield. Thus, in laying hens, the introduction of 30% pea in the diet is still tolerable in order to avoid a decrease in egg weight. Anti-nutritional factors are supposed to protect the seed against fungi, bacteria, insects, but they also have a negative effect on farm animals. Tannins are polyphenolic compounds that can be divided into two groups: hydrolysable tannins and condensed tannins. The latter are found in cereal and legume seeds, mainly located in the seed coats. Their biological effects are due to their ability to complex with food proteins and/or enzymes. They are thus responsible for decreases in protein digestibility in birds (Longstaff and Mcnab, 1991). However, most pea varieties produced in Europe belong to the hortense subspecies (white flowers), without tannin.

Phytates, which are the plant's reserve form of phosphorus, represent 0.5 to 3.4% of the dry matter of the main plant raw materials used in animal feed, with peas having particularly low levels (0.5 to 0.6%) (Pointillart, 1994). At low pH, the bonds are made between phytic acid, which is strongly negatively charged, and positively charged proteins; at high pH, proteins and phytates are negatively charged and multivalent cations such as calcium are involved in the formation of protein-phytate complexes. However, the association of proteins with phytates depends on the accessibility of charged amino acids (O'Dell and De Boland, 1976). Dietary proteins, as well as enzymes, can be involved in the formation of these complexes. The addition of microbial phytases to the diet has a variable effect on digestibility according to the studies (Sebastian *et al.,* 1997).

Soybean and bean lectins have an affinity for N-acetylgalactosamine and galactose, which are present in the glycocalyx of mature cells in the upper part of the intestinal villi, and therefore could alter the functionality of these cells. Pea and faba bean lectins, on the other hand, have an affinity for D-mannose or D-glucose. These oligosaccharides are present in the glycocalyx of the less mature cells, such as those in the lower part of the intestinal villi, so these lectins would have little effect on digestion. In the case of pea lectins, although they are not very sensitive to hydrolysis along the digestive tract and therefore present until the end of the small intestine, no effect has been demonstrated (Pusztai *et al.,* 1993).

Trypsin inhibitors are the most studied anti-nutritional factors, especially in soybeans where they are present in particularly large quantities and have a negative effect on protein digestion. They act by forming irreversible enzyme inhibitor complexes that inactivate enzymes (Huisman and Jansman, 1991). This results in hypertrophy of the pancreas and hypersecretion of pancreatic enzymes in small animals such as mice, rats, guinea pigs and chickens. This enzyme hypersecretion therefore represents a loss of endogenous protein and consequently a decrease in apparent digestibility. In the case of peas, the effect of tryptic inhibitors on protein digestibility is controversial. It has been observed that for winter varieties, richer in tryptic inhibitors, protein digestibility is lower than for spring varieties (Carré *et al.,* 1991; Jondreville *et al.,* 1992; Perez and Bourdon, 1999).

The effect of this factor remains to be clarified. Among all these anti-nutritional factors, only tryptic inhibitors could be present in sufficient quantities in pea to modify protein digestibility.

The pea protein is made up, like all legume proteins, of three classes of proteins: globulins, albumins and so-called "insoluble" proteins (Guéguen and Cerletti, 1994). Peas account for 10% of poultry feed. However, its massive incorporation in the feed sometimes leads to lower digestibility values than in soybean-based diets, as well as to strong variations in protein digestibility. Thus, apparent fecal digestibility varies between 67 and 83% in chickens (Crevieu-Gabriel, 1999).

Pea trypsin inhibitors are also albumins and generally represent less than 2% of total seed protein. They are low molecular weight monomeric proteins, capable of binding irreversibly to the active sites of trypsin and chymotrypsin (two independent sites) (Birk and Smirnoff, 1992). Each polypeptide contains 7 disulphide bridges (Huisman and Jansman, 1991; Perrot, 1995). Peas are rich in protein (18-30%) and lysine (15 g/kg), and are a good complement to cereals. Moreover, its methionine, cysteine, threonine and tryptophan contents are relatively high (6.0; 5.5; 1 g/kg respectively) (Larbier and Leclercq, 1992; Dragoul *et al.,* 2004). According to Benabedldjalil, (1990), the use of raw and untreated peas in meal diets at a rate of 30% does not deteriorate the growth performance of broilers. Indeed, Huyghebaert et al. (1979) found that apparent energy was significantly improved ($p<0.05$) in a 20% protein diet compared to that of lower protein diets (l8%), particularly in the finishing phase.

Conclusion

Our findings suggest that the use of faba beans to partially substitute soybean meals up to 30% in diets and containing other protein sources give rise to acceptable performance. Faba beans as a locally available source of protein could be a potential alternative to substitute soybean meal in the broiler diet.

Competing Interest

The authors declare that they have no competing interests.

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