The use of extruded chickpeas in diets of broiler turkeys

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ABSTRACT: In an experiment with 200 one-day-old broiler turkeys, the effect of partial and total replacement of soybean meal with chickpeas (*Cicer arietinum* L.) on productivity and meat composition was determined. In the 12-week experiment, turkeys were allocated to five dietary treatments: ECKP0, ECKP200, ECKP400, ECKP600 and ECKP800 of 40 birds each, and received a diet *ad libitum.* The diet for ECKP0 treatment contained no chickpeas (control), while those for treatments ECKP200, ECKP400 ECKP600 and ECKP800 included 200, 400, 600 and 800 kg/t of wet extruded (at 120°C for 20 s) chickpeas, respectively. Replacement of soybean meal with extruded chickpeas, at inclusion levels up to 200 kg/t of diet, resulted in similar productive performance. At the end of the experiment, the body weight (BW) and the feed conversion ratio for ECKP0 treatment were 7 782 g and 2.46 g of daily feed consumption per g of BW gain, respectively. However, the replacement of soybean meal with extruded chickpeas at higher inclusion levels (400, 600 and 800 kg/t of diet) decreased body weight by 7.7% ($P < 0.05$) and increased feed conversion ratio by 14.9% ($P < 0.05$) compared to the control. Moreover, carcass yield traits were not affected ($P > 0.05$) by feeding diets with increasing levels of extruded chickpeas. Thus, extruded chickpeas can be used as an alternative protein source to replace soybean meal in broiler turkey diets, at inclusion levels up to 200 kg/t.

Keywords: extruded chickpeas; broiler turkeys; performance; carcass characteristics

The chickpea (*Cicer arietinum* L.) is one of the world's most important grain legumes (FAO, 1993). Although most chickpeas are produced for human consumption, they provide the livestock industry with an alternative protein and energy feedstuff. The crude protein (CP) content of chickpeas ranges from 124 to 306 g/kg of dry matter (DM), and the sulphur amino acids are the first limiting, followed by valine, threonine and tryptophan (Chavan et al., 1989). Chickpeas, like other legumes, contain a variety of anti-nutritional factors (ANF), such as protease and amylase inhibitors, as well as lectins, polyphenols and oligosaccharides, which impair nutrient absorption from the gastrointestinal tract and can result in detrimental effects on animal health and growth (Chavan et al., 1989; Perez-Maldonaldo et al., 1999). In order to improve the nutritional value, and to provide effective utilization of chickpeas to a maximal level in diets of broiler turkeys, it is essential that ANF activity is removed and that a higher protein and energy digestibility is obtained (Van der Poel, 1989). Many ANF in raw chickpeas are inactivated by heat treatment, the effectiveness of which depends, among other factors, on a combination of process temperature and heating time (Van der Poel, 1989).

Intensive poultry production is based on diets high in cereal grains and a protein supplement, with soybean meal (SBM) being the most common. However, the need to lessen the impact of imported and therefore high SBM prices on poultry producers has led to research on local protein sources, such as chickpeas, as animal feeds. Although chickpeas have been reported to be suitable as a protein

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concentrate for broiler chickens (Farrell et al., 1999; Viveros et al., 2001; Christodoulou et al., 2006), no information is available on the nutritional value of extruded chickpeas for broiler turkeys. Extrusion improves the utilization of starch, fat and protein contained in legumes by poultry (Spais, 1997), and also offers very good results in destroying ANF of legumes (Van der Poel, 1989). Our objective was to evaluate extruded chickpeas as a protein and energy replacement for SBM in diets of broiler turkeys relative to performance and carcass characteristics.

MATERIAL AND METHODS

Chickpeas

Chickpeas (variety 'Serifos', Table 1) were used in an experiment with broiler turkeys, at the Animal Research Institute, National Agricultural Research Foundation (N.AG.RE.F.), in Giannitsa (Greece). Chickpeas were obtained from the Fodder Crops and Pasture Institute (N.AG.RE.F.) in Larissa (Greece). Cultivation practices of these chickpeas, as well as five other Greek chickpea varieties were reported by Iliadis (2001).

Table 1. Chemical composition (g/kg, as fed basis) of extruded chickpeas and soybean meal

	Extruded chickpeas	Soybean meal
n	3	3
Dry matter	923.0	892.0
Crude protein	239.0	424.0
Crude fat	51.0	15.0
Crude fibre	38.0	59.0
Ash	39.0	55.0
Arginine	20.7	31.1
Glycine + serine	15.9	20.8
Histidine	7.0	12.3
Isoleucine	10.7	20.6
Leucine	19.0	30.1
Lysine	17.8	28.8
Methionine	1.8	6.0
Methionine + cystine	6.2	12.3
Phenylalanine	12.2	23.1
Phenylalanine + tyrosine	19.5	38.9
Proline	6.9	9.3
Threonine	8.9	19.1
Tryptophan	3.2	5.9
Valine	11.3	19.7

Extrusion of chickpeas

Chickpeas were extruded to reduce ANF levels as, among the various available processing techniques, it was judged that extrusion offered the best possibilities to inactivate chickpea ANF (Saini, 1989; Van der Poel, 1989; Vooijs et al., 1993).

Chickpeas were ground to pass a 2 mm screen using a hammer mill. Ground chickpeas were wet extruded at 120°C (i.e. the barrel temperature near the exit) for 20 s using a Berga model ME-103 extruder (Berga, Impianti Cereali S.p.A., Treviso, Italy). The extruded chickpeas were reground to pass a 2 mm screen before mixing into the diets. The combination of process temperature and heating time was based on reports of Van der Poel (1989) and Vooijs et al. (1993).

Experiment: broiler turkeys

Two hundred day-old male broiler turkeys from a commercial strain (B.U.T. 9) were randomly allocated to five dietary treatments (ECKP0, ECKP200, ECKP400, ECKP600 and ECKP800) after individual weighing. Turkeys of each treatment were divided into five subgroups (replications) of 8 birds each, and accommodated to 5 floor pens/treatment. All 25 pens were identical; with the same direction, the same covered area (0.5 m^2/turkey), and were equipped with similar troughs for diets and water. During the 84-day experimental period, all turkeys in the five treatments received two types (starter and finisher) of an optimal diet (Table 2); starter from 1 to 42 days of age, and finisher from 43 to 84 days of age, according to nutrient requirements of turkeys as given by Spais et al. (2001). Both diets for ECKP0 treatment had no chickpeas (control), while those for treatments ECKP200, ECKP400, ECKP600 and ECKP800 included 200, 400, 600 and 800 kg/t of extruded chickpeas, respectively. All diets in each type were isonitrogenous and isoenergetic (12.7 MJ of metabolisable energy/kg of the diet), having the same level of the amino acids lysine, methionine and cystine, according to NRC (1994) nutrient composition values.

During the experiment conventional management procedures were employed, natural and artificial light was provided on a continuous basis, ambient temperature was controlled and birds were fed and watered *ad libitum*. All birds were vaccinated at 15 days of age against Newcastle Disease with B1-Hitchner (Intervet®). Turkey body weights (BW) were measured individually at 1, 42 and 84 days of age. Daily feed consumption (DFC) within each subgroup was recorded during these time intervals and the feed conversion ratio (FCR) was subsequently calculated. Mortality was recorded daily.

At the end of the experiment, ten turkeys, randomly selected from each treatment (2 from each subgroup), were fasted for 18 h (water was allowed), weighed, and euthanized. After dressing, the carcases including heart, liver and gizzard (i.e. commercial carcass) were weighed. The weights of the right breast muscles (*m. pectoralis superficialis* and *m. pectoralis profundus*), and the right leg muscles, as well as heart, liver, and gizzard were measured separately. Additionally, carcass yield and relative weights of the breast muscles, leg muscles, heart, liver, and gizzard, expressed in g/100 g of BW, were calculated.

All birds used in the experiment were cared for according to applicable recommendations of U.S. National Research Council (NRC, 1996).

Chemical analyses

Extruded chickpeas, SBM and diets were analyzed for DM by drying at 102°C for 16 h in a forced air oven, and for CP, crude fat, crude fibre and ash according to methods 976.06, 920.39, 978.10 and 942.05, respectively, of AOAC (1990). Extruded chickpeas, SBM and diets were also analyzed for amino acids (AA) with an AAA400 AA analyzer (INGOS, Czech Republic). All AA, except methionine, cystine, and tryptophan, were determined after hydrolysis with 6 M HCl, while methionine and cystine, and tryptophan were determined after oxidative and alkaline hydrolysis, respectively.

Statistical analysis

Performance and carcass characteristics of the broiler turkeys were statistically analyzed by one-way analysis of variance, while significant differences between treatment means were tested using Duncan's multiple range test at the 0.05 probability level (Steel and Torrie, 1980). Mortality was analyzed by chi-square test (Remington and Schork, 1970). The statistical analysis was undertaken with the SPSS Statistical Software Package (Release 10.0, 1999), and the Microsoft Excel (2000).

RESULTS

The results for BW, DFC and FCR are presented in Table 3. At the end of the experiment, BW and FCR were similar in treatments ECKP0 and ECKP200, and DFC was similar in all treatments. However, final BW was lower by 7.7% ($P < 0.05$) and FCR was higher by 14.9% ($P < 0.05$) in treatments ECKP400, ECKP600 and ECKP800, compared to treatment ECKP0. Additionally, FCR was higher by 13.0% ($P < 0.05$) in treatment ECKP400, by 9.7% ($P < 0.05$) in treatment ECKP600, and by 17.3% ($P < 0.05$) in treatment ECKP800 compared to treatment ECKP0 till 42 days of age. No differences were observed in broiler turkey performance between treatments ECKP400, ECKP600 and ECKP800. Mortality was not affected by the treatments. The mortality rate for ECKP0, ECKP200, ECKP400, ECKP600 and ECKP800 was 3/40 (7.5%), 2/40 (5.0%), 1/40 (2.5%), 2/40 (5.0%), and 1/40 (2.5%), respectively. All deaths occurred within the first week of age and were attributed to stress due to transportation. Moreover, fasted BW was similar in treatment ECKP200, but lower ($P < 0.05$) in treatments ECKP400, ECKP600 and ECKP800, compared to treatment ECKP0 (Table 4). Broiler turkeys' carcass yield traits were not affected by feeding diets with increasing levels of extruded chickpeas.

DISCUSSION

In this experiment, partial replacement of SBM with extruded chickpeas (i.e. 200 kg/t of diet) resulted in similar performance of broiler turkeys. The diets containing higher inclusion levels of extruded chickpeas (i.e. 400, 600 and 800 kg/t of diet) did not affect DFC at the end of the experiment, but negatively influenced final BW and FCR, compared to the control diet. There are no reports to compare about the use of extruded chickpeas in poultry; however, there are several studies on the use of raw and heated chickpeas. Christodoulou et al. (2006) showed that raw chickpeas can par-

Table 2. Composition[1] of starting (1 to 42 days of age) and finishing (43 to 84 days of age) turkey diets (i.e. starter diet and finisher diet, respectively), as fed basis

	Starter diet[2]					Finisher diet[2]				
	ECKP0	ECKP200	ECKP400	ECKP600	ECKP800	ECKP0	ECKP200	ECKP400	ECKP600	ECKP800
Ingredient composition (kg/t)										
Maize grain, ground	508.8	399.6	297.2	190.1	32.7	585.9	477.7	374.3	267.2	108.8
Maize gluten meal (620 g/kg CP)	120.0	120.0	120.0	120.0	68.0	60.0	60.0	60.0	60.0	8.0
Soybean meal (424 g/kg CP)	260.0	175.0	85.0	0.0	0.0	260.0	175.0	85.0	0.0	0.0
Chickpeas extruded (239 g/kg CP)	0.0	200.0	400.0	600.0	800.0	0.0	200.0	400.0	600.0	800.0
Herring meal (720 g/kg CP)	50.0	50.0	50.0	50.0	50.0	25.0	25.0	25.0	25.0	25.0
Soybean oil	20.0	14.0	7.0	0.0	12.0	24.0	18.0	11.0	4.0	17.0
L-Lysine monohydrochloride	6.3	5.3	4.4	3.3	0.0	6.3	5.3	4.4	3.3	0.0
DL-Methionine (990 g/kg)	0.4	0.6	0.9	1.1	1.8	1.0	1.2	1.5	1.7	2.4
Choline chloride (600 g/kg)	1.2	1.2	1.2	1.2	1.2	1.0	1.0	1.0	1.0	1.0
Limestone	16.0	15.0	14.0	13.0	12.0	16.0	15.0	14.0	13.0	13.0
Monocalcium phosphate	12.0	14.0	15.0	16.0	17.0	15.0	16.0	18.0	19.0	19.0
Salt	2.3	2.3	2.3	2.3	2.3	2.8	2.8	2.8	2.8	2.8
Avatec (150 g/kg lasalocid)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin-mineral premix[3]	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Chemical composition (g/kg)										
Metabolisable energy (MJ/kg)	12.73	12.73	12.75	12.73	12.72	12.76	12.77	12.77	12.75	12.76
Crude protein	275.0	276.0	274.0	275.0	273.0	228.0	228.0	226.0	227.0	225.0
Crude fat	52.0	51.0	48.0	46.0	60.0	55.0	54.0	51.0	49.0	64.0
Crude fibre	31.0	30.0	29.0	28.0	32.0	32.0	31.0	30.0	29.0	33.0
Ash	31.0	32.0	33.0	34.0	38.0	28.0	29.0	30.0	31.0	36.0
Calcium	10.2	10.3	10.2	10.2	10.2	10.1	10.0	10.1	10.1	10.3
Phosphorus	6.9	7.1	7.0	6.9	7.0	7.1	7.0	7.1	7.1	6.9
Sodium	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Linoleic acid	24.9	22.8	20.4	17.9	24.6	27.8	25.8	23.3	20.7	28.0
Arginine	14.4	15.5	16.4	17.5	20.1	12.6	13.7	14.6	15.7	18.2
Glycine + serine	18.7	19.2	19.8	20.4	19.8	14.6	15.1	15.7	16.3	15.7
Histidine	6.8	6.9	6.9	7.0	7.3	5.9	5.9	6.0	6.0	6.3

Table 2 to be continued

	Starter diet[2]					Finisher diet[2]				
	ECKP0	ECKP200	ECKP400	ECKP600	ECKP800	ECKP0	ECKP200	ECKP400	ECKP600	ECKP800
Isoleucine	12.0	12.0	11.9	11.9	12.1	9.8	9.8	9.7	9.7	9.9
Leucine	28.6	28.6	28.5	28.6	25.3	21.9	22.0	21.9	22.0	18.6
Lysine	17.6	17.7	17.7	17.6	17.6	15.9	15.9	15.9	15.9	15.9
Methionine	5.7	5.5	5.4	5.3	5.2	5.0	4.9	4.8	4.6	4.6
Methionine + cystine	9.8	9.8	9.9	9.9	9.9	8.6	8.6	8.6	8.6	8.6
Phenylalanine	14.4	14.3	14.2	14.1	13.7	11.7	11.6	11.5	11.4	11.0
Phenylalanine + tyrosine	25.3	25.0	24.6	24.3	23.1	20.4	20.1	19.6	19.3	18.2
Proline	14.9	14.6	14.3	14.0	10.9	11.3	11.0	10.7	10.5	7.3
Threonine	10.6	10.4	10.1	9.8	10.0	8.8	8.6	8.3	8.1	8.2
Tryptophan	2.7	2.7	2.8	2.8	3.2	2.3	2.4	2.4	2.5	2.9
Valine	12.9	13.0	13.1	13.3	13.3	10.5	10.6	10.7	10.9	10.9

[1]Dry matter content 905 g/kg

[2]ECKP0 = control treatment, ECKP200 = treatment with 200 kg/t extruded chickpea, ECKP400 = treatment with 400 kg/t extruded chickpea, ECKP600 = treatment with 600 kg/t extruded chickpea, ECKP800 = treatment with 800 kg/t extruded chickpea

[3]premix supplied per kg of diet: 15 000 I.U. vitamin A; 1 mg vitamin B1; 5 mg vitamin B2; 25 mg niacin; 11 mg pantothenic acid; 0.5 mg vitamin B6; 0.05 mg biotin; 1 mg folic acid; 200 mg choline; 0.015 mg vitamin B12; 10 mg vitamin C; 2 400 I.U. vitamin D3; 15 mg vitamin E; 2 mg vitamin K3; 0.25 mg Co; 7.5 mg Cu; 1.5 mg I; 40 mg Fe; 50 mg Mn; 0.15 mg Se; 50 mg Zn

Table 3. Body weight (BW), daily feed consumption (DFC), and feed conversion ratio (FCR) of male broiler turkeys from 1 to 84 days age

	Treatment[1]					SEM
	ECKP0	ECKP200	ECKP400	ECKP600	ECKP800	
BW (g)						
1st day of age	55.0	54.3	53.5	53.3	53.9	0.28
42nd day of age	2.012[ab]	2.126[b]	1.874[ac]	1.785[c]	1.805[c]	33.7
84th day of age	7.782[a]	7.803[a]	7.168[b]	7.191[b]	7.183[b]	90.7
DFC (g/day)						
1–42nd day of age	85.9	87.1	90.1	83.7	90.5	1.15
1–84th day of age	225.7	229.0	237.6	240.4	241.0	3.58
FCR (g DFC/g BW gain)						
1–42nd day of age	1.85[a]	1.77[a]	2.09[b]	2.03[b]	2.17[b]	0.04
1–84th day of age	2.46[a]	2.48[a]	2.81[b]	2.83[b]	2.84[b]	0.06

[1]ECKP0 = control treatment, ECKP200 = treatment with 200 kg/t extruded chickpea, ECKP400 = treatment with 400 kg/t extruded chickpea, ECKP600 = treatment with 600 kg/t extruded chickpea, ECKP800 = treatment with 800 kg/t extruded chickpea

[a-c]means within each row with different superscripts are significantly different ($P < 0.05$)

tially replace SBM at inclusion levels of 120 kg/t of diet without affecting final BW, DFC and FCR of broiler chickens compared to the SBM diet, whilst a higher inclusion level (240 kg/t of diet) adversely affected productive performance. Farrell et al. (1999) and Viveros et al. (2001) also found a negative effect on BW, DFC and FCR of broiler chickens fed diets containing raw chickpeas up to 450 kg/t of diet. Additionally, Viveros et al. (2001) reported that feeding autoclaved chickpeas up to 150 kg/t of diet increased BW gain and DFC, and did not change FCR compared with those fed the control diet. Moreover in laying hens, chickpeas supported excellent production when included at 250 kg/t of diet (Perez-Maldonaldo et al., 1999).

In comparison with other legumes, such as soybeans, chickpeas contain relatively small amounts of trypsin and chymotrypsin inhibitors (Saini,

Table 4. Carcass characteristics of male broiler turkeys at 84 days of age

	Treatment[1,2]					SEM
	ECKP0	ECKP200	ECKP400	ECKP600	ECKP800	
Fasted body weight (BW, g)	7 860[a]	7 900[a]	7 234[b]	7 350[b]	7 290[b]	82.90
Carcass weight (g)	6 061	6 033	5 700	5 601	5 584	64.20
Carcass yield (g/100 g BW)	77.1	76.3	78.8	76.2	76.6	0.56
Right breast muscles (g/100 g BW)	10.1	10.8	10.7	10.1	10.2	0.21
Right leg muscles (g/100 g BW)	8.6	8.1	8.6	8.0	8.4	0.09
Heart yield (g/100 g BW)	0.51	0.50	0.54	0.55	0.52	0.01
Liver yield (g/100 g BW)	1.44	1.40	1.54	1.45	1.47	0.03
Gizzard yield (g/100 g BW)	1.34	1.47	1.51	1.43	1.42	0.03

[1]ECKP0 = control treatment, ECKP200 = treatment with 200 kg/t extruded chickpea, ECKP400 = treatment with 400 kg/t extruded chickpea, ECKP600 = treatment with 600 kg/t extruded chickpea, ECKP800 = treatment with 800 kg/t extruded chickpea

[2]number of turkeys/treatment = 10

[a,b]means within each row with different superscripts are significantly different ($P < 0.05$)

1989). However, Chavan et al. (1989) reported similar ANF contents for chickpeas and soybeans, and Chavan et al. (1989) and Saini (1989) showed the possibility to reduce effects of ANF by various cooking and processing methods. Van der Poel (1989) reported that, among the various processes for heat treatment, extrusion offers very good results in destroying ANF of legumes. The combination of process temperature and heating time used in our study was based on Van der Poel (1989), who reported that trypsin inhibitor and haemagglutination activity of grain legumes (i.e. phaseolus bean) decreased, after extrusion at 145°C for 16 s, to 2 to 22% and 2 to 7%, respectively, of that determined in raw beans, and on Vooijs et al. (1993), who reported that trypsin inhibitor activity of grain legumes (i.e. phaseolus bean) decreased, after extrusion at 100°C and 130°C for 10 s, to 6 and 3% respectively, of that in raw beans.

In our study, carcass yield traits were not affected by the inclusion of extruded chickpeas in diets of broiler turkeys. Huisman and Van der Poel (1989) showed that some organs might become hypertrophic in chickens due to ANF contained in legume seeds. Feeding raw chickpeas to broiler chickens at inclusion levels up to 450 kg/t of diet resulted in increased weights of gizzard, liver and pancreas, and feeding autoclaved chickpeas at inclusion levels up to 150 kg/t of diet resulted in increased weight of the gizzard, and decreased weight of the liver, compared with those fed the control diet (Viveros et al., 2001). Carcass yield traits and internal organ weights of broiler chickens were not affected when raw chickpeas were incorporated at the inclusion level of 120 kg/t of diet, but they were negatively influenced by the higher inclusion level of 240 kg/t of diet (Christodoulou et al., 2006).

CONCLUSIONS

Replacement of SBM with extruded chickpeas, at inclusion levels up to 200 kg/t, in diets of broiler turkeys resulted in similar productive performance. However, replacement of SBM with extruded chickpeas at higher inclusion levels (400, 600 and 800 kg/t of diet) decreased BW by 7.7% and increased FCR by 14.9% compared to the control. Thus, extruded chickpeas can be used as an alternative protein source to replace SBM in broiler turkey diets at inclusion levels up to 200 kg/t.

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