The use of extruded chickpeas in diets for growing-finishing pigs

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ABSTRACT: The effect of partial and total replacement of soybean meal (SBM) with extruded chickpeas (*Cicer arietinum* L.) and partial replacement of SBM with raw chickpeas on pig growth and carcass characteristics was determined in a 17 week experiment. Sixty growing-finishing pigs were allocated to five dietary treatments: CKP0, ECKP100, ECKP200, ECKP300 and CKP100 of 12 animals each, and received a diet *ad libitum*. The diet for CKP0 treatment had no chickpeas (control), while those for treatments ECKP100, ECKP200 and ECKP300 included 100, 200 and 300 kg/t of extruded (at 120°C for 20 s) chickpeas, respectively, and for treatment CKP100 it included 100 kg/t of raw chickpeas. Body weight (BW) gain linearly increased ($P < 0.05$) and feed conversion ratio (FCR) linearly decreased ($P < 0.05$) with the inclusion of increasing levels of extruded chickpeas during the growing period. However, in both the growing and finishing period, there were no differences between extruded chickpea inclusion treatments in final BW, BW gain, daily feed consumption (DFC), FCR, and carcass yield traits. Partial replacement of SBM with raw chickpeas negatively affected ($P < 0.05$) BW gain and DFC during the finishing period. Extrusion offers a practical method for the heat processing of chickpeas for use in pig diets. Thus, extruded chickpeas can be used as an alternative protein source to SBM at inclusion levels up to 300 kg/t of diet.

Keywords: chickpeas; extrusion; pigs; growth 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; Salgado et al., 2001).

Intensive pig 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 pig 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 concentrate for pigs (Batterham et al., 1993; Mustafa

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et al., 2000), no information is available on the nutritional value of extruded chickpeas. Extrusion improves the utilization of starch, fat and protein contained in legumes by pigs (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 growing-finishing pigs relative to performance and carcass characteristics. Moreover, the use of raw chickpeas at a low inclusion level was also evaluated.

MATERIAL AND METHODS

Animals and treatments

Partial and total replacement of SBM with extruded or raw chickpeas in diets of growing-finishing pigs was studied in 60 weaned crossbred (Landrace × Large White) pigs (53 ± 4 days of age) in a 17-week experiment. All pigs used in the experiment were cared for according to applicable recommendations of European Union (EEC, 1986). Pigs, after individual weighing, were randomly allocated to five dietary treatments (CKP0, ECKP100, ECKP200, ECKP300 and CKP100) of 12 (6 intact males and 6 females) and accommodated in 4 floor pens/treatment of 3 pigs, being two pens of 3 males and two pens of 3 females. At the beginning of the experiment, the mean body weight (BW) of male and female pigs for the five groups was 19.5 ± 0.4 and 20.0 ± 0.4 kg, respectively. All 20 pens were identical, with the same covered area (2 m^2/pig), and were equipped with similar troughs for diets and water.

During the 119 days experimental period, pigs were weighed individually at the commencement, at 94 days of age and at the end, and BW gain was calculated. Feed intake was measured daily on a pen basis, and daily feed consumption (DFC) and feed conversion ratio (FCR) were calculated. At the end of the experiment, 3 male and 3 female pigs, randomly selected from each treatment, were fasted for 18 h (water was allowed), weighed and slaughtered. After dressing and storing refrigerated for 24 h at 3°C, carcasses were weighed according to European Union (EC, 1993) guidelines. Weights of heart, liver, kidney and kidney fat were recorded separately. Additionally, carcass yield and relative

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

	Chickpeas (*n* = 3)	Extruded chickpeas (*n* = 3)	Soybean meal (*n* = 3)
Dry matter	876	923	892
Crude protein	229	239	424
Crude fat	48	51	15
Crude fibre	36	38	59
Ash	30	39	55
Arginine	20.1	20.7	31.1
Histidine	6.8	7.0	12.3
Isoleucine	10.0	10.7	20.6
Leucine	18.5	19.0	30.1
Lysine	17.1	17.8	28.8
Methionine	1.7	1.8	6.0
Methionine + cystine	6.0	6.2	12.3
Phenylalanine	11.3	12.2	23.1
Phenylalanine + tyrosine	18.5	19.5	38.9
Threonine	8.4	8.9	19.1
Tryptophan	3.1	3.2	5.9
Valine	11.1	11.3	19.7
Gross energy (MJ/kg)	19.01	18.91	20.45
Digestible energy (MJ/kg)	13.93	14.68	14.82

Table 2. Composition[1] of growing (53 to 94 days of age) and finishing (95 to 171 days of age) pig diets (i.e. grower diet and finisher diet, respectively), as fed basis

	Grower diet[2]					Finisher diet[2]				
	CKP0	ECKP100	ECKP200	ECKP300	CKP100	CKP0	ECKP100	ECKP200	ECKP300	CKP100
Ingredient composition (kg/t)										
Maize grain, ground	250	250	250	250	250	250	250	250	250	250
Barley grain, ground	219.9	175.4	120	51.3	170.4	284.4	241.9	197.3	143.2	237.8
Wheat grain, ground	100	100	100	100	100	100	100	100	100	100
Wheat bran	150	150	150	150	150	150	140	120	100	140
Maize gluten meal (620 g/kg CP)	45	63	78	55	66	21	30	34	11	32
Soybean meal (424 g/kg CP)	160	80	0	0	80	120	60	0	0	60
Chickpeas extruded (239 g/kg CP)	0	100	200	300	0	0	100	200	300	0
Chickpeas (229 g/kg CP)	0	0	0	0	100	0	0	0	0	100
Sunflower meal (290 g/kg CP)	10	20	40	36	20	10	17	39	40	17
Vegetable fat	25	21	20	17	23	26	22	20	17	24
L-Lysine monohydrochloride	2	2.5	3	1.4	2.6	1.6	1.6	1.6	0	1.7
DL-Methionine 990 g/kg	0.1	0.1	0	0.3	0	0	0	0.1	0.3	0
Limestone	16	16	15	15	16	15	14.5	13.5	13	14.5
Monocalcium phosphate	14	14	16	16	14	14	15	16.5	17.5	15
Salt	4	4	4	4	4	4	4	4	4	4
Vitamin-mineral premix[3]	4	4	4	4	4	4	4	4	4	4
Chemical composition (g/kg)										
Digestible energy (MJ/kg)	13.71	13.70	13.71	13.72	13.72	13.51	13.50	13.51	13.53	13.52
Crude protein	182	179	180	182	181	154	152	155	157	154
Crude fat	51	51	53	53	53	52	51	52	52	53
Crude fibre	46	45	47	46	45	46	45	47	46	45
Ash	29	29	28	30	28	28	28	28	29	27
Calcium	9.6	9.6	9.6	9.7	9.6	9.1	9.1	9.1	9.2	9.1
Phosphorus	7.6	7.4	7.6	7.5	7.4	7.5	7.5	7.5	7.5	7.4
Sodium	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Linoleic acid	12.6	13.8	15.1	16.2	13.7	12.4	13.6	14.7	15.7	13.5
Lysine	9.5	9.5	9.5	9.5	9.5	8.0	8.0	8.0	8.0	8.0
Methionine + cystine	6.4	6.4	6.4	6.4	6.4	5.4	5.4	5.4	5.4	5.4
Threonine	6.7	6.4	6.1	6.2	6.4	5.7	5.5	5.3	5.4	5.5
Tryptophan	2.0	1.9	1.8	2.0	1.9	1.8	1.7	1.7	1.8	1.7

weights of the heart, liver, kidney, and kidney fat, expressed in kg/100 kg of BW, were calculated.

Carcasses were also classified according to the European 'SEUROP' system (EC, 1993). Loin lean depth ('F' value, mm) and loin fat depth ('S' value, mm) were measured after the last lumbar vertebra and in the middle of the *gluteus medius* muscle, respectively, using a scale (Branscheid et al., 1990; Ambrosiadis and Georgakis, 1994). This information was used with tables of the Research Centre for Nutrition and Food (Kulmbach, Germany) to estimate lean yield (kg/100 kg of BW) and, accordingly, to classify carcasses to 'SEUROP'.

Diets and feeding

Chickpeas (variety 'Serifos', Table 1) were used in this experiment with growing-finishing pigs, at the Animal Research Institute, National Agricultural Research Foundation (N.AG.RE.F.) in Giannitsa (Greece). Among six Greek chickpea varieties, 'Serifos' was assessed to have the highest nutritional value (Eberová et al., 2003). A portion of the chickpeas was heat treated to reduce ANF levels by extrusion 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). Ground chickpeas were 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 combination of process temperature and heating time was based on reports of Van der Poel (1989) and Vooijs et al. (1993).

During the experiment, all pigs in the five treatments received two types of diet (i.e. a grower diet or finisher diet; Table 2) *ad libitum*; a grower diet from 53 to 94 days of age (growing period), and a finisher diet from 95 to 171 days of age (finishing period), according to NRC (1998) nutrient requirements of pigs. Both diets for CKP0 treatment had no chickpeas (control), while those for treatments ECKP100, ECKP200 and ECKP300 included 100, 200 and 300 kg/t of extruded chickpeas, respectively, and for treatment CKP100 they included 100 kg/t of raw chickpeas. All diets in each type were isonitrogenous and isoenergetic, having the same level of the amino acids lysine, methionine and cystine, according to NRC (1998) nutrient composition values.

Chemical analyses

Chickpeas, extruded chickpeas, SBM and diets were analysed 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 AOAC (1990). Chickpeas, extruded chickpeas and SBM were also analysed for amino acids (AA) with an AAA400 AA analyser (INGOS, Czech Republic) and for gross energy content with a MS 10A adiabatic oxygen bomb calorimeter (ILABO, Czech Republic). All AA, except methionine, cystine, and tryptophan, were determined after hydrolysis with 6M HCl, while methionine and cystine, and tryptophan were determined after oxidative and alkaline hydrolysis, respectively. Digestible energy of chickpeas, extruded chickpeas and SBM was determined in a digestibility trial with pigs conducted at the Department of Animal Nutrition, University of Agriculture in Prague, Czech Republic (Mudřik Zdeněk, 2005, unpublished data).

Statistical analysis

Pig performance and carcass characteristics were statistically analysed as a factorial experiment with treatment, sex and treatment by sex interactions as factors in the model. The experimental unit was the pen of pigs for pig growth performance and the individual carcass for carcass characteristics. Differences between treatment means were tested using linear and quadratic contrasts at the 0.05 probability level (Steel and Torrie, 1980).

Explanation to Table 2

[1]Dry matter content 890 g/kg

[2]CKP0 = control, ECKP100 = 100 kg/t extruded chickpea, ECKP200 = 200 kg/t extruded chickpea, ECKP300 = 300 kg/t extruded chickpea, CKP100 = 100 kg/t chickpea

[3]premix supplied per kg of diet: 15 000 I.U. vitamin A; 1 mg vitamin B_1; 5 mg vitamin B_2; 25 mg niacin; 11 mg pantothenic acid; 0.5 mg vitamin B_6; 0.05 mg biotin; 1 mg folic acid; 500 mg choline; 0.015 mg vitamin B_{12}; 10 mg vitamin C; 2 400 I.U. vitamin D_3; 15 mg vitamin E; 2 mg vitamin K_3; 0.5 mg Co; 15 mg Cu; 3 mg I; 80 mg Fe; 100 mg Mn; 0.3 mg Se; 100 mg Zn, and 60 mg Salinomycin

Table 3. Body weight (BW), BW gain, daily feed consumption (DFC), and feed conversion ratio (FCR) of pigs from 53 to 171 d of age

	Treatment[1,2]										SEM	Significance level[3]							
	males					females						CKP0 vs. ECKP				CKP0 vs. CKP100			ECKP100 vs. CKP100
	CKP0	CKP 100	CKP 200	CKP 300	CKP 100	CKP0	CKP 100	CKP 200	CKP 300	CKP 100		T_{linear}	$T_{quadratic}$	S	S × T	T	S	S × T	
BW (kg)																			
53 days of age	19.5	19.5	19.5	19.5	19.5	20.0	20.0	20.0	20.0	20.0	0.308	0.989	0.995	0.498	0.992	0.983	0.671	0.993	0.994
94 days of age	46.5	47.0	49.3	49.6	48.4	46.7	49.3	50.0	49.0	47.5	0.624	0.186	0.551	0.678	0.929	0.528	0.865	0.805	0.900
171 days of age	121.5	120.2	123.5	124.0	121.4	120.3	113.8	117.7	111.8	107.6	1.175	0.626	0.806	0.015	0.482	0.132	0.082	0.138	0.604
BW gain (kg/day)																			
53–94 days of age	0.64	0.65	0.71	0.72	0.69	0.63	0.70	0.71	0.69	0.63	0.009	0.032	0.320	0.909	0.608	0.452	0.308	0.481	0.668
95–171 days of age	0.97	0.96	0.96	0.97	0.95	0.96	0.84	0.88	0.82	0.78	0.013	0.171	0.510	0.013	0.388	0.047	0.064	0.086	0.618
53–171 days of age	0.86	0.85	0.87	0.88	0.86	0.84	0.79	0.82	0.77	0.73	0.011	0.703	0.864	0.067	0.732	0.124	0.057	0.156	0.616
DFC (kg/day)																			
53–94 days of age	1.87	1.85	1.90	1.91	1.88	1.89	1.90	1.89	1.90	1.78	0.012	0.171	0.610	0.403	0.429	0.326	0.422	0.251	0.391
95–171 days of age	3.45	3.40	3.42	3.41	3.33	3.42	3.36	3.38	3.35	3.33	0.014	0.165	0.433	0.080	0.965	0.013	0.477	0.715	0.062
53–171 days of age	2.89	2.85	2.88	2.88	2.82	2.88	2.85	2.85	2.83	2.78	0.011	0.270	0.403	0.150	0.625	0.042	0.433	0.629	0.104
FCR (kg DFC/kg BW gain)																			
53–94 days of age	2.93	2.85	2.68	2.66	2.73	3.00	2.71	2.66	2.75	2.83	0.035	0.008	0.089	0.991	0.501	0.082	0.348	0.860	0.993
95–171 days of age	3.56	3.54	3.56	3.51	3.50	3.57	4.00	3.84	4.08	4.27	0.092	0.356	0.707	0.005	0.182	0.105	0.063	0.068	0.703
53–171 days of age	3.37	3.36	3.31	3.27	3.28	3.43	3.60	3.48	3.68	3.81	0.061	0.670	0.988	0.014	0.412	0.303	0.072	0.126	0.750

[1]CKP0 = control, ECKP100 = 100 kg/t extruded chickpea, ECKP200 = 200 kg/t extruded chickpea, ECKP300 = 300 kg/t extruded chickpea, CKP100 = 100 kg/t chickpea

[2]number of pigs/treatment = 6 males and 6 females, the experimental unit was the pen of pigs, and number of experimental units/treatment = 4 pens

[3]numbers are probability values

T = treatment; S = sex

RESULTS

There were very few feed refusals, and so the feed consumption of concentrates was similar in diets with increasing extruded chickpea inclusion levels (Table 3). Male pigs ate the same amount of concentrate as female pigs throughout the experiment, and there was no treatment by sex interaction for any response parame-ter. For the overall feeding period, the inclusion of extruded chickpeas in the diets did not affect pig performance. However, males exhibited a higher BW ($P = 0.015$) and a lower FCR ($P = 0.014$) than females. For the growing period alone, increasing extruded chickpea inclusion levels in the diets had a positive linear effect ($P < 0.05$) on BW gain and FCR compared with those fed the control diet, while in the finishing period, males gained weight substantially faster ($P = 0.013$) than females (0.97 vs. 0.88 kg/day), resulting in a lower ($P = 0.005$) FCR for males. Moreover, DFC and BW gain were lower ($P < 0.05$) in treatment CKP100 compared to treatment CKP0 for the finishing period, while there were no differences in perfor-mance between treatments ECKP100 and CKP100. All pigs remained healthy throughout the experiment.

There was no treatment by sex interaction for any response parameter of the CKP0 vs. ECKP treatments related to carcass weight or its composition (Table 4). Fasted BW, as well as cold carcass weight, carcass yield and lean yield were not affected by feeding diets with increasing levels of extruded chickpeas. There were no differences in weights of the heart, liver and kidney, either. In contrast, the weight of the kidney fat had a quadratic effect ($P = 0.047$; maximum at the intermediate extruded chickpea inclusion level). For the extruded chickpea diets alone, all response parameters were unaffected by sex, and all carcass yield traits between treatments CKP0 and CKP100, except the fasted BW and the weight of the heart, were similar for males and females. No differences occurred in pig yield traits between treatments ECKP100 and CKP100. The 'SEUROP' carcass classification system indicated superior (S) or excellent (E) quality for the majority of the carcasses irrespective of diet. Carcasses in treatment CKP0 were classified to the grade S (33.3%) and E (66.7%), in treatment ECKP100 to the grade S (50%) and E (50%), in treatment ECKP200 to the grade S (16.7%), E (66.7%), and U (16.7%), in treatment ECKP300 to the grade S (50%) and E (50%), and in treatment CKP100 to the grade S (33.3%), E (50%) and U (16.7%).

DISCUSSION

In this experiment, increasing extruded chickpea inclusion levels in the diets positively influenced BW gain and FCR during the growing period, but did not affect BW, BW gain, DFC and FCR during the whole growing/finishing period. The increased performance in growing pigs of the ECKP treatments may be attributed to the extrusion which improved the utilization of starch, fat and protein contained in chickpeas by pigs (Spais, 1997). The diet containing raw chickpeas negatively influenced BW gain and DFC during the finishing period, compared to the SBM diet, suggesting that pigs may have been susceptible to the ANF contained in raw chickpeas. In a study of young pig gut morphology, Salgado et al. (2001) observed moderate villus atrophy and crypt hyperplasia with the chickpea diets, resulting in impaired nutrient absorption and decreased performance. In comparison with other legumes, such as soybeans, chickpeas contain relatively small amounts of trypsin and chymotrypsin inhibitors (Saini, 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.

Mustafa et al. (2000) studied the nutritional value of raw chickpeas in an experiment with 64 growing-finishing pigs. For the finishing and whole experimental periods, BW gain, DFC and FCR were similar in the particular treatments, while the inclusion of raw chickpeas (300 kg/t) appeared to depress performance relative to the control SBM diet during the growing period. In another study, Batterham et al. (1993) evaluated the nutritional value of raw chickpeas in diets of growing pigs using concentrate mixtures containing SBM vs. Kabuli and Desi chickpeas (Mediterranean and Indian type, respectively) in proportions of 425:0 kg/t (control) vs. 325:250, 228:500 and 130:750 kg/t, and 281:250, 140:500 and 0:750 kg/t, respectively, and found that BW gain, DFC and FCR were similar in the treatments. Moreover, Visitpanich et al. (1985) found that BW gain and FCR for growing pigs were not affected when pigs received concentrate mixtures containing SBM vs. Kabuli and Desi chickpeas in proportions of 186:0 kg/t (control) vs. 46:263 and 46:272 kg/t, respectively.

Table 4. Carcass characteristics of pigs at 171 days of age

	Treatment[1,2]										SEM	Significance level[3]							
	males					females						CKP0 vs. ECKP				CKP0 vs. CKP100			ECKP100 vs. CKP100
	CKP0	CKP 100	CKP 200	CKP 300	CKP 100	CKP0	CKP 100	CKP 200	CKP 300	CKP 100		T_{linear}	$T_{quadratic}$	S	S × T	T	S	S × T	
Carcass characteristics																			
Fasted body weight (BW, kg)	122.3	113.3	124.0	123.7	121.0	121.7	118.0	121.0	114.3	111.3	0.712	0.782	0.423	0.244	0.071	0.197	0.030	0.044	0.486
Cold carcass weight[4] (kg)	95.4	91.6	98.5	96.4	95.6	95.9	91.8	93.5	88.7	87.6	0.725	0.528	0.892	0.107	0.311	0.319	0.053	0.037	0.667
Carcass yield (kg/100 kg of BW)	78.0	80.9	79.5	77.9	79.0	78.8	77.7	77.3	77.6	78.6	0.414	0.528	0.454	0.248	0.505	0.454	0.665	0.301	0.797
Lean yield (kg/100 kg of BW)	58.7	58.7	57.3	60.1	59.0	60.3	59.7	56.5	60.7	61.9	0.447	0.919	0.089	0.567	0.858	0.472	0.126	0.637	0.257
Heart yield (kg/100 kg of BW)	0.33	0.34	0.39	0.38	0.34	0.39	0.36	0.41	0.37	0.35	0.010	0.444	0.777	0.438	0.753	0.222	0.022	0.154	0.803
Liver yield (kg/100 kg of BW)	1.81	1.88	1.75	1.88	1.92	1.72	1.70	1.86	1.65	1.69	0.026	0.982	0.550	0.095	0.191	0.671	0.068	0.373	0.911
Kidney yield (kg/100 kg of BW)	0.27	0.32	0.29	0.29	0.33	0.27	0.28	0.24	0.28	0.28	0.005	0.773	0.855	0.100	0.524	0.131	0.215	0.151	0.940
Kidney fat yield (kg/100 kg of BW)	0.59	0.66	0.83	0.67	0.65	0.58	0.49	0.84	0.57	0.47	0.021	0.116	0.047	0.181	0.495	0.614	0.156	0.185	0.856

[1]CKP0 = control, ECKP100 = 100 kg/t extruded chickpea, ECKP200 = 200 kg/t extruded chickpea, ECKP300 = 300 kg/t extruded chickpea, CKP100 = 100 kg/t chickpea
[2]number of pig carcasses/treatment = 3 males and 3 females, the experimental unit was the individual carcass, and number of experimental units/treatment = 6 carcasses
[3]numbers are probability values
[4]according to EC (1993)

Our findings that pigs slaughtered at approximately 119 kg of fasted BW did not differ in cold carcass weight, carcass yield and lean yield when the different chickpea inclusion levels were used, are consistent with Mustafa et al. (2000), who showed that pigs slaughtered at an average weight of 102 kg had the same carcass yield (76.1 kg/100 kg of BW) and lean yield (59.7 kg/100 kg of BW) in the groups fed SBM or with 300 kg/t inclusion le-vels of chickpeas and field peas in the concentrate. Moreover, pigs slaughtered at 45 to 50 kg had the same carcass yield (73.1 to 74.7 kg/100 kg of BW) when chickpeas were added to the diets, even at 750 kg/t (Visitpanich et al., 1985; Batterham et al., 1993).

In our study there were no differences in the weight of heart, liver and kidney, while the weight of kidney fat had a quadratic effect. Similarly, diet supplementation with chickpeas at inclusion levels of 250, 500 and 750 kg/t had no effect on liver weight of pigs (Batterham et al., 1993). However, feeding raw chickpeas to rats, at inclusion level of 527 kg/t of the concentrate mixture, higher than the level of extruded chickpeas in this study, resulted in increased liver weight, while the weight of heart and kidney remained unchanged, compared to those fed SBM (Rubio et al., 1999).

CONCLUSIONS

Extruded chickpeas can be used for pig diets, at inclusion levels up to 300 kg/t, as an alternative protein source to soybean meal, without affecting their performance and carcass characteristics.

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