Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)
Available online at www.inia.es/sjar
http://dx.doi.org/10.5424/sjar/2014121-4714

Spanish Journal of Agricultural Research 2014 12(1): 180-185
ISSN: 1695-971-X
eISSN: 2171-9292

Short communication. Effect of soybean meal heat procedures on growth performance of broiler chickens

Mohaddeseh Tousi-Mojarrad[1], Alireza Seidavi[1]*, Mohammad Dadashbeiki[2] and Ana Isabel Roca-Fernandez[3]

[1] Department of Animal Science. [2] Department of Veterinary Science. Rasht Branch. Islamic Azad University. Rasht, Iran. [3] Department of Animal Production. Galician Institute of Food Quality. Agrarian Research Centre of Mabegondo. A Coruña, Spain

Abstract

The aim of this research was to study the effect of soybean meal (SBM) heat procedures on growth performance of broiler chickens. A trial was carried out using 200 male Ross 308 strain chickens during 3 feeding periods (starter, grower and finisher, 42 days). The experiment was based on a completely randomized design with 5 treatments giving 4 replications of 10 broilers per treatment. Treatments consisted on: T1 (control, un-processed SBM), T2 (autoclaved SBM: 121°C, 20 min), T3 (autoclaved SBM: 121°C, 30 min), T4 (roasted SBM: 120°C, 20 min) and T5 (microwaved SBM: 46°C, 540 watt, 7 min). Growth performance of animals was examined by determining body weight (BW), body weight grain (BWG), feed intake (FI) and feed conversion rate (FCR). Higher BW ($p < 0.05$) and BWG ($p < 0.05$) and lower FCR ($p < 0.05$) were found in broiler chickens fed heat processed SBM diets compared to those fed a raw SBM diet, probably due to higher nutrient availability. However, no differences were found among heat SBM procedures (autoclaving, roasting and microwaving) on growth performance of animals for the starter, grower and finisher periods. From the results of this experiment, it is concluded that further research needs to be developed to establish the effect of temperature-time heat procedures on nutritive value of SBM in terms of levels of anti-nutritional factors (trypsin inhibitor activity and phytic acid) and amino acids profile and its influence on growth performance of broilers.

Additional key words: feed conversion ratio; poultry nutrition; thermal processes; *Glycine max*.

Soybean meal (SBM) is the primary source of plant protein commonly used in poultry nutrition since its amino acid balance is appropriate for diets (Marsman *et al.*, 1997). However, the use of raw SBM by monogastric animals is not totally efficient due to the presence of anti-nutritional factors (ANFs) (Ebrahimi-Mahmoudabad & Taghinejad-Roudbaneh, 2011). These ANFs interfere with metabolic processes and reduce nutrient availability (Coulibaly *et al.*, 2011). In fact, feeding raw unprocessed SBM usually reduces growth rate and feed efficiency, causes pancreatic gland enlargement and decreases digestibility and availability of amino acids in broiler chickens (Gilani *et al.*, 2005). Hamilton & Sandstedt (2000) also reported that body weight (BW), body weight gain (BWG) and feed intake (FI) were higher and feed conversion ratio (FCR) was lower on broiler chickens when raw unprocessed SBM was replaced by heat processed SBM.

To inactivate or remove ANFs in poultry diets, various heat procedures (extrusion, cooking, toasting and roasting) have been reported to be efficient in reducing trypsin inhibitor activity (TIA) and phytic acid (PA) in soybeans (Ari *et al.*, 2012). Habiba (2002) declared that cooking, autoclaving and microwaving are the most successful soybean heat procedures that may have an important role in removing these ANFs. Unfortunately, limited research has been developed on the comparison of different soybean heat procedures (Ari *et al.*, 2012) in poultry performance (Akande & Fabiyi, 2010). To fill this gap, an experiment was carried out with the aim of investigating the effect of SBM heat procedures (autoclaving, roasting and microwaving) *vs.* un-processed raw

* Corresponding author: alirezaseidavi@iaurasht.ac.ir
Received: 07-07-13. Accepted: 10-02-14.

Abbreviations used: ANFs (anti-nutritional factors); BW (body weight); BWG (body weight gain); FCR (feed conversion ratio); FI (feed intake); PA (phytic acid); SBM (soybean meal); TIA (trypsin inhibitor activity A).

SBM on growth performance of broiler chickens in three feeding periods (starter, grower and finisher).

The experiment was performed in the poultry farm of Islamic Azad University, Rasht Branch, Iran in 2011. Two hundred male Ross 308 strain broiler chickens were weighed, allocated in 20 pens of 1.5 × 1 m and randomly assigned to 1 of 5 treatments giving 4 replicates of 10 broilers per treatment. The dietary treatments were: T1 (control, un-processed SBM), T2 (autoclaved SBM: 121°C, 20 min), T3 (autoclaved SBM: 121°C, 30 min), T4 (roasted SBM: 120°C, 20 min) and T5 (microwaved SBM: 46°C, 540 watt, 7 min). The experiment was a completely randomized block design. Three periods were considered: starter (14 days), grower (21 days) and finisher (7 days). Feed ingredients and nutrient composition of the diets during the starter, grower and finisher periods are presented in Table 1. In the experiment, feed and water were provided *ad libitum*. Ventilation system was supplied using window fans and air conditioner. Hall lighting was supplied by 100 watt light bulb in a 23 hour-light and 1 hour-dark cycle. The room temperature was warmed up to a level of 32-33°C. Then, the temperature was gradually reduced to 22°C in day 27th and maintained until the end of the experimental period.

The SBM processing methods were carried out as reported Nahavandinejad *et al.* (2012). The SBM was prepared as 1.5 kg per batch. For the autoclaving process, the SBM was autoclaved at 121°C and 1 Pascal pressure using Iran Teb Zaeem autoclave power 2000 for 20 min (T2) and 30 min (T3). In the case of roasting, SBM was spread out in an aluminium tray to obtain an evenly 2 cm thick layer and placed in a digital oven (Memmert Do 636, UNB 400 model) set at 120°C for 20 min (T4). For the microwave processing, SBM was microwaved in an oven (LG, TCR 4284-CC, Korean) set at 46°C and 540 watts (T5). Before moisture processing, the SBM was measured by the psychrometer and brought to 25% moisture content. Then, the SBM was placed in a 50-70 mm diameter Pyrex plate and microwaved for 7 min. After autoclaving, roasting and microwaving, the SBM samples were transferred to a tray to cool down prior to stocking into plastic bags and then were kept refrigerated at 4°C until use.

At the beginning of the experiment and at the end of each week (1-6) and feeding period (starter, grower and finisher) the BW (g) and FI (g day^{-1}) were determined on all the tested groups. Both values were used to calculated BWG (g day^{-1}) and FCR. Data were analyzed by SPSS and GLM procedure was used. The

Table 1. Feed ingredients and nutrient chemical composition of used diets during the three experimental periods[1]

	Starter	Grower	Finisher
Ingredients			
Corn (%)	46.09	50.91	48.88
Soybean meal (%)	40.00	35.00	39.97
Fish meal (%)	3.00	3.00	0.00
Meat meal (%)	3.00	3.00	0.00
Soya oil (%)	4.56	5.45	7.38
DL-Methionine (%)	0.29	0.23	0.17
L-Threonine (%)	0.30	0.00	0.00
Calcium (22%) & Phosphorus (18%)	0.99	0.75	1.64
$CaCO_3$ (%)	0.98	0.76	1.00
KCl (%)	0.05	0.03	0.00
NaCl (%)	0.37	0.37	0.37
Vitamin & mineral mixture (%)	0.60	0.50	0.50
Nutrients			
Dry matter (%)	89.54	89.54	89.86
Crude protein (g kg^{-1})	24.9	23.0	22.0
Metabolizable energy (kcal kg^{-1})	3,025	3,150	3,200
Calcium (%)	1.05	0.90	0.85
Available phosphorus (%)	0.50	0.45	0.42

[1] Periods: starter (14 days), grower (21 days) and finisher (7 days).

Table 2. Mean comparison (± standard error of the mean) of body weight (BW, g), body weight gain (BWG, g day^{-1}), feed intake (FI, g day^{-1}) and feed conversion ratio (FCR) among the five studied treatments

	Periods[1]	Treatments[2]				
		T1	T2	T3	T4	T5
BW (g)	Starter	$369^{a} \pm 7.5$	$432^{b} \pm 7.2$	$438^{b} \pm 4.6$	$425^{b} \pm 10.3$	$435^{b} \pm 6.3$
	Grower	$1,884^{a} \pm 24.1$	$2,090^{ab} \pm 18.2$	$2,128^{b} \pm 71.6$	$2,071^{ab} \pm 51.9$	$2,141^{b} \pm 75.8$
	Finisher	$2,424^{a} \pm 15.4$	$2,546^{ab} \pm 92.0$	$2,677^{b} \pm 32.1$	$2,595^{b} \pm 27.4$	$2,614^{b} \pm 28.8$
BWG (g day^{-1})	Starter	$23.1^{a} \pm 0.58$	$27.5^{b} \pm 0.47$	$27.9^{b} \pm 0.31$	$27.0^{b} \pm 0.71$	$27.8^{b} \pm 0.45$
	Grower	72.1 ± 1.44	78.9 ± 5.39	80.5 ± 3.19	78.4 ± 2.67	84.3 ± 3.91
	Finisher	70.6 ± 4.35	72.8 ± 6.05	82.9 ± 8.88	78.9 ± 7.17	71.4 ± 5.31
	Total	$57.6^{a} \pm 0.27$	$60.8^{ab} \pm 1.08$	$63.8^{b} \pm 0.65$	$61.8^{b} \pm 0.68$	$62.3^{b} \pm 0.59$
FI (g day^{-1})	Starter	38.7 ± 0.92	39.5 ± 0.81	38.4 ± 1.18	36.7 ± 0.63	39.1 ± 1.38
	Grower	133.1 ± 1.35	136.6 ± 1.97	143.8 ± 4.70	143.6 ± 3.61	145.5 ± 3.40
	Finisher	167.5 ± 11.59	146.5 ± 9.15	161.4 ± 12.25	156.1 ± 9.80	148.4 ± 10.90
	Total	$121.8^{a} \pm 1.71$	$105.8^{b} \pm 2.33$	$114.5^{ab} \pm 2.34$	$112.2^{ab} \pm 2.90$	$110.0^{ab} \pm 3.07$
FCR	Starter	$1.67^{a} \pm 0.065$	$1.43^{b} \pm 0.062$	$1.37^{b} \pm 0.055$	$1.36^{b} \pm 0.056$	$1.41^{b} \pm 0.063$
	Grower	1.87 ± 0.044	1.75 ± 0.035	1.78 ± 0.028	1.84 ± 0.089	1.81 ± 0.060
	Finisher	$2.37^{a} \pm 0.092$	$2.02^{b} \pm 0.055$	$1.97^{b} \pm 0.091$	$1.99^{b} \pm 0.080$	$2.08^{b} \pm 0.050$
	Total	$2.11^{a} \pm 0.022$	$1.74^{b} \pm 0.106$	$1.79^{b} \pm 0.055$	$1.81^{b} \pm 0.078$	$1.76^{b} \pm 0.089$

[1] Periods: starter (14 days), grower (21 days) and finisher (7 days). [2] Treatments: T1 (control, unprocessed SBM); T2 (autoclaved SBM at 121°C during 20 min); T3 (autoclaved SBM at 121°C during 30 min); T4 (roasted SBM at 120°C during 20 min) and T5 (microwaved SBM at 46°C and 540 watt during 7 min). [a,b] Means in each row followed by different letters for each treatment are significantly different at $\alpha = 0.05$.

means were compared by Duncan multiple range test. The results were considered significantly different when $p < 0.05$.

The results showed that there were differences ($p < 0.05$) on BW of broiler chickens for the starter period between the control treatment and the others (Table 2). Lower BW of animals ($p < 0.05$) was found for the starter period in the control treatment (369 ± 7.5 g) compared to the average BW of animals in the heat processed SBM treatments (433 ± 7.1 g). Differences ($p < 0.05$) were also found on BW for the grower period between the control treatment (1,884 ± 24.1 g) and the treatments T3 and T5 (2,128 ± 71.6 and 2,141 ± 75.8 g, respectively), however, no differences were found on BW of broiler chickens among both heat processed SBM treatments. The BW of broiler chickens for the finisher and total periods was lower ($p < 0.05$) in the control treatment (2,424 ± 15.4 g) than in the treatments T3, T4 and T5 (2,677 ± 32.1, 2,595 ± 27.4 and 2,614 ± ± 28.8 g, respectively), without any significant differences among these heat SBM treatments. There were differences ($p < 0.05$) on BWG between the T1 and the others (T2-T5) for the starter period. Lower BWG of broiler chickens ($p < 0.05$) was found for the starter period in the control treatment (23.1 ± 0.58 g day^{-1}) compared to the average BWG reached by animals in the heat processed SBM treatments (27.6 ± 0.49 g day^{-1}), without any differences among the four compared heat SBM treatments. No differences ($p > 0.05$) were found between the five treatments on BWG for the grower and finisher periods. However, total period BWG of broiler chickens was lower ($p < 0.05$) in animals fed the control treatment diet (57.6 ± 0.27 g day^{-1}) than in those fed the heat processed SBM diets in T3 (63.8 ± 0.65 g day^{-1}), T4 (61.8 ± 0.68 g day^{-1}) and T5 (62.3 ± 0.59 g day^{-1}). No differences were found in BWG of animals for the total period among the heat processed SBM treatments. There were not differences ($p > 0.05$) between treatments on FI of broiler chickens for the starter, grower and finisher periods. Nevertheless, total period FI was higher ($p < 0.05$) in the control treatment (121.8 ± 1.71 g day^{-1}) than in the T2 (105.8 ± 2.33 g day^{-1}) but no differences ($p > 0.05$) were found for the other heat processed SBM treatments (T3, T4 and T5). Differences were found ($p < 0.05$) on FCR for the starter, finisher and total periods between the unprocessed treatment and the heat processed SBM treatments. Higher ($p < 0.05$) FCR values were found in broiler chickens fed the control treatment for the starter (1.67 ± 0.065), finisher (2.37 ± 0.092) and total

(2.11 ± 0.022) periods compared to the average FCR of animals in the heat processed SBM treatments (1.39 ± 0.059, 2.02 ± 0.069 and 1.78 ± 0.088, respectively). However, no differences were found between the four heat SBM treatments on FCR of broiler chickens for the starter, grower, finisher and total periods.

Results from the current study pointed out a greater growth performance and feed efficiency on broiler chickens fed heated (autoclaving, roasting or microwaving) SBM as compared with raw SBM. Broiler chickens fed heat-processed SBM are considered, therefore, more efficient users of food in terms of growth performance, probably due to higher nutrient availability, than those fed raw SBM. Our findings are in line with those of several authors who reported that SBM heat procedures improve the nutritive value and remove ANFs in poultry diets, causing better growth performance of broiler chickens: dry heating (Prachayawarakorn *et al.*, 2006) extrusion (Kidd *et al.*, 2005), cooking (McNaughton & Reece, 1980), roasting (Hamilton & McNiven, 2000), toasting (Huisman & Tolman, 1992), autoclaving (Anderson-Hafermann *et al.*, 1992), microwaving (Hafez *et al.,* 1983) and infrared (Ebrahimi-Mahmoudabad & Taghinejad-Roudbaneh, 2011). Contrasting results have been reported by Waldroup & Cotton (1974) who found similar BWG by broilers fed heat processed full-fat soybeans or SBM containing diets. Papadapoulos & Vandoros (1988) included heat processed full-fat soybeans in broiler diets at a level of 15% and reported that BW of animals at 6 weeks of age was not adversely affected. Differently, Leeson *et al.* (1987) included toasted full-fat soybeans in broiler starter and finisher diets at a level of 30% of the diet and they reported reduced growth rates of birds during the starter period because of a decrease in FI of animals possibly due to the heat treatment of the soybeans used in this trial might not have been adequate to completely destroy growth inhibitors. However, the detrimental effects became less severe as bird age increased. When 100% of raw SBM was replaced by roasted or autoclaved full-fat soybeans, Chohan *et al.* (1993) reported lower BW of animals at 3 weeks of age. Among the birds fed the full-fat soybeans containing diets, those fed the heat-treated soybeans had higher BW and BWG than those fed the diets containing raw full-fat soybeans or low trypsin inhibitor full-fat soybeans. They attributed this to trypsin inhibitor levels in the diets containing raw full-fat soybeans or low trypsin inhibitor full-fat soybeans were not sufficiently reduced to support acceptable growth rates of broiler chickens, even when methionine supplementation was used in these diets. In contrast, growth performance of the birds fed diets that contained autoclaved full-fat high protein soybeans was similar to that obtained with diets containing autoclaved full-fat soybeans when the diets were isonitrogenous and isocaloric. They stated that autoclaved full-fat high protein soybeans may replace autoclaved full-fat soybeans in broiler chickens starter diets if the formulation is adjusted for the differences in protein and fat.

In our experiment no significant differences were found among heat SBM procedures on growth performance of broiler chickens. In contrast, Cheva-Isarakul & Tangtaweewipat (1995) reported that broiler chickens fed full-fat roasted soybean showed inferior growth performances than those fed streamed or extruded products. It was attributed to the fact that streaming was superior to roasting or extrusion in the destruction of TIA. Ari *et al.* (2012) corroborated it because all the thermal processing soybean methods examined by them (extrusion, cooking, toasting and roasting) reduced TIA and PA compared to unprocessed soybean. The percentage reduction of TIA was the highest when cooking method was applied (85%) to soybean. This value was closely followed by extruded soybean (61%). Meanwhile, the reduction proportions of TIA for toasted and roasted soybean were the lowest (52 and 54%, respectively). The highest reduction in PA was, however, observed with roasted soybean (72%) and closely followed by 71% in extruded soybean while cooked was a bit lower (67%) and toasted soybean gave the least reduction in PA (48%). The reduction in TIA observed in the experiment of Ari *et al.* (2012) was consistent with the report of Cheva-Isarakul & Tangtaweewipat (1995), who indicated that steaming was more effective than roasting in TIA inactivation while PA reduction is best achieved through roasting.

Energy value of SBM heat products depends highly on technique processes, which influence on nutrient chemical composition, digestibility and availability of amino acids (Ari *et al.*, 2012). Nevertheless, the method, time and temperature used needs to be optimized since under-heating part of the ANFs are not well destroyed while over-heating causes unavailability of some amino acids. In fact, the digestibility and availability of essential amino acids are increased when autoclaving occurs at 121°C further than 20 min, causing higher growth performance of broiler chickens as happened with the T3 of our trial due to higher destruction of ANFs by the heat treatment, while the excessive hot processing when SBM is autoclaved at 121°C for 40 min decreases digestibility and availability of lysine and cystine (Parsons *et al.*, 1992) and provokes lower growth performance of broiler chickens (Anderson-Haferman *et al.*, 1992). Marsman *et al.* (1997) showed that at a relatively stable FI level, higher BWG and better FCR were observed when SBM heating process was applied, indicating that nutrients are better absorbed in the gastrointestinal tract of broiler chickens. Kaankuka *et al.* (1996) also stated that the consumption of raw unprocessed SBM compared to those heating processed increases pancreas and duodenal weight but reduces FI and growth performance of broilers. It agrees with the results of Tousi-Mojarrad *et al.* (2012) from the current experiment, where maximum pancreas weight was observed in broiler chickens fed the raw SBM diet than in those fed the heat processed SBM diets. There is, however, little information on the effectiveness of microwaving process, but Hafez *et al.* (1983) found that the best growth performance values on broiler chickens were achieved when microwaving SBM process occurred during 9 min.

From the results of the current experiment, it is concluded that broiler chickens fed heat processed SBM diets showed higher BW and BWG and lower FCR than those fed a raw SBM diet. However, no differences were found among heat SBM procedures (autoclaving, roasting and microwaving) on growth performance of animals. Further research needs to be developed to establish the effect of temperature-time heat procedures on the nutritive value of SBM in terms of levels of ANFs (TIA and PA), amino acids availability and its influence on growth performance of broilers.

Acknowledgements

We are grateful to Islamic Azad University in Iran for supporting the M. Tousi- Mojarrad´s MSc Thesis.

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