Research Article

Effect of Replacement of Soybean Meal with Toasted Pigeon Pea (*Cajanus cajan*) Seed Meal on Growth Performance of Broiler Chickens

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Abstract | Scarcity and the high market price of conventional protein concentrates are some of the major constraints of poultry production in the tropics. To alleviate this problem utilization of non-conventional feedstuffs like pigeon pea could contribute to the increased supply of animal protein sources in the tropics. to determine the effects of replacement of soybean meal with toasted pigeon pea seed meal (PSM) on the growth performance of broilers. A total of 180 unsexed, day-old broiler chicks were divided into four groups and randomly assigned to four treatment rations containing 0 % (T_1), 10% (T_2), 20% (T_3), and 30% (T_4) toasted PSM in a complete randomized design with three replications. There were highly significant differences (P<0.001) in daily and total DM intake overall. The birds fed T_3 and T_4 had significantly (P<0.05) higher daily and total DMI compared to the control group during the finisher phase and the overall period. There were high significant (P<0.001) BW gain, and ADG during the finisher phase and overall period. Birds fed T_3 and T_4 had significantly (P<0.05) higher, BW gain, and ADG compared to the control group birds. There was no significant (P>0.05) difference in FCR in all phases. Therefore, replacement of SBM by toasted PSM in diets of broiler particularly at the levels of 20% and 30% enhanced optimum growth of birds without any adverse effect on the growth performance of broiler birds.

Keywords | Broilers chicks, Toasted pigeon pea, Growth Performance, DMI, BW gain

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INTRODUCTION

Poultry production is one area of livestock production with a significant contribution to human food production. However, poultry producers in the tropics particularly in Ethiopia have been limited by scarcity and the high market price of conventional protein and energy concentrates. In the case of commercial poultry production feed accounts for 60-70% of the total cost of production (Thirumalaisamy et al., 2016). The large segment of the energy acquirement of poultry is obtained from cereal grains, which are cultivated mainly for human consumption in the tropics. Thus poultry production is directly competitive with human population for the available scarce energy feed resource. Moreover, there is a shortfall in the supply of soybean meal used as protein source source in the tropics, including Ethiopia. Therefore, a conventional source of raw materials, which are less exploited by man, is one of the solutions to reduce the cost of production and contribute to the increased supply of animal protein to the rich of poor people (Amin and Cheah, 2010). One of such feed sources that could be used to reduce the problem of the high cost of conventional protein sources in livestock diets with particular reference to poultry is the pigeon pea (Igene et al., 2012).

Pigeon pea has a good nutritional profile that could replace maize and soybean (Amaefule and Obioha, 2001). It seems to be a better and cheaper protein source for poultry feeding as compared to other legume grains. Pigeon pea (*Cajanus*

cajan) seed contains crude protein (CP) of 22–27%, crude fiber (CF) of 7.3–10%, nitrogen-free extract (NFE) of 61.2%, ether extract (EE) of 1.7–2.1%, ash of 3.1–4.2%, and lysine of about 7.59%. It is also a good source of soluble vitamins, especially thiamin, riboflavin, niacin, and choline (Ahmed et al., 2006). However, like most legumes pigeon pea seeds also contain some anti-nutritional factors such as oligosaccharides (raffinose and verbascose), polyphenols (phenols and tannins), phytolectins, and enzyme inhibitors (Saxena et al., 2010). The effect of the antinutritional factors could be reduced through processing and supplementation with the enzyme (Akintunde et al., 2010). Heat treatment has been established as an effective method of destroying these antinutritional factors. Therefore, this study was conducted to study the feasibility of replacing soybean meal with toasted pigeon pea (*Cajanus cajan*) seed meal in the broiler diet.

MATERIALS AND METHODS

Preparation of pigeon pea seeds

The experiment was conducted in the Poultry Farm of Agriculture Technical Vocational Education and Training College, Wolaita Sodo. The pigeon pea (*Cajanus cajan*) seed was obtained from the local market. The seed was toasted on a hot plate at 100 °C for 15 min (Etuk et al., 2002). The toasted seeds were spread out in the air to cool, dehulled, ground and included in the treatment diets as shown in Table 1.

Ethical consideration

The experimental chicks were treated or managed according to an animal experimental protocol approved by the Ethics Commission of the Wolaita Sodo University.

Experimental ration and treatments

Four treatments of each of the starter and finisher broilers rations were prepared. The treatment rations were formulated to be iso-caloric and iso-nitrogenous according to the standard for commercial broiler birds recommended by Leeson and Summers (2005). The starter and finisher control treatment diet were formulated to contain about 35% and 28% soybean meal, respectively. Therefore, four broiler treatment diets containing 0, 10, 20, and 30% of Pigeon pea as a replacement of soybean meal were formulated as shown in Table 1.

Experimental design

A total of 180-day-old unsexed broiler birds (Cobb-500) were purchased from a commercial farm. The birds with an initial mean body weight of 41.44±0.71g were randomly divided into 4 dietary treatments and the four starters treatment rations were randomly assigned to the experimental chicks in a completely randomized design with three replications. The experimental chicks were introduced to the finisher treatment ration at the end of 28 days feeding trial.

Management of birds

The birds were raised for 7 weeks in a deep litter housing system. The house was portioned into 12 pens and all the pens had the same space and dimension of 1.50*1.65m. Wood shavings were used as litter material at a depth of 10 cm. The birds were placed under an electric brooder heated by 200-watt bulbs with gradual height adjustment. The brooding temperature was maintained at 32°C during the first week and reduced by 2°C until it reached the room temperature of 24°C. Feeds and water were provided on *ad-libitum* throughout the experimental period. The chicks were vaccinated against Newcastle disease and infectious bursal disease (Gumboro).

Chemical analysis

The dietary feed ingredients, feed offered, and refusals were analyzed Dry matter, Ether extract (EE), Crude fiber (CF), and total ash and crude proteins were determined according to the procedure of AOAC (2005). Calcium was determined by atomic absorption spectrophotometer and phosphorus by calorimetric methods as described by AOAC (2005). All samples were analyzed in the food science and nutrition research Laboratory of Ethiopia public health institute and Chemistry laboratory of Arba Minch University. The metabolizable energy (ME) was estimated by the formula: ME (Kcal/kg DM)= 3951 + 54.4EE - 88.7CF- 40.8Ash (Wiseman, 1987).

Bodyweight gain and feed conversion ratio (FCR)

Birds were weighed in the group at the beginning and weekly interval until the end of the experiment. The birds were weighed early in the morning before feeding. The average final body weight was calculated as the difference between the two successive weights divide by the number of birds. Average daily gain (ADG) was calculated as the mean of final body weight change to the number of experimental days. The feed conversion ratio was calculated as the ratio of average feed intake to average BW gain.

Nutrients intake

The feed intakes were determined as the difference between the feed offered and refused (Tusar et al., 2015). Dry matter (DM), Crude protein, and Metabolizable energy (CP and ME) were calculated by difference from offered and refusals on a dry matter basis. The DM, CP, and ME intake were computed by multiplying the daily as well as the total feed consumption by their respective DM, CP, and ME contents.

Table 1: Ingredients and nutrient contents of the starter and finisher diets fed to broilers.

Ingredients (%)	Starter phase				Finisher phase			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
Maize	43	46.7	41.7	44.7	56	56	51	49.63
Soya bean meal	35	31.5	28	24.5	28	25.2	22.4	19.6
Wheat middling	13	8	9	5	5.7	5.7	7.7	7.7
Noug cake	4.3	5.5	9.5	10.5	6.07	6.07	9.07	11.07
PSM (toasted)	-	3.5	7	10.5	-	2.8	5.6	8.4
Limestone	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Salt	1	1	1	1	1	1	1	1
Vitamin premix	2	2	2	2	2	2	2	1
Methionine	0.3	0.3	0.3	0.3	0.13	0.13	0.13	0.2
Lysine	0.7	0.8	0.8	0.8	0.4	0.4	0.4	0.7
Total	100	100	100	100	100	100	100	100
Nutrient content (% DM basis)								
ME (kcal/kg)	2993	2990.5	2993.6	2992.7	3160.1	3160.2	3160.5	3161
Dry matter	92.64	92.76	92.81	92.79	89.46	89.59	89.91	90.14
Crude Protein	22	21.7	21.87	21.8	19.02	18.92	18.92	18.9
Crude Fiber	5.9	6.31	6.66	6.89	6.58	6.88	6.9	7.68
Ether Exract	2.46	2.28	2.31	2.16	1.78	1.90	1.92	2.18
Calcium	0.99	1	1	1.2	0.96	0.96	0.97	0.99
Phosporous	0.79	0.71	0.74	0.68	0.51	0.51	0.51	0.48

T1 = 0% PPSM; T2 = 10 % PPSM; T3 = 20 % PPSM; T4 = 30 % PPSM; ME=Metabolizable, PSM= Pigeon Pea Seed Meal.

Protein and energy efficiency ratio

The Protein Efficiency Ratio (PER) was calculated as the ratio of weight gained to protein consumed and the Energy Efficiency Ratio (EER) was calculated as weight gain multiplied by hundred over the total ME intake (Kamran et al., 2008).

Statistical analysis

Data were subjected to ANOVA using the general linear models (GLM) procedures to determine the treatment effects on growth performance traits. SAS statistical package version 9.3 was used to analyze the data (SAS, 2010). A treatment difference between group means was evaluated by Duncan's Multiple Range Test at a 5% level of significance.

RESULTS AND DISCUSSION

Nutrient intake of broilers

Dry matter, crude protein, and Metabolizable energy intake of broiler birds fed on different levels of toasted PSM are presented in Table 2. There were significant differences (P<0.001) among treatment groups in mean daily and total DM intake during the both the starters and finishers periods. The birds fed on T_3 (the ration containing 20% of PSM as substitute of soya bean meal) had significantly (P<0.05) higher daily and total DMI followed by the groups fed on T_4, T_2, and T_1 during the finisher phase and the entire period. The group birds placed on T_2 and T_3 had significantly (P<0.05) higher DMI compared to the group birds fed on T_1 (control treatment).

There was significant difference (P<0.001) in crude protein (CP) intake among treatments during the starter phase and the entire period. At the starter phase, the groups fed on the treatments containing PSM (T_3,T_4 and T_2) showed improvement in CP intake (P<0.05) than the group birds assigned to the control treatment (T_1) birds. There was a significant difference (P<0.05) among group treatments in mean daily crude protein intake during the finishers phase. From all treatments, T_3 diet group birds show high (P<0.05) CP intake than the control (T_1) group and the rest of the treatment birds in starter and finisher phases. Also, it was increased by 20.76%, 16.2%, and 17.44% compared to the control group during the starter, finisher, and the entire period, respectively. However, in both phases, there were no significant differences (P>0.05) in CP intake between T_4 and T_2 diet group birds. Although, T_4 and T_2 diet group birds had significantly high CP intake in contrast to the control (T_1) group (P<0.05).

The metabolizable energy intake was high significant (P<0.001) among the dietary treatments during the starter, finisher phases, and the overall period. However, birds fed

under T_3 intake significantly (P<0.05) high metabolizable energy followed by T_4, T_2, and control (T_1) during the starter phase and the entire period. Also, it was increased by 9.2% compared to the control group during the starter, finisher, and the entire period with a similar intake pattern. Whereas, during the finisher phase, birds fed under the control group (T_1) had significantly less ME intake (P<0.05) followed by T_4 and T_2. However, the two dietary treatments (T_4 and T_2) had better (P<0.05) ME intake compared to the control group birds.

Growth performance of broilers

The effect of PSM as a replacement at different levels on broiler growth change: Bodyweight, (BW), BW gain, ADG, and FCR are shown in Table 3. The final BW, BW gain, and ADG during the starter phase were not significantly different (P>0.05) among the dietary treatment group birds. However, during the finisher phase and the overall period, there were highly significant differences (P<0.001) among the dietary treatment group. The initial BW of birds at day-old has no significant differences (P>0.05) among the treatment groups. The birds under dietary treatment T_3 have significant (P<0.05) higher Final BW, BW gain, and ADG compared to the control (T_1) and the rest of the treatment birds during the finisher phase and entire period and it shows an increment of 24.58% and 20.88% in BW gain in contrast to the control group birds at finisher phase and entire period, respectively. The same is true for BW and ADG. However, birds under dietary treatment T_2 group had no significant difference (P<0.05) to that of the control (T_1) group birds. Although there is an improvement in BW gain, the FCR was not significantly different (P>0.05) among the treatments at starter, finisher, and entire period.

Protein and energy efficiency ratio

The protein Efficiency Ratio (PER) and energy efficiency ratio (EER) of broiler birds fed on different levels of toasted pigeon pea seed meal are presented in Table 3. The PER and EER were significantly (P<0.05) differences among the treatments during the finisher phase and entire periods, while on the contrary there were no significant differences (P>0.05) among the treatment group birds at the starter phase. During the finisher phase and the entire period, the PER of birds fed dietary treatment (T_2 and T_3) were not significantly (P>0.05) affected compared to the control group (T_1) birds. However, PER was significantly influenced (P<0.05) by dietary treatment (T_3 and T_4) compared to the control group (T_1) and T_2 group birds during the finisher phase. Similarly, during the entire period birds on dietary treatment T_3 and T_4 were significantly (P<0.05) considerable EER compared to the control (T_1) and (T_2) treatment group birds. All mortality recorded during the first week of the starter phase from T_2, T_3, and T_4 were 1, 2, and 4 birds, respectively.

The 20% replacement of toasted PSM (T_3) group birds had better daily DMI (18.25%) and total DMI (18.22%) compared to the control group during the overall period. The result obtained in the present study showed an improvement over the observation of Ani and Okeke (2003) that broiler starters fed 27% toasted PSM had lower feed intake than birds fed 5.5-21.5% toasted PSM diets. This is possibly due to finisher broiler are more adapted to

Table 2: Nutrient CP and Metabolizable energy intake of broiler birds fed partial substitution of roosted PSM at different levels.

Parameter	Phase	Dietary treatments					P-value
		T1	T2	T3	T4	SEM	
DMI (g/bird/day)	Starter	38.87^{c}	42.39^{b}	44.29^{a}	41.6^{b}	0.51	0.001
	Finisher	104.93^{d}	108.60^{c}	125.29^{a}	115.61^{b}	0.65	< 0.001
	Entire period	76.6^{d}	80.23^{c}	90.58^{a}	83.89^{b}	0.48	< 0.001
DMI (g/bird)	Starter	816.3^{c}	890.29^{b}	930.23^{a}	873.62^{b}	10.85	0.001
	Finisher	2938.12^{d}	3,041^{c}	3,508.38^{a}	3,237.05^{b}	18.39	< 0.001
	Entire period	3754.41^{d}	3931.3^{c}	4,438.62^{a}	4,110.67^{b}	23.7	< 0.001
CPI (g/bird)	Starter	216.88^{c}	246.44^{b}	261.91^{a}	248.20^{b}	3.29	< 0.001
	Finisher	584.33^{c}	653.57^{b}	679.06^{a}	612.21^{b}	11.36	0.002
	Entire period	801.21^{d}	900.01^{c}	940.97^{a}	860.41^{b}	11.71	< 0.001
MEI (kcal/bird/day)	Starter	140.93^{d}	147.11^{c}	153.89^{a}	151.83^{b}	0.58	< 0.001
	Finisher	338.25^{d}	364.4^{b}	369.35^{a}	353.06^{c}	1.39	< 0.001
	Entire period	253.68^{d}	264.30^{c}	277.01^{a}	273.30^{b}	1.04	< 0.001

Mean values within the same row having different superscript letters are significantly different (P<0.05); PSM= Pigeon Pea Seed Meal; T_1= 0% PSM; T_2= 10 %PSM; T_3= 20 % PSM; T_4= 30 %PSM; DMI = Dry matter intake; CPI = crude protein intake; MEI=Metabolizable energy intake; SEM = Standard Error of the Mean.

Table 3: Performance of broiler chicks fed partial substitution of roosted PSM at different levels.

Parameter	Phase	Dietary treatments					P-value
		T1	T2	T3	T4	SEM	
Initial BW(g)		42.32	40.57	41.42	41.45	0.52	0.212
Final BW(g)	Starter	617.41	672	691	677	22.31	0.17
	Finisher	1678.49^{c}	1764.83^{c}	2019.33^{a}	1888^{b}	28.0	<0.001
BWG(g)	Starter	575.09	631.97	649.66	636.42	22.57	0.17
	Finisher	1066.07^{c}	1092.28^{c}	1328.0^{a}	1219.12^{b}	33.85	0.002
	Entire Period	1636.2^{c}	1724.26^{c}	1977.9^{a}	1846.56^{b}	28.13	<0.001
ADG(g)	Starter	26.63	30.09	30.93	30.30	1.01	0.065
	Finisher	39.40^{c}	40.46^{c}	48.91^{a}	44.7^{b}	1.21	0.002
	Entire Period	33.4^{c}	35.2^{c}	40.4^{a}	37.66^{b}	0.56	<0.001
FCR	Starter	1.42	1.43	1.43	1.37	0.06	0.89
	Finisher	2.76	2.78	2.65	2.67	2.76	0.41
	Entire Period	2.29	2.28	2.24	2.22	2.29	0.58
	Starter	2.65	2.56	2.48	2.56	0.099	0.68
PER (g)	finisher	1.81^{b}	1.67^{c}	1.95^{ab}	1.97^{a}	0.045	0.005
	Entire period	2.04^{ab}	1.91^{b}	2.10^{ab}	2.14^{a}	0.045	0.002
	Starter	18.89	19.81	20.10	20.6	0.68	0.04
EER (g)	finisher	11.65^{bc}	11.1^{c}	13.24^{a}	12.65^{ab}	0.31	0.006
	Entire period	13.16^{b}	12.87^{b}	14.57^{a}	14.23^{a}	0.21	0.001
	Starter	-	1	2	4	-	-
Mortality	Finisher	-	-	-	-	-	-
	Entire period	-	1	2	4	-	-

Mean values within the same row having different superscript letters are significantly different (P<0.05); PSM= Pigeon Pea Seed Meal; T_1= 0% PSM; T_2= 10 %PSM; T_3= 20 % PSM; T_4= 30 %PSM; BWG=Bodyweight gain; ADG =Average daily weight gain; FCR= Feed conversion ratio.

the high intake of pigeon pea seed meal than starter broiler. The increased DM intake by birds on toasted PSM diets also suggests that roasting for 30 min was able to eliminate the anti-nutritional factors in pigeon pea. Reduction in antinutritional factors when they subjected Sorrel seed to toasting. Reduction in the contents of the anti-nutritional factors suggests the ability of toasting as an effective method of detoxification Pigeon seed, therefore this might lead to an increase on feed intake. The current study finding in agreement with that of Etuk et al. (2002), who reported that there was better daily total feed intake of broiler birds fed with 20% of soaked processed PSM during starter and finisher phases.

The CP intake of the groups fed on T_3 (20% PSM) was increased by 20.76%, 16.2%, and 17.44% compared to the control group during the starter, finisher, and the entire period, respectively. This result agreed with Igene et al. (2016) who reported that there where better daily CP intake of chicken fed with 20% of boiled PSM during the starter and finisher phases. The metabolizable energy intake of birds assigned to T_3 was increased by 9.2% compared to the control group at the starter, finisher, and entire periods. However, contrary to the current finding, Tusar et al. (2015) and Ahmed et al. (2006), and Babiker et al. (2006) reported that there was no change in ME intake between the control and treatment group birds when broiler birds fed with soaked PSM at the levels of 0, 0.5, 1, 1.5%. The discrepancy with the current finding might be due to the difference in the processing method and replacement level alteration.

The birds under dietary treatment T_3 have significant higher Final BW, BW gain, and ADG compared to the control (T_1) and the rest of the treatment birds during the finisher phase and entire period and it shows an increment of 24.58% and 20.88% in BW gain and ADG in contrast to the control group birds, respectively. This result contradicts that of Etuk et al. (2002) which indicted that there was a significant depression in weight gain among birds fed diets containing 20-50% cooked pigeon pea seed meal. The result obtained in this study seems to suggest that broiler finishers can be fed diets substituting soybean by toasted PSM up to 20% without any BW deterioration. The improvement in BW gain and ADG in the current study is due to an increase in DM, CP, and ME intake which consequently leads to an increase in BW gain. Also, the effect of mixed protein sources or using more than one

protein source could improve the performance of broiler across the treatment (Alhafiz et al., 2013). These coincide with Amaefule and Obioha (2005) who concluded that the replacement of 10% toasted PSM in broiler diets supported bird growth and development at finisher and overall experimental period. In other trials, Tusar et al. (2015) reported that BW gain increased with the inclusion of 10% and 15% pigeon pea, compared to the control and 5% treatment groups. Similarly, Babiker et al. (2006) reported that the more replacement of PSM greater than 10% improve BW gain and ADG of broiler was that of 7.5% and 5% dietary treatments at the finisher phase. In contrast to the current study, Abdelati et al. (2009) reported that the inclusion of 10% soaked pigeon pea seed, decorticated with an added enzyme and decorticated toasted had no effects on feed intake and BW weight gain. However, in this study, the FCR was not affected by the treatments. The findings of this study disagree with that of Etuk et al. (2002) who reported that there was a change in FCR of broiler starter and finisher chicken fed 20% of graded levels of PSM. Similarly, Alhafiz et al. (2013) reported that the birds fed with Pigeon pea recorded high FCR value. The difference in FCR might be due to the difference in the processing methods which lead to the destruction of lysine and methionine in the roasting process. Also, Wallis and Balnave (1984), stated that lysine, glutamic acid, aspartic acid, threonine most liable to be damaged by heat.

The PER and EER of 20 and 30% substitution of soybean by PSM was not significantly influenced by birds during the finisher phase and overall period. This leads to a non-substantial change in FCR as well. the current result in agreement with Ani and Okeke, (2011) indicated there is no change in PER and FCR between 0, 6.5, 13.0, 19.5, 26.0 and 32.5% roasted PSM. This strongly indicates that broiler finishers' diet at 26% and 27% toasted PSM, may be incorporated into broiler finisher diets without any deleterious effect on the growth performance of broiler birds. On contrary, Ahmed et al. (2006) indicated that soaked PSM at 0, 50, 100, and 150 g/kg of inclusion in the broiler diet were not different in EER among treatments. However, in the current study, the PER and MER were not significantly different at higher substitution levels. The difference in results is due to a reduction in antinutritional factors (oxalate, tannic acid, etc.) which affect the metabolizable energy (ME) and protein or nitrogen retention in chicks which might be minimized due to the processing of pigeon pea by toasting.

CONCLUSIONS AND RECOMMENDATION

As the levels of PSM replacement increase greater than 30% the feed intake of bird decline. Broilers BW gain and ADG were significantly influenced by 20% and 30% PSM replacement for SBM. Therefore, Toasted PSM at 20% and 30% levels was suitable to be used in broiler diets as a source of protein without any adverse effect on the growth performance of broiler birds. However, further research is needed to determine the optimum level PSM with different processing methods to achieve the optimum growth performance and effects on carcass yield and qualities of meat.

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NOVELTY STATEMENT

Pigeon pea seed is a superb supply of protein for chicken feeding. unfortunately, Its have an anti-nutritional element that limits its usage with the aid of using chicken. There are lots of remedies are to be had to reduce those anti-nutritional effects, from this heat treatments are one of them and it appears the best way to overcome this problem. however, the extent of substitution of the soybean meal by pigeon peameal in the ration still does not exceed 10 and 20% of replacements. The present study provides a recommended level of replacement of soybean meal by toasted Pigeon peameal.

AUTHOR'S CONTRIBUTION

Both authors collect the necessary data and write up the article.

Conflict of interests

The authors have declared no competing interest.

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