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Different processing methods of pigeon pea (*Cajanus cajan*) seed meal: Effect on nutritive value, growth and production performance of commercial layers

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Abstract

The experiment was conducted with 150 Bovans brown pullets to evaluate the performance of grower pullets and layers fed raw or processed pigeon pea seed meal diets from 18th week stage of life. Each treatment had three replicates and ten birds per replicate in a completely randomized design (CRD) with pullets and layers fed comprised of 20% pigeon pea seed meal diets that were isoenergetic and isonitrogenous. Live weight, feed intake, live weight gain, egg production and mortality parameters were measured. Pullets fed 20% boiled and soaked PPSM diets attained significantly higher ($P<0.05$) final body weight at point of lay and daily feed intake than those fed control, raw and toasted PPSM diets. Results revealed that non-significant ($P>0.05$) differences among the layers fed PPSM diets in hen-day egg production, average daily feed intake and average mortality parameters but significant differences ($p<0.05$) were observed on hen-housed egg production and age at first egg lay parameters. It was concluded that PPSM could be a good protein source for grower pullets and layers, which could be incorporated into the diets at 20% of the whole diet without any adverse effect on growth and egg production performance.

Keywords: Age at first egg lay; Egg production; Grower pullets; Growth performance; Processed pigeon pea seed meal

1. Introduction

In Ethiopia, in highly populated areas where it may be complex to continue agronomic activities, subsistence poultry can be the best alternative form of income resources, plays a significant role in family nutrition. Above all, smallholder poultry provide a good opportunity to address poverty alleviation [1]. However, scarcity of conventional feedstuffs and food insecurity problems by rapidly increasing population growth are the most aggravating factors at present [2]. Most of the population in Ethiopia depends on cereals as stable foods which are also required for poultry feeding. This means, it is difficult to use cereals for poultry with having human food insecurity burden and replacing expensive cereals and less available agro-industrial by-products. Hence unconventional source of raw materials, which are less exploited by man, is one of the solutions to reduce cost of production and contribute to increased supply of animal protein to rich of poor people's [3].

However, in Ethiopia this strategy is not practiced because of the less characterization of non-conventional feed sources from rural areas rather dependent on high costs of conventional feed ingredients (maize, soybean and others), which are primarily utilized in the human food and industrial input application [4]. This elevates the prices of the products like egg and chicken meat. Diets formulated on a least cost basis are vital and essential. It is generally assumed that improvements in alternative feed resources utilization will be associated with increased rate of productivity and

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product quality [5]. One of such unconventional feed sources that could be used to reduce the problem of high cost of conventional protein sources in livestock diets with particular reference to poultry is the pigeon pea. The pigeon pea seeds have low human food preference and unlike soybean and groundnut cake, its value in livestock feeding has not been fully investigated**.** Pigeon pea could provide nutritional importance as a protein source due to relative high crude protein (CP) value ranging from 12 to 32% [6] and appreciable amounts of essential amino acids. [7] reported lysine 1.66%, methionine 0.29%, cysteine 0.29%, argentine 1.59% and tryptophan 0.11% in pigeon pea seed. It could be a better and cheaper protein alternative as compared to other legume grains. *Cajanus cajan* 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% [8]. It is also a good source of soluble vitamins, especially thiamin, riboflavin, niacin, and choline. However, the use of pigeon pea seed in poultry diets is limited by the presence of several antinutrients which affects their utilization in poultry feeding; especially the raw seeds [9]. The previous studies revealed that different processing methods of raw pigeon pea seeds will reduce ant-nutritional factors either by boiling [6; 10; 11), boiling and dehulling [12], toasting [6; 13; 14], roasting [15], soaking [6; 10] or supplementation with enzyme [10].

Although, pigeon pea seed meal is cheap sources of nutrients and its availability, the extent of practical use in poultry ration is inadequate under Ethiopian condition and limited researches have been conducted on it as a feed ration for commercial layer chickens. Therefore, the aim of the study was to study the effect of different processing methods on the nutrient utilization of pigeon pea seed meal (PSM) (*Cajanus cajan*) and on growth performance and production performance of commercial layer chickens.

General Objective

- To study the effect of different processing methods on the nutrient utilization of pigeon pea seed meal (PSM) (*Cajanus cajan*), growth and production performance of commercial layer.

Specific Objectives

- To determine the effect of different processing methods on nutritive value of pigeon pea seed meal.
- To evaluate the effect of pigeon pea seed meal on growth performances of commercial layer.
- To evaluate the effect of pigeon pea seed meal on production performance of commercial layers.

2. Material and methods

2.1 Pigeon pea seed meal preparation

The dietary ingredients used in this experiment were maize (white), soybean (roasted), wheat bran, noug seed cake, pigeon pea seed meal, limestone and salt. Pigeon pea seeds was procured from a local market of Wolaita Sodo city. The collected seeds were cleaned by winnowing and hand picking of stones and debris and then subjected to different processing treatments (raw, Toasting, Boiling and Soaking). Toasting was done in a manner similar to what was described by [16]. The seeds were poured into a large locally made frying pan set over burning firewood with temperatures fluctuating between 100-110°C and constantly stirred to prevent charring for about 12-15 min until about 75% of them were cracked to reveal a slight change in colour (from brown to darker brown) and a "roasted" aroma was achieved. The seeds were then spread out in the air to cool and then crushed and included in the diet. Boiling of pigeon pea seeds were done in water for 30 minutes at 100oC, soaking in water (30kg seed in 100litre of water) for 24 hours, soaked seeds were first sun-dried and all are milled with a 2.0hp Lister powered local mill for use in the experiments.

2.2 Experimental diets

Five isoenergetic and isonitrogenous pullet and layer diets were formulated with raw, boiled, toasted and soaked Pigeon pea seed meal. Several studies have been conducted on pigeon pea seed meal as poultry feeds. [9] demonstrated that 20% and 30% inclusion of raw, boiled or toasted pigeon pea seed meal (PPSM) in grower and layer diets respectively could not adversely affect egg production, external and internal egg quality characteristics. [17] also stated inclusion of 26 and 27% of roasted pigeon pea seed meal can be included in broiler started and finisher diets respectively without adverse effect on growth performance of broiler. Toasted pigeon pea was included at 10% of diet without any determinant effect on growth performance and carcass yield of Japanese Quails [11]. Hence, with this basis and based on the result of the chemical analysis five pullets and layer diets were formulated to contain PPSM 0% (T_1), Raw PPSM 20% (T_2), Toasted PPSM 20% (T_3), Boiled PPSM 20% (T_4) and Soaked PPSM 20% (T_5) (Table 1). The raw or processed

pigeon pea seed meal replaced part of soybean meal and maize in the diets. The amount of Pigeon pea seed meal required for the feeding trial was determined based on the total number of chicks and duration of the trial.

Table 1 Gross composition of the pullets (grower) experimental diets (% on DM basis)

Ingredients	Treatments				
	T_1 (0% PSM)	**T_2 (20% PPSM) raw**	**T_3 (20% PPSM) toasted**	**T_4 (20% PPSM) boiled**	**T_5 (20% PPSM) soaked**
PPSM	0	20	20	20	20
Maize	59.8	51.8	50	50.5	52
Noug seed cake	5	5	5	5	5
Wheat bran	15	12	11.8	11.8	11.8
Soya bean meal	17	8	10	9.5	8
Limestone	2	2	2	2	2
DL-methionine	0.1	0.1	0.1	0.1	0.1
Lysine	0.1	0.1	0.1	0.1	0.1
Vitamin premix	0.5	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100
Calculated ME (Kcal/Kg DM)	2955.93	2970.06	2969.98	2980.55	2969.84
Calculated CP%	16.54	16.62	16.64	16.74	16.66
ME: CP	178.71	178.70	178.48	178.05	178.26

Layer pullets (grower): ME (Kcal/Kg DM) = 28000 and CP (%) = 16; PPSM (Pigeon Pea Seed Meal).

Table 2 Gross composition of the layer experimental diets (% on DM basis)

Ingredients	Treatments				
	T_1 (0% PPSM)	**T_2 (20% PPSM) raw**	**T_3 (20% PPSM) toasted**	**T_4 (20% PPSM) boiled**	**T_5 (20% PPSM) Soaked**
PPSM	0	20	20	20	20
Maize	58	48.5	47	47.3	48.8
Noug seed cake	5	5	5	5	5
Wheat bran	14.7	14.8	14.7	15	14.5
Soya bean meal	18	7.5	9	8.5	7.5
Limestone	3	3	3	3	3
DL-Methionine	0.1	0.1	0.2	0.1	0.1
Lysine	0.1	0.1	0.1	0.1	0.1
Vitamin premix	0.5	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5	0.5

Total	100	100	100	100	100
Calculated ME (Kcal/Kg DM)	2928.98	2890.24	2886.77	2893.43	2891.65
Calculated CP%	16.77	16.55	16.45	16.52	16.58
ME: CP	174.66	174.64	175.49	175.14	174.41

Layer pullets (grower): ME (Kcal/Kg DM) = 2750 and CP (%) = 16.50; PPSM (Pigeon Pea Seed Meal)

2.3 Experimental birds and their management

A total of 150 Bovans brown pullets with 18 weeks of age were purchase from Debre Zeit cooperative farms. Before commencement of the actual experiment, the experimental pens were properly cleaned, disinfected by formalin, well ventilated and watering and feeding troughs were also thoroughly cleaned and disinfected. At the beginning of the study period, there was a preliminary period of one week before data collection to allow acclimatization of birds to experimental diets. After adaptation, one hundred fifty chickens were randomly selected; tagged, weighed individually on a digital balance and transferred into the experimental pens. Ten (10) birds were distributed in each of the 15 pens making a total of 150 birds. The birds were kept in 1.50 m x 1. 50 m wire-mesh partitioned deep litter floor housing, which was covered with sawdust litter material of 12 cm depth. Feed was offered twice a day at 8:00 am in the morning and at 3:00 pm in the afternoon throughout the experimental period. Feed refusals were collected, weighed and recorded every day at 7.00am. Feed and water was provided *ad libitum*. Feed offered and refused was recorded. Eggs were collected daily and recorded. Disease control measures such as vaccination against Newcastle disease and regular pen cleaning (once in four weeks) was taken throughout the study period. Vitamins was given through drinking water according to the manufacturer's recommendation.

2.4 Experimental Design and Treatments

The experimental design used for this feeding trial was a completely randomized design consisting of 5 dietary treatments with 3 replications (Table 1). Accordingly, one hundred fifty (150) Bovans brown pullets (growers) chickens were divided into 5 groups of 30 birds each. Each group was further divided into 3 replicates of 10 birds.

Table 3 Experimental design of the feeding trial with Bovans brown chickens

Treatment	Inclusion Level of PPSM (%)	Replicates	Chickens per replicate	Number of Chickens per treatment
T_1	0 (Control)	3	10	30
T_2	20 (Raw PPSM)	3	10	30
T_3	20 (Toasted PPSM)	3	10	30
T_4	20 (Boiled PPSM)	3	10	30
T_5	20 (Soaked PPSM)	3	10	30
Total			50	150

2.5 Measurements

2.5.1 Feed data collection

Samples of the feed offered and refused was taken daily for chemical analysis. Body weight was measured at the beginning and every week during the experiment period. The chicks were weighed early in the morning prior to feeding using a digital balance. From the collected data, feed intake and body weight gain and feed conversion ratio were calculated. Mortality was be recorded throughout experimental period as it occurred.

Egg production traits

Egg laid by all birds in each replication were recorded daily using egg recording format (date of egg lay, number of birds alive and dead). Egg production data was collected starting from age at first laying eggs. The number of eggs laid by the birds were estimated as follows:

- Number of eggs (hen-day): - Total number of eggs produced by the birds divided by the number of hens alive during the period.
- Number of eggs (hen-housed): - Total number of eggs produced by the birds divided by the number of hens initially housed.

Therefore, the hen-day egg production (HDEP) and hen-housed egg production (HHEP) were calculated using the following formula [18]:

$$\text{HDEP (\%)} = \frac{\text{Total eggs produced}}{\text{(Number of birds alive) x (Number of days in lay)}} \times 100$$

$$\text{HHEP (\%)} = \frac{\text{Total eggs produced}}{\text{(Number of birds initially housed) x (Number of days in lay)}} \times 100$$

2.5.2 Chemical Analysis

Different treated pigeon pea seed meal (raw, toasted, boiled and soaked), feeds offered and refused were analyzed for dry matter (DM), ether extract (EE), crude fibre (CF) and total mineral (ash) by proximate analysis procedures [19] and nitrogen free extract (NFE) was calculated by difference. A micro-Kjeldahl procedure of nitrogen analysis was employed to determine the nitrogen content. The crude protein (CP) was then determined as nitrogen content x 6.25. All samples were analyzed in duplicates at Chemistry laboratory of Arba Minch University.

The Metabolizable energy (ME) will be estimated by the formula:

ME (Kcal/kg DM) = 3951 + 54.4EE - 88.7CF - 40.8Ash [20]

2.6 Statistical Analysis

The effect of different treated pigeon pea seed meal on the growth performance and carcass traits were subjected to analysis of variance (ANOVA) and differences between treatment means were separated using Duncan's Multiple Range Test [21].

2.6.1 Model .1

$$Yijk = \mu + Ai + eik;$$

Where, Yijk =individual values of the dependent variables;
μ = overall mean of the response variable;
Ai = the effect of the i^{th} Treatment (*i* = 0PPSM, 20RPPSM, 20TPPSM, BPPSM, 20SPPSM) on the dependent variable
eik= error associated with the experimental study.

2.6.2 Model 2

$$Y_{ij} = \mu + \alpha_i + b_j + ab_{ij} + e_{ij}$$

μ= overall mean
i= effect of sex,
j= effect of different treated PPSM on dietary treatments, 1, 2, 3, 4 and 5
αb_{ij}= effect of i^{th} sex on j^{th} different treated PPSM
e_{ij} = error associated with the experimental study

3. Results and discussion

The result of proximate composition analysis of raw and processed pigeon pea seed meal (PPSM) is presented in Table 4. There were no major differences in the proximate composition of the raw or processed pigeon pea seed meal even though toasted pigeon pea seed meal had lower numerical values for crude protein but higher nitrogen free extract than raw, boiled and PPSM. And CP of processed pigeon pea seed meal was numerical lower the raw which may probably

due to processing enhances degradation [22]. Boiling for example has been related with solubilization and leakage of some nitrogenous compounds into the processing water [23]. The decrease in the CP of the toasted pigeon pea seed meal could be due to loss of water, nitrogen and volatilization during dry heat application. The differences in the proximate composition of the raw and processed pigeon pea seed meal were due to the effect of processing [24].

Table 4 Proximate composition of raw or processed pigeon pea seed meal (DM%)

Composition	Raw	Toasted	Boiled	Soaked
Dry matter	91.48	93.42	91.64	90.39
Crude protein	24.15	16.41	23	21
Ether extract	1.05	1.16	1.08	0.91
Crude fiber	7	5.65	7.75	6.93
Ash	3.5	3.15	2.92	3.46
Nitrogen free Extract	55.78	67.05	56.89	58.09
ME (Kcal/Kg DM)	3244.42	3384.43	3203.19	3244.65

NFE = DM - (CP + EE + CF + Ash); ME (Kcal/kg DM) = 3951 + 54.4EE - 88.7CF - 40.8Ash [20]

3.1 Performance of chickens

Table 5 Performance of grower pullets fed raw/processed pigeon pea seed meal diets from grower starter of life

Parameters	Treatments					SEM	P value
	T1	T2	T3	T4	T5		
Initial weight (g/b)	177.84	175.99	176.55	176.96	177.08	0.8	0.59
Final weight (g/b)	1450.20^{b}	1448.74^{b}	1451.13^{b}	1501.84^{a}	1501.54^{a}	2.05	<0.001
Daily weight gain (g/b)	12.97	12.89	12.74	13.33	13.67	0.59	0.8
Daily feed intake (g/b)	65.16^{b}	64.43^{b}	65.01^{b}	66.23^{a}	66.06^{a}	.037	0.02

a - c Means in the same row followed by different superscripts are significantly different (P<0.05). SEM = Standard error of mean

The average final body weight, daily weight gain and daily feed intake of Bovans brown pullets fed diets with different processing methods of pigeon pea seed meal was presented in Table 5. Daily weight gain of chickens was not significantly ($p>0.05$) affected by feeding different processing methods of pigeon pea seed meal. This result is in agreement with [25] who reported non-significant differences ($P>0.05$) among grower pullets fed the different processing methods of pigeon pea seed meal in daily weight gain. However, final weight and there was no significant ($p>0.05$) difference on daily feed intake of pullets fed T4 (boiled PPSM) and T5 (soaked PPSM) but significantly ($p<0.05$) higher than those fed the rest three treatments. Boiled pigeon pea seed diets resulted in higher final body weight and better feed intake than toasted pigeon pea seed diets. This could be due to the boiling processing method of pigeon pea seed meal has been reported to be better than toasting [26]. The difference in performance could be due to greater reduction of anti-tryptic and hemagglutinating activities of pigeon pea seeds achieved by boiling [22]. The results of the present study were in agreement with the findings of Onu and Okongwu (2006), who reported significant differences in feed intake and final body weight among the pullet groups fed diets containing raw, boiled and toasted processed pigeon pea seed meal.

The feed intake trend (Fig. 1), followed pattern of growth rate, this may have been in response to nutrient requirements for growth and development [27]. The average daily weight gain of pullets fed raw or processed pigeon pea seed meals from the grower stage (Fig. 2) showed that the pullets had uniform growth pattern from 7-15 weeks of age bud had different growth pattern to the point of lay from 16 weeks of age. Pullets fed toasted PSM diet had a more pronounced negative growth rate than the rest. Daily weight gain peaked at week 17 except for those fed boiled pigeon pea seed meal and dropped sharply by week 18. The daily weight gain of this study fell within the range (12.74 -13.67 g/b/d) which is higher than the result reported by [25] (9.9-11.5 g/b/d) on performance of grower pullets fed raw or processed

Pigeon Pea Seed Meal Diets and [28] reported (4 -12.4 g/b/d) on dietary protein and energy effects on reproductive characteristics of commercial egg-type pullets reared in arid hot climate.

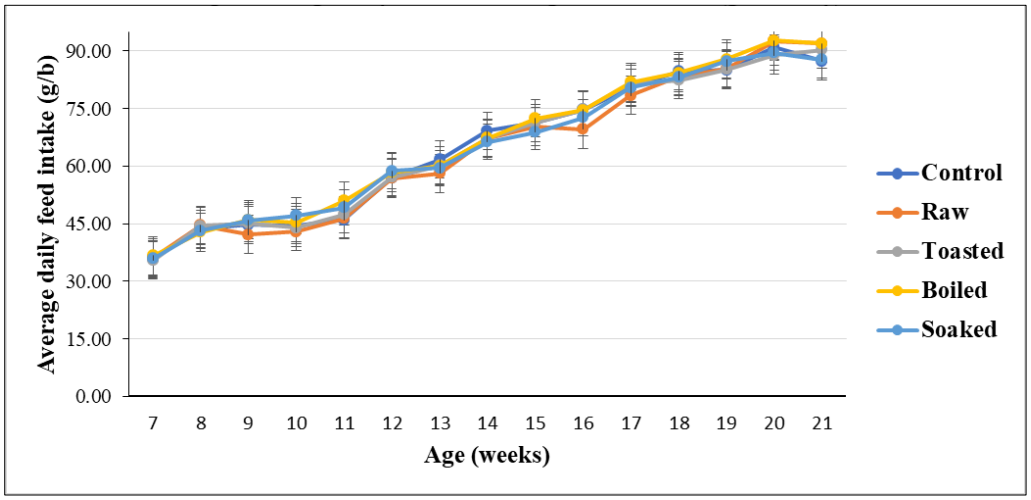

Figure 1 Average daily feed intake of grower chicken (g/bird/day)

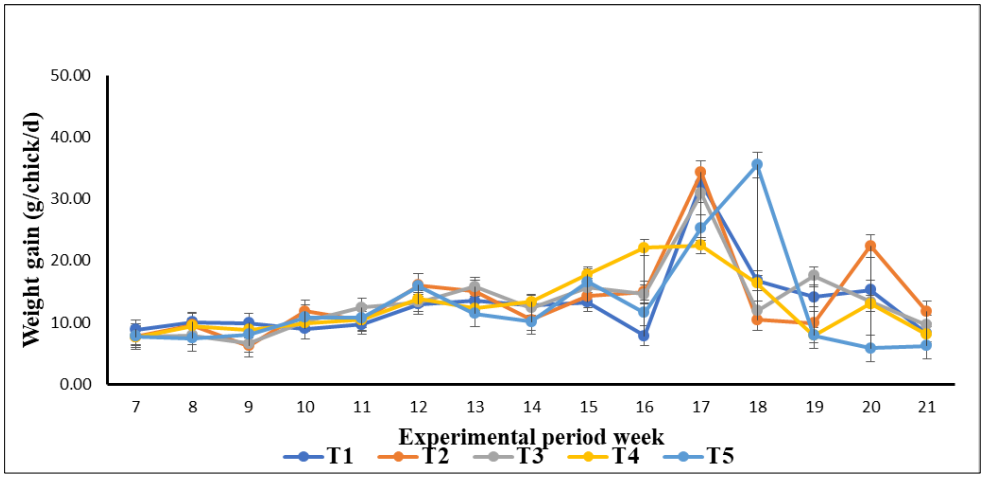

Figure 2 Weight gain performance of grower chickens during the experimental weeks

3.2 Performance of layers

The performance of layers fed raw or processed pigeon pea seed meal during the grower and layer stages of life is presented in Table 6. Hen-day egg production (%), average daily feed intake (g/b/d) and mortality were not significantly (P>0. 05) affected by layers fed raw, toasted, boiled and soaked processed methods of pigeon pea seed meal or control diets. The non-significant (P>0.05) average daily feed intake that was not affected by different processing methods of the pigeon pea seed meal is not in agreement with the result of [9] reported that layers fed control and raw diets were significantly (P<0.05) lower than those of toasted, boiled and soaked processed pigeon pea seed meal diets.

The significant (p<0.05) difference of age at first egg lay (sexual maturity) among layers fed different processing methods of pigeon pea seed meal could be due to feed restriction practiced during the pullet growing period [9; 29]. The average age at first egg lay of this study range (151.3 – 161.7 days) is considered normal and agrees with 142-160 days of [30], 148-158 days of [31] and 153-175 days of [9]. Layers fed raw pigeon pea seed meal diet reached sexual maturity (age at first egg lay) 4.7-10.4 days later than those fed processed pigeon pea seed meal diets and control diets; and this could be due to the presence of antinutritional substances in the raw pigeon pea seed meal. This result is in agreement with [9] in case of late sexual maturity (2-4 days later than those fed processed pigeon pea seed meal) but higher in days. The present result showed more delayed age at first egg lay and it is not in line with the report of [32] on commercial laying hens showed earlier average age at-first-of lay to be 126±1.02 days and according to [33]

commercial egg type layers started laying eggs at the age of 140-147 days. This could be attributed to the difference of breed and intensive management [34].

Table 6 Performance evaluation of layers fed raw or processed pigeon pea seed meal diets

Parameters	Treatments						
	T1	T2	T3	T4	T5	SEM	P value
Hen-housed egg production (%)	63.13[a]	63.09[b]	61.29[b]	61.29[a]	68.42[a]	4.26	0.008
Hen-day egg production (%)	70.23	67.62	68.15	70.82	70.80	0.58	0.75
Average daily feed intake (g/b/d)	99.9	100.8	100.01	100.1	100.4	0.32	0.28
Average Mortality (%)	10	6.7	10	13.3	3.3	6.54	0.84
Age at first egg lay (days)	151.3[b]	161.7[a]	152.7[b]	154.3[b]	157[ab]	2.12	0.05

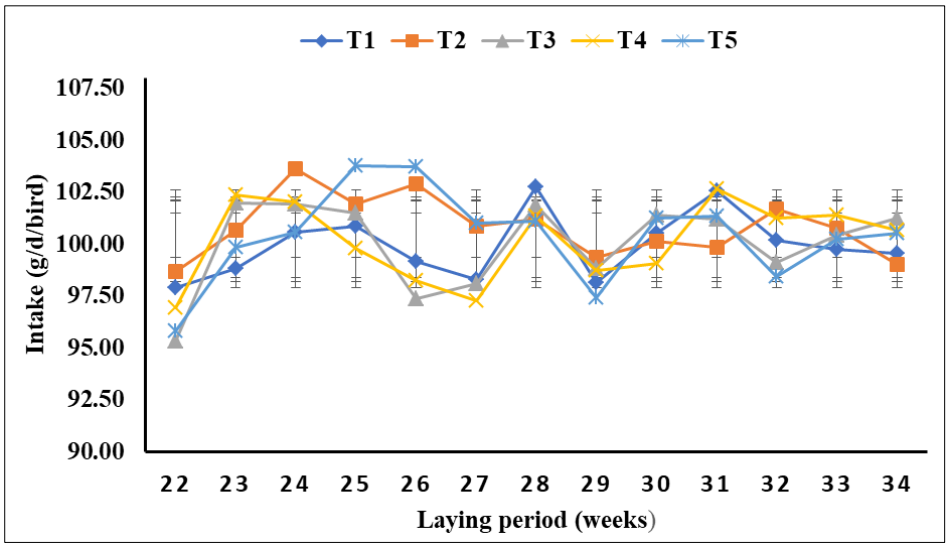

Figure 3 Layers Daily feed intake across experimental period (g/d/bird)

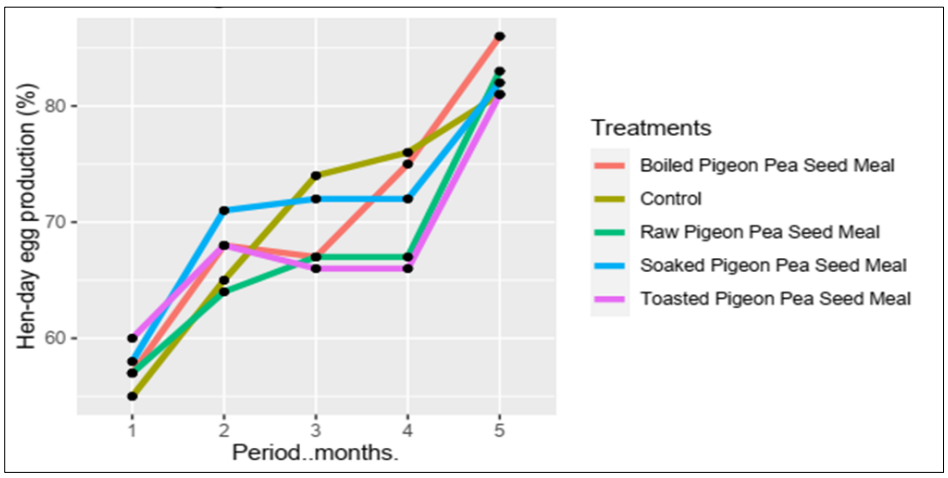

Figure 4 Average Percent hen-day egg Product in of layers fed raw or processed pigeon pea seed meal diets during layer stage of life

The hen-day production (%) of layers fed boiled, soaked pigeon pea seed meal and control diets did not show significant ($P>0.05$) difference but significantly ($p<0.05$) higher than that of birds fed raw and toasted pigeon pea seed meal diets. Hen-day production showed peaks at the 5th month (Fig. 4). The overall average of hen-day egg production for the current study is 69.5% from point of lay to 42 weeks of age which is 13.4% lower than hen-day egg production reported by ISA Hendrix Genetic Company under intensive management system (www.isapoultry.com). But it is in agreement with the report of [9] 71.5% of hen-day egg production on laying performance and egg quality characteristics of pullets fed raw or processed pigeon pea seed meal diets during grower and layer stage of life. The egg production performance could be due to breed, feed consumption (quality and quantity), water intake, intensity and duration of light received, parasite infestation, diseases, management and environmental factors [35].

4. Conclusion

The study revealed that pigeon pea seed meal could be a good protein source for grower pullets and layers, which could be incorporated into the diet at 20% of the whole diet. Any of the processed or raw pigeon pea seed meal diets could be fed to the pullets from the 7th week of age to the layer stage of life without adverse effect on growth and egg production performance.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors declare no competing interest for publication of this paper.

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