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Replacement of Soybean Grain with Cowpea Grain (*Vigna unguiculata*) as Protein Supplement in Sasso x Rir Crossbred Chicks Diet

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Abstract

This experiment was conducted to evaluate the feeding value of cowpea (*Vigna unguiculata*) grain for the replacement of soybean grain on the performance of SASSO x RIR crossbred chicks. A total of one hundred ninety five 21-day-old unsexed SASSO x RIR crossbred chicks were grouped into 15 pens of 13 chicks each, and randomly assigned to five treatments with a supplement of 100% soybean as control (T1), 75% soybean +25% cowpea in T2, 50% soybean +50% cowpea in T3, 25% soybean +75% cowpea in T4 and 100% cowpea supplement in T5 to the 30% of TMR. The results showed that the mean dry matter intake and dry matter conversion ratio did not vary (P>0.05) among the dietary treatments. However, significantly (P<0.05) inferior daily weight gain was obtained in chicks fed 100% cowpea supplement than the rest of dietary treatments. The CP intake was reduced (P<0.05) when the cowpea grain inclusion level is increased. Similarity in growth performance between chicks fed the control and a supplement of 25% soybean +75% cowpea was observed. Based on this, it could be concluded that soybean grain could be replaced by cowpea grain in chicks rations at the level of 75% without any adverse effect on growth performance of chicks so as to increase the economic efficiency.

Keywords Cowpea; Dry matter intake; Replacement; Soybean

Introduction

In Ethiopia, high animal feed cost is in general associated with high cost of imported protein concentrates, soybean meal and fish meals. According to Robinson and Singh [1], it is predicted that soybean which is the major source of plant protein in poultry diets will be in short supply and expensive due to the expanding economies in emerging Asian and south American countries. There has been overdependence on soybean meal as a source of protein due to lack of alternative source of protein in Ethiopia which has led to high production costs in the poultry industry. As a result of high cost of ingredient used in poultry production, conventional poultry feeds continue to increase in price in the country over several decades. The use of low price ingredient is encouraged to reduce the cost of production. It is therefore, necessary to search for readily available local feedstuffs to replace imported protein sources during period of soybean shortage [2]. Among the potential sources of plant protein, grain legumes like cowpea could be good alternatives to soybean meal because they are known to have a similar amino acid profile [3,4]. The cheapness of the most legumes seeds as plant protein sources compared to animals ones can encourage their utilization in feeding animals and poultry especially in under developing tropical countries, in which the climatic condition are suitable for their growth and occurrence.

Cowpea (*Vigna unguiculata*) is an herbaceous short term, annual legumes plant which is grown in many tropical and subtropical countries [5]. The crop can be grown on a wide range of soil conditions even in marginal areas by poor resource farmers. It is an excellent and inexpensive source of protein, fatty acid, essential amino acid, vitamins and minerals [6]. Recent works have revealed that cowpea has promising potential as feedstuff for poultry. Its incorporation in diets of these species has reduced the cost/kg of feed and improved growth and production parameters [2,4,7]. However, the utilization of row cowpeas (*Vigna unguiculata*) was limited by the presence of anti-nutritional factors that negatively affect chicks performances. Hence, cooking reduces ANFs in legumes grains, as a result it improve protein utilization [2,4,7]. According to Shi et al. [8] soybean meal, as the primary and most dependable protein source for poultry feed, is becoming progressively expensive; therefore, there is a need to look for alternative economical, easily available and quality protein sources. The objective of the current study was to evaluate the performance of SASSO x RIR crossbred chicks and to determine the economic viability when soybean grain is substituted with different levels of cowpea grain.

Materials and Methods

Study area

The study was conducted in Ethiopia within Amhara Regional State Wag hemra Zone at Dehana district which is located at 120 27' N latitudes and 380 51'E longitudes at an altitude of 2338 m.a.s.l and 793 km east of Addis Ababa. The mean annual rainfall of the area amounts to 750 mm and the average minimum and maximum temperatures are 18 and 370°C, respectively.

Management and experimental chicks

A total of 195 three weeks old unsexed SASSO x RIR crossbred chicks were used in this experiment. They were purchased from Mekelle Ethio chicks p.l.c poultry farm as day olds and brooded for a total of 3 weeks. During this period they were fed on commercial chick mash diet until they were 21 days old. At day 22 these 195 chicks with average body weight of 221.4 ± 4.1 g were randomly divided into 15

pens in a completely randomised design with 13 chicks/pen. The 15 pens were randomly assigned to five treatment groups. Replicates were housed in the partitioned house with all the necessary facilities for 12 weeks experimental period. Standard vaccination schedule was done and strict sanitary measures were followed during the experimental period. The chicks were vaccinated with live vaccine against Newcastle Disease on day seven and Infectious Brusala disease (Gumboro) at the age of 14 and 24 through drinking water and health precaution and biosecurity measure were taken during the entire experimental period.

Experimental diets

The feed ingredients, which were used in the formulation of the different experimental ration of this study, were cowpea, soybean grain, maize, wheat short, fishmeal, mineral, vitamin premix and salt (Table 1). Cowpea was purchased from Dehana district local market and soybean grain was purchased from Addis Ababa. Cowpea and soybean grain were sorted and screened to remove the bad ones and treated by soaking in water overnight and cooked for 15 minutes to minimize the anti-nutritional factor based on the recommendation of Mwale [9]. After treating, grains were sun-dried for five consecutive days by sparsely spreading on canvas. All the ingredients were hummer milled to 3 mm sieve size.

The five treatment rations used in this study were formulated substituting soybean grain with the cowpeas grain at 0 %, 25 %, 50 %, 75 % & 100 % levels in the ration. All the treatment rations were iso-caloric (3200 kca lME/kg DM) and iso-nitrogenous (20% CP). Feed and water were provided on ad libitum basis. Feed intake and refusals were weighed and recorded every day to estimate the feed consumption for each replicate and treatment. The chicks were also weighed individually at the beginning and subsequently every 7 days during the experimental period and at the end of 12 weeks by sensitive balance.

Laboratory analysis

Representative samples were taken from each of the feed ingredients used in the experiment and analyzed before formulating the actual dietary treatments at Debre Zeit National Veterinary Institute in the Nutrition and Biochemistry Laboratory. Feed samples were analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash [10,11]. The metabolizable energy (ME) levels of feed ingredients were calculated using the formula:

ME (kcal/kg DM)=3951+54.4 EE-88.7 CF-40.8 Ash.

Measurements and observations

Feed intake of each replicate was recorded daily throughout the experimental period. Individual weight of each replicates was taken once per week. The body weight measurements were used to determine pen averages and to calculate the feed conversion ratio. The average feed intake was recorded (g/day). Feed conversion ratio was calculated as gram feed intake/per gram body weight gain. Body weight gain was calculated by subtraction of the live body weight at the beginning of the week from that of the second measuring date (BWG, g/d). Feed cost per live weight gain was computed by the cost of feed consumed to attain a kilogram (kg) live weight gain.

Experimental design and statistical analysis

The data collected were analyzed as completely randomized designs following the procedures [12] and adopting one way ANOVA using SAS, 2003, version, 9.1 software. Means comparison of treatment was tested using Tukey test. Simplified model for statistical procedure of GLM (generalized linear model) was utilized.

Results and Discussion

Chemical analysis and nutritive value

The results of the chemical analysis and estimation of nutritive values of the different feed ingredients is given in Table 2. As shown in Table 2, higher level of crude protein (26.31%) was observed in treated cowpea grain. Its CP content is comparable with the values 26.51% reported by Chakam et al. [7] in Cameron, however it is higher than the values 20.3%, 23.6% and 24.91% reported by Ayana et al. [13], Abdelgani et al. [14], and Khattab and Arntfield [15], respectively. Variation in nutritive value of cowpea in different studies obviously depends on different factors such as cultivars, growing environment, methods of processing and post-harvest handling [15].

Ingredient	T1	T2	T3	T4	T5
Maize	40.1	42	43.3	44.4	45
Wheat short	23	20	17.3	14.8	12
Soybean grain	30	22.5	15	7.5	0
Cowpea grain	0	7.5	15	22.5	30
Fish meal	5.7	6.8	8.2	9.6	11.8
Salt	0.5	0.5	0.5	0.5	0.5
Limestone	0.5	0.5	0.5	0.5	0.5
Vitamin premix	0.2	0.2	0.2	0.2	0.2
Total	100	100	100	100	100
Calculated analysis					

Crude protein	20.33	20.12	20.05	20.02	20.42
ME (kcal/kg DM)	3202	3200	3204	3201	3201
ME:CP ratio	155.5:1	159.6:1	159.8:1	159.8:1	156.76

ME: Metabolizable Energy; CP: Crude Proteins.

T1=100% cooked soybean; T2=75% cooked soybean+25% cooked cowpea; T3=50% cooked soybean+50% cooked cowpea; T 4=25% cooked soybean +75% cooked cowpea and T5=100% cooked cowpea grain supplements.

Vitamin premix was offered with feed per quintal (100 kg) diet contains vitamin A=0.610716965; vitamin D3=0.122143393 g; vitamin E=0.000610717g; Vitamin B1=0.129132231 g; Vitamin B2=0.258264463 g; Vitamin B6=0.516528926 g; Vitamin B12=0.001291322 g; Vitamin C=2.582644628g; Calcium-D-pantothenate=0.516528926 g; Niacin amide=1.549586777 g; Folic acid=0.025826446 g; Sodium, Potassium, Calcium and Magnesium=103.3057851 g; lysine=12.91322314 g and methionine=77.47933884 g.

Table 1: Ingredients of experimental diets fed to SASSO x RIR chicks (DM base).

Ingredients	DM	Ash	CP	EE	CF	ME Kcal/kg DM
Maize	90	8.5	7.53	2.9	4.67	3340
Wheat short	88	7.9	12.45	1.09	19.96	3654.93
Soybean grain	95.5	4	35.85	21.66	10.67	4062.9
Cowpea grain	90.5	2	26.31	1.54	5.33	3562.01
Fish meal	92.27	20.7	64.8	10.4	3.97	3320

Fishmeal analysis result was taken from Heuzé et al. (2015).

Table 2: The chemical composition of feedstuffs used in the study (DM base).

From the calculated value in Table 2, it can be seen that cowpea and soybean grain contained relatively fair amount of metabolizable energy (3562 and 4063 Kcal/kg DM), respectively. With respect to the total protein content, cowpea and soybean most likely seemed to be good protein supplement feed ingredient for poultry as a whole. Based on the chemical analysis, the CP, EE and CF content of soybean was higher than that of cowpea. Results reported in literature revealed that all of these protein supplements constitute comparatively high percentage of crude protein with fair composition of amino acid to satisfy amino acid requirements of chicks.

Dry matter (DM) intake

The mean daily dry matter intakes of the five groups of chicks fed the five treatment rations for 12 consecutive weeks are shown in Table 4. The statistical analysis showed that there is no significant difference in dry matter intake (P>0.05) among the dietary treatments. Similar result was reported by Chakam et al., [7] as he fed graded levels of cooked cowpea seeds to broilers indicating that cowpea can replace up to 30% soybean.

This might be due to the fact that all diets contain similar level of nutritive value mainly energy, protein and crude fiber (Table 3). Thus, supplementation of cowpea grain did not affect the DM intake of chicks and it improved the mean daily and cumulative feed consumption of chicks. This is an advantage for poultry producers, as cowpea is regarded as a fodder for livestock that can be bought cheaply, and reduce the production cost without affecting the feed consumption in Ethiopia. In contrast to this finding, Balaiel [16] reported significant difference in dry matter intake (P<0.05) among the dietary treatments with different level inclusion of untreated cowpea grain in chick's diet.

Nutrients (%)	T1	T2	T3	T4	T5
Offer					
DM%	91.41	91.11	90.83	90.53	90.27
EE%	8.8	7.37	6	4	3.13
ASH%	2.06	2.18	2.31	2.45	2.62
CF%	4.63	4.52	4.39	4.26	4.1
CP%	20.33	20.12	20.05	20.02	20.42
NFE	57.32	56.92	58.08	59.8	60

ME(kcal/kg DM)	3202.6	3200.22	3204.6	3200.82	3200.96
Left over					
DM%	90.53	90.56	90.17	90.46	90.15
EE%	4.09	4.15	3.92	4.32	2.92
ASH%	4.08	4.45	4.35	4.14	3.89
CF%	9.92	9.84	9.97	9.72	9.38
CP%	19.63	19.47	18.39	20.21	16.78
NFE	52.81	52.65	53.54	52.07	57.18
ME(kcal/kg DM)	3127.13	3122.39	3102.43	3154.93	3119.13
ME: Metabolizable Energy; NFE: Nitrogen Free Extract; CP: Crude Proteins; DM: Dry Matter; EE: Ether Extract; CF: Crude Fiber.					

Table 3: The chemical compositions of treatment diets used in the experiments (DM basis).

Parameter	Treatment					SEM	Sign	CV (%)
	T1	T2	T3	T4	T5			
TDM intake (g/chicks)	6049.6	6028.7	6024.9	6031.6	5837.9	115.39	NS	1.93
DDM intake(g/chicks)	67.22	66.99	66.94	67.02	64.86	1.28	NS	1.93
IBW (g/chicks)	222.81	223.53	219.97	224.81	220.65	4.07	NS	1.84
FBW (g/chicks)	1799.78^{a}	$1778.45^{a,b}$	$1771.63^{a,b}$	$1778.73^{a,b}$	1743.43^{b}	18.95	*	1.07
DBWG (g/chicks)	17.52^{a}	$17.22^{a,b}$	$17.18^{a,b}$	$17.19^{a,b}$	16.93^{b}	0.2	*	1.16
TBWG (g/chicks)	1576.97^{a}	$1554.92^{a,b}$	$1551.67^{a,b}$	$1553.92^{a,b}$	1522.78^{b}	16.28	**	1.05
DMCR	3.85	3.88	3.89	3.88	3.8	0.07	NS	1.87
CP intake (g/chicks/day)	14.17^{a}	13.96^{a}	$13.81^{a,b}$	13.66a,b	13.10^{b}	23.78	**	1.92
EE intake (g/chicks/day)	5.60^{a}	4.84^{b}	3.97^{c}	2.69^{d}	1.69^{e}	0.077	***	1
ASH intake (g/chicks/day)	2.82^{a}	$2.73^{a,b}$	$2.63^{b,c}$	2.53^{c}	2.33^{d}	0.049	***	1.88
CF intake (g/chicks/day)	4.24^{a}	4.01^{b}	3.79^{c}	3.53^{d}	3.12^{e}	0.07	***	1.93
PER	1.24	1.23	1.24	1.26	1.29	0.03	NS	2.41
Mortality (%)	0.077	0.1	0.15	0.1	0.1	0.07	NS	0.64

ME: Metabolizable Energy; CP: Crude Protein; DDMI: Daily Dry Matter; DBWG: Daily Body Weight Gain; DMCR: Dry Matter Conversion Ratio; FBW: Final Body Weight; IBW: Initial Body Weight; PER: Protein Efficiency Ratio; SEM: Standard Error of Mean; CF: Crude Fiber; EE: Ether Extract; TDM: Total Dry Matter; TLWG: Total Live Weight Gain.

Since we are comparing more than two means we use F value not t value so that the means are represented in such away.

^{b,c,d,e}Represents <1% coefficient value.

^{a,b}Represents 1% coefficient value.

^{a}Represents 5% coefficient value

*($P < 0.05$); highly significant at **($P < 0.01$); highly significance at ***($P < 0.001$) and NS ($p \geq 0.05$) (no significance).

Table 4: Overall performance of SASSO x RIR crossbred chicks on the experimental diets.

The mean daily CP intake of the five groups of chicks fed the five treatment rations are shown in Table 4. The statistical analysis showed that there is a significant difference in CP intake (P>0.05) among the dietary treatments. T1 and T2 showed higher CP intake than T5. There were non-significant difference among T1, T2, T3 and T4. The result of this study showed that substitute of soybean with cowpea up to 75% did not brought significance difference in CP intake.

Mean body weight gain

The mean daily body weight gains (DBWG) and final body weight (FBW) of the five groups of chicks fed the five treatment rations are shown in Table 4. The control diet (T1) had significantly higher body weight gain than T5. This means, in case of the group fed with the diet containing 30% of cowpea grain, body weight gain was significantly lower than the group fed with control diet. Accordingly, incorporation of cowpea in SASSO x RIR crossbred chicks ration above 22.5% in TMR, resulted in progressive declining of mean daily body weight gain. Thus, cowpea grain can replace soybean grain up to 75% efficiently in the diets of SASSO x RIR crossbred chicks without affecting BWG. The reduction in live weight gain of T5 as compared to the control might relate to higher nutritive (biological) value of soybean (16%) than cowpea (14.25%) [17]. Huang et al. [18] stated that during chicks diet formulation, choosing ingredients to maximize nutrient availability, rather than simply meeting energy or amino acid levels, is necessary. In line with this, Proskina et al. [19] reported that faba bean, which have comparable CP (22-35%) with cowpea, could not fully replaced soybean meal in standard poultry feed mixtures because of low CP contents. In contrast to this result Chakam et al. [7] reported similar total weight gain as he fed graded levels of cooked cowpea seeds to broilers. It can be concluded that SASSO x RIR crossbred chicks can tolerate up to 22.5% level of inclusion of processed cowpea seeds without deleterious effect on performance and with simultaneous reduction in cost of production.

Dry matter conversation ratio

Dry matter conversion ratio of the experimental chicks expressed as grams of dry matter consumption per unit body weight gain, were shown in Table 4. Dry matter conversion ratio showed non-significant difference among the dietary treatments. Similar result was reported by Chakam et al. [7] as he fed graded levels of cooked cowpea seeds to broilers at 0%, 15%, 20%, 25% and 30% indicating that cowpea can replace soybean grain.

Economics analysis

The cost effectiveness of this experimental diet is shown in Table 5. Feed cost/live weight gain was 30.36, 28.99, 27.47, 25.52 and 22.51 Ethiopian Birr for the groups fed on the control diet (100% cooked soybean), 75% cooked soybean+25% cooked cowpea, 50% cooked soybean+50% cooked cowpea, 25% cooked soybean +75% cooked cowpea and 100% cooked cowpea grain supplements, respectively. The inclusion of different level of cowpea grain in chicks ration and feed cost per kg were inversely proportional. The feed cost per kg was decreased with increasing cowpea grain in diets as compared with control group. The cost/kg feed of treatment containing 30% cowpea grain was lowest, due to the low price of cowpea grain in Ethiopia as compared to soybean grain and it had the positive effect on economic value of production. However, the daily weight gains of chicks in T5 were relatively lower. For this reason, treatment rations relatively with better daily weight gain and economic return could be recommended as the biological and economical optimum for raising chicks. Based on this, it could be concluded that soybean grain could be replaced by cowpea grain in chicks rations at the level of 75% (from the TMR 22.5%) without any adverse effect on growth performance of chicks so as to increase the economic efficiency.

Parameter	T1	T2	T3	T4	T5	sign
Average body weight gain in kg	1.58^{a}	1.56^{a,b}	1.55^{a,b}	1.55^{a,b}	1.52^{b}	**
Feed intake per chicks in kg	6.05	6.03	6.03	6.03	5.83	NS
Feed cost per kg (ETB)	7.93	7.5	7.06	6.56	5.87	NS
Feed cost/kg live weight gain	30.36a	28.99^{a}	27.47^{a}	25.52^{a,b}	22.51^{b}	**
Total feed cost per chicks	47.97^{a}	45.22^{a,b}	42.55b,c	39.56c	34.20^{d}	***
Selling revenue (ETB)	114	116	112	113	111	NS
Net revenue (ETB)	66.03^{e}	70.78^{d}	69.45^{c}	73.44^{b}	76.8^{a}	***
Economic efficiency (EE)	1.38^{e}	1.57^{d}	1.63^{c}	1.86^{b}	2.25^{a}	***
Relative economic efficiency (REE)	1^{d}	1.14^{c}	1.18^{c}	1.35^{b}	1.63^{a}	***

Means with different superscripts in a row differ significantly, **P<0.05, ***P<0.01.

Birr is Ethiopian currency which is equal to exchange rate of 24.65 USD at the time of the research work.

^{a,b,c,d,e}Means with different superscripts in a row differed significantly at * (P < 0.05); highly significant at **(P < 0.01); highly significance at ***(P < 0.001) and NS (p ≥ 0.05) (no significance).

Since we are comparing more than two means we use F value not t value so that the means are represented in such away.

^{b,c,d,e}Represents <1% coefficient value.

^{a,b}Represents 1% coefficient value.

[a]Represents 5% coefficient value.

Table 5: Partial budget analysis of SASSO x RIR crossbreed chicks expressed as feed cost/kg live weight gain.

Conclusion

Based on the result of this study, it can be concluded that treated cowpea grain can efficiently replace soybean grain up to 75% in SASSO x RIR crossbred chicks diet without affecting feed intake, body weight gain and feed conversion ratio. However, at 100% replacement of soybean grain with cowpea grain, there was a reduction in body weight gain of chicks. For this reason, replacing of soybean grain with treated cowpea grain at 22.5% of TMR (T4) would be recommended as the biological optimum for raising chicks. Thus, this result clearly indicated that the inclusion of treated cowpea grain at 22.5% of TMR in chicks ration reduces production cost, economically feasible and brought high economic efficiency without affecting feed intake, weight gain and feed conversion efficiency of chicks as compared to the control diet. Therefore, cowpea as replacement of soybean for poultry diet initiates rural smallholder farmers to cultivate cowpea in low productive potential land, which leads an increase income source for cowpea producers, and accessibility of protein source diet for poultry enterprises in the country.

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