SOYBEAN-MEAL AS A SUBSTITUTE FOR FISH-MEAL IN BROILER/CHICKEN DIET ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS

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ABSTRACT

A feeding trial was conducted for 5 weeks to evaluate the effects of soybean meal (SBM) as a substitute for fish meal (FM) on growth performance and carcass characteristics of broilers (Ross 308). A total of 112 Ross 308 broilers were used for the experiment. The experimental design was completely randomized design (CRD). One experiment diet formulated with soya bean (T1) replacing fish meal and a basal diet with fish-meal (T2) were used for this study. Each treatment was replicated four times with each replicate having fourteen (14) birds. Parameters measured included feed intake, body weight gain, feed conversion ratio, and carcass and organs characteristics. Student T-test was performed on the data using Genstat (2012) at p<0.05. Broilers fed on fish meal-based diet had higher (p<0.05) feed intake, body weight gain, and the final body weight than those fed on soya bean meal based diet. The feed conversion ratio was however not significantly different (p>0.05) between the two treatments. Carcass parameters such as live weight, bled weight, de-feathered weight, dressed weight, neck weight, head weight, and wing weight were significantly higher (p<0.05) in broilers under the fish meal treatment than those under the soya bean meal treatment, but abdominal fat, thigh and drum sticks, dressing percentage, breast weight, and shank weight were not different among the two treatments. No significant differences were observed between the two treatments for all the internal organs measured. It can be concluded that broilers fed on fish meal-based diet performs better in growth performance and carcass characteristics than those on soya bean meal-based diet.

Keywords: *Broiler, diet, fish meal, protein ingredient, soya bean meal*

INTRODUCTION

Feeding as one of the major factors in poultry production is critical in ensuring the success of the poultry business. Feed cost constitutes about 70% of the cost of production in commercial poultry (Wongnaa *et al*., 2023). In the formulation of poultry feed, protein ingredient constitutes one of the largest components after the energy-yielding ingredient; therefore, attention is often focused on both protein and energy levels of poultry feed for profitable production. The choice of dietary protein source in poultry diet has considerable effect on feed cost (Skinner *et al.,* 1992).

Protein from plant and animal products are the two important protein sources in poultry diets. The cost of protein ingredients, especially the animal source, is dependent on the world supply and demand for the product (Karimi, 2006). Reducing the protein level is one way to cut the feed cost as protein ingredient is the most expensive part, however, this causes decrease in weight gain and increases the abdominal fat (Diambra and McCartney, 1985; Alagawany *et al.*, 2019).

Conversely, plant-based protein is relatively cheaper as compared to the animal-based protein and some antioxidants as well, but it lacks essential amino acids such as lysine and methionine (Rohaeni, 2015). This requires the use of synthetic amino acids when only plant-based protein ingredients are used. Some studies conducted to replace fish meal in broiler diets have used plant protein sources such as groundnut meal, cotton seed meal, full fat soybean meal, soybean meal, canola meal, rapeseed meal, and leaf protein concentrate (Oduguwa *et al.*, 2004; Olomu and Offiong, 1985). Among these plant protein sources, soybean meal is the most common plant protein used in broiler diets throughout the world (Saki, 2011) and has the highest feeding value (Olomu and Offiong, 1985) due to its high protein content and essential amino acids needed to meet the nutrient requirements of poultry (Yasothai, 2016; Elangovan and Shim, 2000). It has crude protein (CP) content of about 40-48%, and this depends on the quantity of hulls as well as the quantity of oil extracted.

The amino acid profile of soybean meal makes it suitable for balancing most cereal-based diets (Crowell, 1999; Ravindran, 2013; Beski *et al.*, 2015). The similarities in its nutritional constituents with fish meal makes it the most suitable plant protein to replace fish meal in broiler diets. DeGroote (1973) reported no differences in broiler body weight and feed conversion ratio (FCR) when birds were fed on milo-soy diet with and without fish meal for 6 weeks, demonstrating that plant proteins can effectively replace fish meal in broiler diets. Aziz *et al.* (2001) reported no differences in body weight gain, feed intake and feed efficiency when birds were fed diets with and without fish meal. He concluded that soybean meal successfully replaced fish meal in broiler diets when supplemented with methionine.

Intensive poultry rearing really affects the production costs incurred especially for feed costs which amount to 70% to 80% of the total production costs. In Ghana, imported fish meal is the traditional animal protein ingredient for broiler production. Researchers have demonstrated that including fish meal in balanced broiler diets resulted in better growth performance (Vogt and Stute, 1967; Herstad, 1973; Mikulec *et al.*, 2004; Karimi, 2006; Cho *et al.*, 2011). However, limited availability in recent years, lack of uniformity (Pike, 1999; Dale *et al.*, 2004) and higher cost relative to plant sources has limited its inclusion in broiler diets (Blair, 2008; Chadd, 2008). Additionally, the presence of trimethylamine in fish meal creates a residual fish smell and flavor in meat and eggs of poultry (Frempong *et al.*, 2019). Factually, the animal source of protein has generally been proven to have a more complete nutrient content to meet the needs of amino acids and minerals but unfortunately, it is expensive and may lead to high feed cost. There is inadequate information on the replacement of fish meal with soya bean meal on performance of broiler chicken especially the Ross 308 strain in Ghana. Hence, this work sought to gather information on replacement of fish meal with soybean meal in Ross 308 strain broiler feed and also to reduce the cost of feed in producing broilers. The purpose of this work was to identify the effect of soya bean meal as a substitute for fish meal in Ross 308 broiler diet on growth performance and carcass characteristics.

MATERIALS AND METHODS

Experimental site and Duration

The experiment was conducted at the Poultry Section, Department of Animal Science, Kwame Nkrumah University of Science and Technology (KNUST). The Department of Animal Science lies between longitude 01º 034' W and latitude

06º 41' N in a hot humid environment. Annually, it receives a rainfall of about 1400 to 1700 mm with a mean temperature range of 25ºC - 35ºC and a relative humidity of 74% - 85%. The study was conducted over a period of five weeks, from November 5, 2021 to December 10, 2021.

Experimental birds and design

A total of one hundred and twelve (112) unsexed day-old broiler chicks of the Ross 308 broiler strain obtained from a recognized distributor; Chicks House Poultry Enterprise at Ahinsan Estate in Kumasi, Ashanti Region were used for this experiment. The experiment was laid out in a Completely Randomized Design (CRD). The broiler chicks were brooded together in separate pens for two (2) weeks before the start of the experiment, with an average mean mass of 39 ± 1.5 g. Strict biosecurity measures were adhered to coupled with good husbandry practices to ensure minimal mortality rates during brooding. The experimental birds were randomly allocated to two treatment groups comprising two dietary treatments (Soya Bean Meal, SBM and Fish Meal, FM) with each having four replicates of 14 birds each of 0.58 kg (± 0.00256) average weight at week 2 of birds' age.

Experimental diets and treatments

An experimental diet and a basal diet were formulated and designed as T1 and T2. T1 contained solely plant protein source, soya bean meal and T2 which served as the control contained animal protein source, fish meal (FM) and wheat bran.

Housing and feeding management

During brooding, temperature and ventilation were adjusted to ensure the birds' comfort. Throughout the trial, the birds were fed and provided with water *ad libitum*. All birds' normal vaccinations and medications were strictly supplied throughout their entire development cycle.

The birds were raised for 5 weeks after brooding in floor pens littered with wood shavings under a 12-hour light-dark cycle at an ambient temperature of around 35°C for the first week, then gradually lowered by 2°C per week to about 25°C at week 7. The coop had 0.11 m^2 of floor area per bird with fourteen (14) birds/pen. The relative humidity was kept between 55 and 65%. Before the trial began, the water troughs and metallic feeders were carefully cleaned, disinfected, and assigned to each pen. Daily, the water troughs were washed and filled with new clean water. Feed spillage was avoided by elevating the feed troughs to the birds' eye level.

During the first two weeks, thus, before the experiment started, the birds were fed with Koudijs Galdus Magic Feed Pre-starter mash and KBSC Concentrate Crumbles (starter) for broilers. The birds were later fed with two different diets containing FM (control) and SBM as the protein sources. The components of the two diets are presented in Table 1.

Data Collection

Growth Parameters Measured

Data were collected on a weekly basis from week-two (2 weeks of age) when the experiment began until the seventh week (7 weeks of age), which was the end of the experiment, depending on factors essential for assessing the birds' growth performance. The following were among the growth parameters taken.

Feed Intake

Feed intake was calculated for each replicated pen of the treatments over the course of the experiment by weighing the feed given to the birds and the leftovers on a daily basis with a digital weighing scale (Unique Power Technology, India), then subtracting the total amount of leftovers from the total feed given to get the feed intake.

Body Weight and Weight Gain

Prior to the start of the experiment, the mean weight of the birds was established for each treatment. Following that, a digital weighing scale was used to weigh the birds at the end of every week for the duration of the experiment per replicate. The average body weight for each

Table 1: Feed ingredient and nutrient composition of the two diets provided to Ross 308 broiler chicken during the experimental period

Feed ingredients inclusion (%)	Treatments T1 (SBM)	T2 (FM)
Yellow Corn	64.37	65.05
Fish Meal	0.00	20.00
Soybean Bean Meal	30.90	0.00
Wheat Bran	0.00	11.77
Synthetic Lysine	0.25	0.00
Synthetic Methionine	0.25	0.00
NaCl	0.25	0.25
Oyster Shell	3.73	2.69
Vitamin Premix	0.25	0.25
Total	100.00	100.00
Chemical composition		
ME (kcal/kg)	2900	2900
CF (%)	3.14	2.68
Ca (%)	1.52	1.80
CP (%)	20	20.26
Lysine (%)	1.27	1.23
Methionine (%)	0.46	0.50
Cystine (%)	0.32	0.34
AV. Phos (%)	0.08	0.04

**T=Treatments, FM=fish meal, SBM= Soya bean meal, ME=Metabolizable energy, CF= Crude fibre, Ca =calcium, CP= Crude protein, NaCl= Sodium chloride*

treatment was calculated by summing the body weights of the birds in each replicate and dividing by the total number of birds per replicate. The weight gain during the period was calculated by subtracting the initial body weight from the final body weight at the end of the trial.

Body weight gain (kg) = Final body weight gain (kg) – Initial body weight at week 2 (kg)

Feed Conversion Ratio

Feed conversion ratio, FCR (feed intake/weight gain) data for each dietary treatment was also computed weekly by dividing the feed intake throughout the experimental period by the average body weight gain over the same period.

Carcass Parameters Measured

At the end of week 7, two birds (1 male, 1 female) from each replication were chosen at random and weighed following a 12-hour feed deprivation and later the birds were slaughtered, defeathered, and eviscerated. Live body weight, carcass weight, abdominal fat weight, and the internal organs such as heart, kidney, gizzard, intestines, liver, bilateral breast and thigh muscles were all weighed separately and recorded using digital electronic scale with 5 g sensitivity (Ingco Cordless 30kg Lithium-Ion Scale, China). Carcass weight is the weight of the feather-scalded, eviscerated carcass after the head, neck, blood, and hocks have been removed (Dilger *et al*., 2006).

The determined carcass parameters were:

- Live weight: The live weight was the weight of the birds before they were slaughtered.
- Bled weight: The bled weight was the weight of the birds after they had been bled out fully following the killing via jugular vein rupture.
- De-feathered weight: This was the weight of the warm carcass of the birds after the feathers and blood had been removed.
- Dressed weight and dressing percentage: The dressed weight is the weight of the warm carcass after defeathering and removing the viscera, which includes the head and hocks. After that, the dressing percentage was computed by dividing the dressed weight by the live weight at slaughter.
- Breast weight: The breast weight of the birds was determined by weighing their breasts on a digital electronic scale.
- Shank weight: The shank weight was determined by weighing the birds' shanks on a digital electronic scale.

- Head weight: the severed de-feathered head was weighed on a modern electronic scale to determine its weight.
- Heart weight: The weight of the heart was measured with a digital electronic scale.
- Liver weight: This was the weight of the liver as measured by a digital electronic scale.
- Full gizzard weight: This was the weight of the gizzard, including all of its contents, as measured on a digital electronic scale.
- Empty gizzard weight: This was the weight of the gizzard after it had been emptied of all its contents and weighed on a digital electronic scale.
- Full intestinal weight: This is the weight of the entire length of the intestine, including all of its contents, weighed on a digital electronic scale.
- Empty intestinal weight: This is calculated by weighing the whole length of the gastrointestinal tract (GIT) without its contents on a digital electronic scale.

Weight of liver, kidney, belly fat, spleen, neck, wing, thigh, and drum stick

The weight of the above-mentioned organs was also measured after evisceration on the day of slaughter.

Economics of Production

The cost per kilogram of feed and the cost per kilogram of weight gain for each bird were used to calculate the economics of production.

Data analysis and presentation

Data gathered were subjected to analysis of variance using Genstat 11th Edition (2012). Tukeys Studentized Range Test was used to separate differences between treatment means at $p<0.05$. The results have been presented in tables for clarity to readers.

RESULTS AND DISCUSSION

Feed intake

The total feed intake recorded per bird was 4.65 kg and 5.39 kg for T1 and T2 respectively (Table 2). Total feed intake for birds fed with fish meal-based diet was higher than that of birds fed with soybean meal-based diet ($P<0.05$). However, works from Aziz *et al*. (2000) and Gerry (1956) confirmed that SBM can successfully replace FM in broiler diets when they observed no significant differences in feed intake between birds fed on SBM diet and birds fed FM diet. The lower feed intake in T1 could be attributed to anti-nutritional factors (ANF) such as trypsin inhibitors and phytic acid present in locally produced SBM in developing countries (Babatunde *et al*., 2021; Abdel-Raheem *et al*., 2023). Erdaw and Bayene (2022) showed that these ANFs can result in poor growth performance. One way of curbing this problem according to Clarke and Wiseman (2000) is to ensure proper thermal processing during the production of SBM. Increase feed intake of FM is usually associated with its high palatability (Alabi, 2023; Babatunde *et al*., 2021).

Body weight (Initial weight, final weight and weight gain)

Birds fed on T1 (SBM diet) and those on T2 (FM diet) had the same mean initial body weight of 0.58 kg at week 2 of age, and there was no significant difference ($P>0.05$) as shown in Table 2. This was due to the fact that same diet was given to all birds at brooding stage before commencement of the experiment. Since the dietary treatments differed, it influenced their final body weight and weight gain. From Table 2, it can also be seen that birds that were fed with an FM diet (T2) had higher ($P<0.05$) final average body weight and total weight gain as compared to birds that were fed on SBM diet (T1). The higher final average body weight and total weight gain of birds fed on T2 could be due to the increased feed intake as stated earlier. The reduced body weight of the birds fed on T1 could partly be due to ANFs present in the meal. Other researchers have reported that a reduction in body weight is mostly associated with decreased in feed consumption (Popkin *et al*., 2021; Garaulet *et al*., 2013).

Table 2: Effects of soya bean-based mea (SBM) and fish-based meal (FM) diets on feed intake and growth performance of Ross 308 broiler chicken

Parameter	Treatment		SEM	P-value	Sig. level
	T1 (SBM)	T2 (FM)			
Total feed intake per bird, kg	4.65[b]	5.39[a]	0.1620	0.019	S
Daily feed intake per bird, kg	0.33[a]	0.15[b]	0.0046	0.019	S
Total body weight gain, kg	2.00[b]	2.27[a]	0.0570	0.028	S
Initial body weight, kg	0.58	0.58	0.0026	0.642	NS
Daily weight gain (kg/day)	0.057[b]	0.065[a]	0.0016	0.028	S
FCR (Feed/Gain)	2.33	2.37	0.0429	0.652	NS
Final body weight, kg	2.58[b]	2.85[a]	0.0570	0.028	S
Feed cost/kg (GH¢)	3.43	3.65	-	-	-
Feed cost /kg wt. gain	7.97	8.65	0.1950	0.131	NS

**Means with different superscripts are significantly different at p<0.05. SEM – Standard Error of Mean; S – Significant (P<0.05); NS – Non-significant (P>0.05): FCR - Feed conversion ratio*

Feed conversion ratio

The recorded FCR in Table 2 indicates that there was no significant difference (P>0.05) between T1 and T2. This observation confirmed the findings of Masey *et al.* (2018) who also conducted a similar experiment and reported no difference in FCR between birds that were fed on a diet containing SBM with synthetic methionine and lysine as protein source and birds that were fed on diet containing fish meal as a protein source. De Groote (1973) also reported no significant difference in the FCR of birds with fish meal and soya bean cake. De Groote concluded based on his results that SBM can successfully replace FM as a protein ingredient in chicken feed. However, with De Groote's work, he observed no significant differences in broiler body weight as well which is contrary to the current results. However, Beski *et al*. (2015) reported that the high digestibility of FM improves FCR, thereby supporting faster growth.

Live weight

The results presented in Table 3 indicates that, the birds that were fed on fish meal-based diet (T2) had a higher (P<0.05) live weight than those fed on soybean basal diet. The high average live weight observed in birds fed with T2 diet led to an increase in the dressed weight of the birds. This result does not agree with the findings of Frempong *et al.* (2019) who concluded that the live weight of birds fed with SBM diets were higher (P<0.05) than those fed with FM diets.

Table 3 shows the effects of T1 and T2 on the carcass parameters that were measured. The dressing percentage, the weights of the shank, breast, thigh and drum sticks, and the abdominal fat of birds fed with soy bean meal-based diet and fish meal based-diet all showed no significant difference (P>0.05), however there was an increasing trend in weight among the birds fed with fish meal basal diet. The non-significant difference between the treatments for the carcass parameters studied (abdominal fat, thigh and drum stick weight, breast weight, shank weight and dressing percentage) suggests that any farmer who is just interested in these parts for sale can equally use SBM as a substitute for FM without any adverse effect on the weights of

Table 3: Effects of soya bean-based meal (SBM) and fish-based meal (FM) diets on the carcass characteristics

Parameter	Treatment		SEM	P-value	Sig. level
	T1 (SBM)	T2 (FM)			
Live Weight (kg)	2.47^{b}	2.78^{a}	0.07	0.011	S
Bled Weight (kg)	2.18^{b}	2.54^{a}	0.08	0.031	S
De-feathered Weight (kg)	2.06^{b}	2.45^{a}	0.08	0.026	S
Dressed Weight (kg)	1.72^{b}	2.10^{a}	0.08	0.04	S
Dressing Percentage (%)	69.56	75.57	1.68	0.152	NS
Breast Weight (g)	446.86	517.39	20.70	0.23	NS
Shank Weight (g)	51.91	60.79	4.17	0.351	NS
Neck Weight (g)	111.64^{b}	143.99^{a}	7.28	0.01	S
Head Weight (g)	48.15^{b}	58.58^{a}	2.31	0.046	S
Wing Weight (g)	187.66^{b}	217.34^{a}	6.58	0.019	S
Thigh and drum stick (g)	471.31	588.04	28.20	0.112	NS
Abdominal fat (g)	30.98	56.44	6.14	0.105	NS

**Means with the no superscripts are not significantly different (p>0.05) while means with different superscripts are significantly different (p<0.05). NS – Not Significant (P>0.05); S – Significant (P<0.05).*
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Table 4: Effects of soya bean-based meal (SBM) and fish-based meal (FM) on the internal organs of broilers

Parameter (g)	Treatment		SEM	P-value	Sig. level
	T1 (SBM)	T2 (FM)			
Gizzard (full)	36.91	50.16	2.92	0.059	NS
Gizzard (empty)	26.58	35.98	2.05	0.054	NS
Intestine (full)	105.46	106.31	2.46	0.817	NS
Intestine (empty)	68.28	77.23	3.87	0.213	NS
Heart	19.33	10.45	2.75	0.109	NS
Liver	42.28	44.51	1.91	0.48	NS
Spleen	2.28	2.39	0.07	0.553	NS

**Means with the no superscripts are not significantly different at p<0.05. NS – Not Significant (p>0.05)* these carcass parameters. The remaining parameters, however, showed significant differences (P<0.05) as presented in Table 3. Most consumers of chicken are usually interested in the thigh and drum stick, breast, shank and the abdomen (Haunshi *et al.,* 2022), rather than the neck and the head, therefore farmers can use SBM instead of FM to get the desired output for these consumers. All the parameters of the internal organs that were measured showed no significant differences (P>0.05) as in Table 4.

Table 4 indicates that there were no significant differences (P>0.05) among the various internal organs of birds fed with soybean and fishmeal-based diets. Here again, in a situation where farmers' interest in the internal organs is of utmost importance, SBM could successfully replace FM as a protein source in broiler diets since this does not affect the chicken internal organs and other products demanded by most chicken consumers (Haunshi *et al.,* 2022) as stated earlier.

No mortality was recorded during the entire experiment. This shows that the use of SBM as a substitute for FM had no adverse health effect on the birds. It also confirms that good management and feeding standards were followed in raising the birds in this work.

Cost benefit analysis

The cost per kg of feed for SBM based diet was lower, ¢3.43 than that for FM which was ¢3.65 (Table 2) indicating that SBM based diet was cheaper than the FM based diet. This could be traced to the high cost of fish meal compared with soy bean meal which is relatively cheaper in the market. Feed cost per weight gain shows how feed was utilized by the birds based on the two treatments diets assessed in this work. There was no significant difference (P>0.05) in feed cost per kg weight gain for both treatments (T1 and T2).

CONCLUSION

The study revealed that feeding birds with soybean meal-based diet reduces feed intake without significantly reducing the total weight gain compared to fish meal-based diet. Feeding soya bean meal-based diet to broilers reduces the cost of producing broilers and gives more profit as compared to the use of fish meal. However, the presence of anti-nutritive factors in SBM should be addressed by adequately processing the soya beans. Based on the results obtained, the use of soya bean meal as protein ingredient, supplemented with methionine and lysine as additional protein sources is recommended to farmers to reduce the cost of producing broilers without any detrimental effect on the birds. Further studies need to be conducted on the effect of substituting fish meal as a protein ingredient in broiler diet with soybean meal at different levels to determine differences in broiler growth and best economic levels of substitution.

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