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ANIMAL HUSBANDRY & VETERINARY SCIENCE | RESEARCH ARTICLE

Growth performance and economic evaluation of broiler Chicken fed with rain tree (*Samanea saman*) seed meal

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Abstract: An 8-week experiment was conducted to assess the growth performance of broiler chicken served with rain tree (*Samanea saman*) seed meal as alternative source of protein. The study was conducted at the Animal Science Department at the Kwame Nkrumah University of Science and Technology in Ghana. The chicks were divided into four treatments and each treatment was replicated thrice with 20 chicks per replicate in a completely randomised design. *S. saman* seed meal was included at 20, 40 and 60 g in the diets as replacement for fish meal and soybean meal from the 3rd to 8th week. The results of the analysis indicated that 20 g *S. saman* seed meal diet resulted in higher weight gain (1.02 kg) and feed intake (1.48) but lower feed conversion efficiency (69%). Control treatment containing 100% fish meal and soybean meal had the best feed conversion efficiency (92%). The result of this study shows that 100% fish meal and soybean meal diet (0 g of *S. saman* seed meal) was more expensive Gh¢ 46.65 per kg of feed than the *S. saman* seed meal at

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PUBLIC INTEREST STATEMENT

Due to high feed cost, particularly of protein based feed such as soybean meal and fishmeal, Ghana is not able to meet the high demand for poultry product resulting in annual importation of about \$200 million. This study was designed to evaluate the level at which *Samanea saman* seed meal could be used as a substitute for fish meal and soybean meal in broiler chicken diet, and to undertake economic evaluation of its inclusion. A feeding trial was conducted where *S. saman* seed meal was included at 20, 40 and 60 g in the broiler diets as replacement for fish meal and soybean meal from the 3rd to 8th week. The 20 g *S. saman* seed meal diet resulted in higher weight gain and feed intake. Also, the 20 g diet gave the highest return. For improved growth rate and higher profit margin, it is advisable to include 20 g *S. saman* seed meal per kg broiler chicken diet.

60 g (Gh¢ 44.62 kg; 1\$ = 3.92 Gh¢). The cost and return analysis shows that 20 g diet gave the highest return (Gh¢ 5,905.08), followed by 0 g of *S. saman* seed meal (Gh¢ 4,346.07) and Gh¢ 2,380.20 for 40 g *S. saman* seed meal diet. For improved growth rate and higher profit margin, it is advisable to include 20 g *S. saman* seed meal per 100 kg broiler chicken diet.

Subjects: Environment & Agriculture; Bioscience; Food Science & Technology

Keywords: *Samanea saman* seed meal; fish meal; broiler chicken; broiler diets; feeding trial

1. Introduction

The interest of developing countries in promoting the production of fast growing animals such as poultry came as a result of increasing demand for animal protein (Obinne & Okorie, 2008). This is attributed to population growth in these countries. In Ghana, the difference between production and consumption of animal protein is below the recommended level. This poses threat to food security and may lead to malnutrition. Thus to avert this trend several attempts has been made to increase animal production in the country to bridge the gap. Most of the effort was directed towards poultry production. The policy to expand the production of poultry is seen as surest way of bridging the gap between production and consumption of animal protein (Adesehinwa, 2008).

Atteh (2004) noted that the protein from poultry meat is of high quality and in several cases, it is used as a standard against which other proteins are compared. This is because broiler chicken grows very fast and provides tender meat for human consumption. However, the cost of production keeps increasing as a result of the cost of feed ingredients particularly protein sources such as soybean and fishmeal. The rising cost of poultry feed is a major concern to the development of the poultry industry in developing countries like Ghana (Hagan, 2013).

According to Banson, Muthusamy, and Kondo (2015) in poultry production about 70% of the total cost can be attributed to feeding cost. The high cost of feed is attributed to the competition for conventional feedstuff for competing uses particularly protein feed ingredients such as fishmeal and soybean meal. Fish meal is an important constituent of broiler chickens diet because of its high protein content and good amino acid profile. Smith (2001) states that "Fishmeal is a high-quality protein food which contains all the essential amino acids, vitamin B12 and choline". However, the use of fishmeal and soybean meal is constrained by its high cost as a result of competition between human, industrial use, and poultry feed. He asserted that "Foods containing high levels of protein are expensive to purchase, and so a diet which is too high in protein is unnecessarily expensive" (Hagan, 2013).

The price of soybean meal and fishmeal continue to increase, consequently increasing the cost of production which influences profit margin of the farmers. Hence there is the need to search for alternative sources of protein which are capable of supplementing fishmeal and soybean meal. One such alternative source that can be utilized is the rain tree (*Samanea saman*) seed. *S. saman* is a multipurpose tree and is the botanical name for rain tree, 5' O clock tree or monkey pod. *S. saman* is native to Northern South America but currently naturalized and distributed throughout the tropics. *S. saman* is often planted in parks and pastures, vacant lots, churches and school grounds, along roadsides and planned landscape. *S. saman* is moderately fast growing with a growth rate of 0.75–1.5 m/year. Outdoors planting is done when the seedlings are 3–5 months old and 20–30 cm tall. It grows best in lowlands from sea level to 300 m high and rainfall of 600–3,000 mm.

The tree is recognized by its characteristic umbrella-shaped canopy or domed broad crown with a diameter of 30 m. Its size reaches 15–25 m in height but in rare cases 50 m. The tree attains heights greater than 40 m under dense conditions with narrower crown than when planted in the open. Rain tree has a short stout trunk of about 1–2 m in diameter. Rain tree has two flowering seasons, February–May and September–November. The pods are plumpy oblong, slightly flattened from side

to side and dark brown with slender u-shaped yellowish markings on the flattened sides. Each pod contains 15–20 seeds and an average of 200–250 kg of pods is found on a mature tree per season. Rain tree shows little local variability and is uniform in appearance throughout its distribution

S. saman pods are green when raw and have 16.70% protein content but it turns black when fully ripe which is also eaten by other farm animals like pig, sheep, goat, and cattle as it is rich in starch and sugar. Also, the sticky pulp around the seed is sweet making it more palatable for animal feeding (Staples & Elevitch, 2006). Flores (2002) also reported that rain tree pods contain 13–18% protein, are edible, nutritious for livestock and makes superb feed supplement. *S. saman* seeds are also used as concentrates for livestock. Its leaves are fairly rich in protein about 22–27% crude protein but are high in tannins. *S. saman* seed reportedly contains a high amount of protein and so could be used as a substitute for fishmeal and soybean meal by farmers.

The pods are edible and eagerly eaten by human and livestock (cattle, goat) both domesticated and wildlife. The seed of *S. saman* is already a good source of protein and energy. It contains 13.57% protein, 89.25% dry matter, 2.98% ether extract (EE), 2.19% crude fibre, 0.23% ash, and 6.44% nitrogen extract. Apart from its nutrient content which is almost comparable to corn, the pod is easily available making it a cheap source of feed for chickens (De la Cruz, 2003).

Preliminary studies done in Venezuela showed that the seed meal fed to cachama (a native fish species belonging to the Characidae family) at moderate levels has no adverse effect on the growth and performance (Hagan, 2013). Staples and Elevitch (2006) reported that rain tree pods are nutritious with 12–18% protein, 40% digestibility and because of the sweet pulp are eagerly eaten by cattle, hogs, horses and goats. Rain tree is grown as a green fodder supplement for goats, sheep, and cattle in Asia. Hence, this study was designed to evaluate at what level *S. saman* seed meal could be used as a substitute for a fish meal and soybean meal in broiler chicken diet and undertake an economic evaluation of its inclusion in broiler chicken diet.

2. Materials and methods

The study was conducted at the Poultry Section of the Department of Animal Science of the Faculty of Agriculture, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi (Ghana) for a total period of 8 weeks. Pods of *S. saman* were obtained from the KNUST campus. *S. saman* pods dropped from the trees on ripening and these were collected from the ground beneath the trees. The pods were sun dried for six days on a concrete floor. The seeds were removed from the pods by beating the pods with a stick and manually hand picking the seeds. Seeds were then sun-dried. The seeds were then ground with a hammer mill to produce the meal.

Three hundred (300) unsexed day-old Cobb commercial strain of broilers chickens were used for this study. The day-old chicks were obtained from a commercial hatchery and reared on litter in a common brooder house for the first 21 days. A broiler starter diet with 21% crude protein (CP) and 2,890 kcal/kg metabolisable energy (ME) were fed to the bird's *ad libitum*. Birds had free access to water. After the 21 days of age (before the commencement of the feeding trail) 240 birds were randomly selected and divided into four groups, each group constituting a treatment with three replicates per treatment in a completely randomized design. Each replicate group of 20 birds were kept in a deep litter pen.

The feeding trial was carried out from the 3th to 8th week of age and, therefore, each of the four groups of birds was fed with one of the dietary treatments for 5 weeks. During the experimental period feed and water were provided *ad libitum*. The birds were vaccinated against Gumboro, Newcastle disease and medicated for Coccidiosis at 3 days of age and again at third week using Sulfadimidine Sodium 33% (Bremer Pharma GMBH, Germany) via the drinking water. Four experimental diets for seed (Table 1) were formulated: a control diet with no *S. saman* seed meals (T1) and three other diets containing processed *S. saman* seed meals incorporated at levels of 20 (T2), 40 (T3) and 60 g (T4).

The results of the proximate chemical composition of the *S. saman* seed meal is presented in Table 2. The results depict the control diet (T1) has a CP value of 23% and the three other diets containing the *S. saman* seed meal at levels of 20 g (T2), 40 g (T3) and 60 g (T4) are 22.06, 21.52 and 20.97% respectively. The CF values were T1 3.95, 5.68, 4.47, 4.97% for T1, T2, T3 and T4 diets, respectively. All of the four experimental diets are rich in CP and agree with the findings of Rath et al. (2014) and Akoja and Amoo (2011).

Data on feed intake was recorded daily, while body weight gain (WG) was determined on weekly basis. Also, feed conversion efficiency was recorded. A proximate analysis of the experimental diets (dry matter, CP, EE, ash and crude fiber -CF-) was carried out using the standard procedures of the Association of Official Analytical Chemists (1990). methodology. Dry matter of the seeds was determined by oven drying at 50°C for 12 h until constant weight. The ME contents of the *S. saman* seed meals was estimated using the formula used by Hagan (2013): ME (kcal/kg) = (37 × % protein) + (81.8 × % fat) + (35.5 × % NFE).

Table 1. Composition of experimental broiler diets including *S. saman* seed meal

Ingredients (g kg ⁻¹)	Treatments: <i>Samanea saman</i> seed meal			
	Control (T1)	20 g (T2)	40 g (T3)	60 g (T4)
Maize	600	600	600	600
Soybean meal	130	120	110	100
Fishmeal	160	150	140	130
<i>Samanea saman</i> seed meal	0	20	40	60
Wheat bran	80	80	80	80
Oyster shell	10	10	10	10
Dicalcium phosphate	10	10	10	10
Vitamin-mineral premix*	5	5	5	5
Salt	5	5	5	5
Total	1,000	1,000	1,000	1,000
Crude protein	226.10	220.60	215.20	209.70
Crude fibre	39.50	56.80	44.70	49.70
Ether extract	20.00	10.00	10.00	15.00
Phosphorus	7.38	7.44	7.48	7.52
Calcium	8.80	9.08	9.36	9.63
Lysine	13.06	13.15	1.319	13.24
Methionine	5.02	5.05	5.11	5.16
Cystine	3.36	3.44	3.48	3.52
Dry matter	89.5	88.5	88.5	89.5
Metabolisable energy (kcal/kg)	2,954.45	2,930.75	2,948.90	2,987.54

*The composition of the vitamin-mineral premix.

Table 2. Weekly mean feed intake (kg/20 birds) of birds for the experimental period

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5
T1 (Control diet)	10	21.00 ^a	24.00 ^a	28.90 ^a	27.40 ^a
T2 (20 g <i>Samanea saman</i>)	10	18.87 ^b	18.77 ^b	28.37 ^a	26.92 ^a
T3 (40 g <i>Samanea saman</i>)	10	18.43 ^b	17.50 ^b	21.77 ^b	25.14 ^b
T4 (60 g <i>Samanea saman</i>)	10	12.43 ^c	13.90 ^c	16.93 ^c	23.22 ^c
p-value	-	<0.001	<0.001	<0.001	<0.001
LSD (5%)	-	0.759	2.299	1.367	1.455
CV (%)	0.00	2.30	6.60	3.00	3.00

Note: Means in the same column bearing different superscripts are significantly different ($p < 0.05$).

3. Methods of analysis

Data collected were subjected to analysis of variance (ANOVA) in GENSTAT computer program and errors were calculated as standard errors of the mean (SEM), while least significant difference (LSD) was used in assessing the significant differences among the treatment means. Significance was accepted at 0.5 level of probability.

In addition, an economic appraisal of the study was done to highlight the efficiency of the *S. saman* seed meal as protein in terms of contribution margin. The cost and return data were analyzed using marginal costing techniques (Emokaro, 2010; Nworgu, 2007; Omokaro, 2015).

Marginal costing principles were adopted to evaluate the return on the broilers fed with *S. saman* seed meal. In marginal costing, fixed production overheads are not absorbed into cost units and stock are valued at marginal or variable cost and fixed production overheads are treated as period cost and charged to profit and loss account for the period which the overhead is incurred. This was done because this analysis is under the experimental station and these overhead are expected to change with time on the farm and from location to location. Thus in this study, the contribution was used as a proxy for profitability as it gives a better indication of profitability based on the nature of the study. Contribution margin is given by:

$$CM = TR - TOC$$

where TR: total revenue; TOC: total operating cost; CM: contribution margin, this is the margin that is contributing to fixed cost and profit. The higher the contribution margin the larger the amount of funds available to defray the fixed cost. The rule is that the contribution margin needs to be positive and the higher it is the better.

4. Results and discussion

4.1. Feed intake

Weekly feed intake of the birds is shown in Table 2. There was a significant difference ($p < 0.001$) among all the four treatments. There was an increase in feed intake throughout the treatment within the weeks. The dietary level of *S. saman* seed meal had a significant effect on the feed intake of the birds. Birds on the 0 g diet (T1) had the highest feed intake throughout the weeks which differed significantly ($p < 0.001$) from others except those fed 20 g *S. saman* seed meal (T2).

The control diet (T1 or 0%) had the highest feed intake followed by the T2 (20 g), T3 (40 g) and T4 (60 g), in this order. This trend could be attributed to the acceptability, palatability, smell, appearance and color of the feed as is known that animals are particular about these attributes of feed. Feed intake of birds fed 40 and 60 g *S. saman* seed meal diets were significantly lower ($p < 0.001$) than those on 0 and 20 g dietary levels. The low-level feed consumed by birds fed with 40 and 60 g *S. saman* seed meal might be attributed to the presence of antinutritional factors like tannins and saponins in *S. saman* seed meal leading to reduced feed palatability, intake, digestion, absorption, utilization and growth. According to Nwocha, Njoku, and Ekwueme (2014) presence of tannins and saponins affects feed intake and digestion. Tannins have also been reported to adversely affect feed intake and feed efficiency in broiler chickens (Greiner, Konietzny, & Jany, 2006; Guan, Yang, Yin, Jia, & Wang, 2014). Similarly, reports from Górká, Przybyło, Kański, and Kloska (2016) show that tannins lower dry matter and protein digestibility.

Table 3. Weekly mean weight gain (kg/20 birds) of birds for the experimental period

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5
T1 (control diet)	5.800 ^a	9.430 ^a	6.570 ^a	8.200 ^a	6.430 ^a
T2 (20 g <i>Samanea saman</i>)	5.100 ^b	6.700 ^b	8.130 ^a	6.900 ^a	10.870 ^a
T3 (40 g <i>Samanea saman</i>)	3.967 ^c	5.070 ^{bc}	6.130 ^a	3.500 ^a	5.370 ^a
T4 (60 g <i>Samanea saman</i>)	1.333 ^d	3.970 ^c	4.270 ^b	5.800 ^a	5.770 ^a
<i>p</i> -value	<0.001	<0.001	0.008	0.458	0.219
LSD (5%)	0.538	1.941	1.807	6.690	6.125
CV (%)	7.10	16.40	15.30	58.00	45.80

Note: Means in the same column bearing different superscripts are significantly different ($p < 0.05$).

This implies that the dietary level of *S. saman* seed meal beyond 20 g does not support feed intake of broiler chicken. However, there was a decrease in feed intake for T1 and T2 at the 5th week which is significant ($p < 0.001$) and could be due to the low feed intake recorded at these level. On the other hand, there was an increasing effect throughout the weeks in birds fed on the 40 and 60 g *S. saman* seed meal and this result is in contrasts with the findings of Guan et al. (2014) and Greiner et al. (2006).

4.2. Weight gain

Weekly WG of birds fed with experimental diets is presented in Table 3. Birds on 40 g (T3) and 60 g (T4) *S. saman* seed meal diets had similar body WG but have significantly ($p < 0.05$) lower weight than those on 0 g (T1) and 20 g (T2) *S. saman* seed meal inclusion levels. This means that any slight increase in *S. saman* seed mealdietary level in broiler chicken diets above 20 g may not support growth and thus reduces WG. This may be due to decreased feed intake and the inability of the birds to utilize the diets as a result of poor digestion and absorption probably due to the presence of anti-nutritional factors. This supports Nwocha et al. (2014) reports showing that the presence of anti-nutritional factors in this plant limits feed intake.

Figure 1 shows the cumulative WG curves of the birds in each treatment. It reveals that birds served 20 g (T2) *S. saman* seed meal diet gained as much weight as those on control diet (0 g or T1).

The average WG of birds in the first week on the experimental diet was significantly different ($p < 0.001$) among the treatments. The result revealed an increase in WG for the second week but reduced on the fifth week as compared with other treatments. The 60 g inclusion level (T4) also increased throughout the experimental period but reduced at the fifth-week while 20 g (T2) and 40 g (T3) inclusion levels recorded increased WG across first to third weeks which declined in the fourth week and increased again in the fifth week. During the fifth week, the highest WG was enjoyed by the 20 g (10.87) inclusion level and this was followed by the 0 g (6.43) but there was no significant difference ($p > 0.05$) between them (T1 and T2). This trend could be attributed to the absence of anti-nutritional factors in the control diet, 0 g (T1) and a reduced Anti Nutritive Factors (ANFs) content in the 20 g (T2) which might have allowed for effective utilization and absorption of nutrients resulting in the highest WG and lowest

Figure 1. Cumulative weekly weight gain curve of broilers fed *S. saman* seed meal diet.

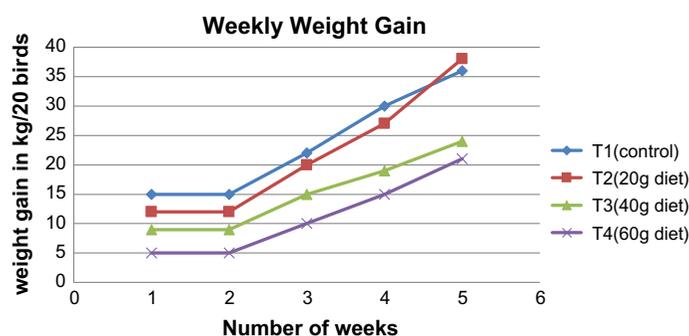


Table 4. Weekly feed conversion efficiency of broiler birds fed with different levels of *S. saman* seed meal diets

Treatments	Week 1	Week 2	Week 3	Week 4	Week 5
T1 (control diet)	1.581 ^a	1.385 ^a	1.329 ^a	0.915 ^a	0.754 ^a
T2 (20 g <i>Samanea saman</i>)	1.602 ^a	1.590 ^b	1.424 ^{ob}	1.048 ^a	0.714 ^a
T3 (40 g <i>Samanea saman</i>)	2.073 ^b	1.962 ^c	1.456 ^b	1.350 ^b	1.049 ^b
T4 (60 g <i>Samanea saman</i>)	2.354 ^b	2.628 ^d	1.786 ^c	1.515 ^b	1.101 ^c
<i>p</i> -value	<0.001	<0.001	<0.012	<0.007	<0.001
LSD (5%)	0.345	0.268	0.244	0.306	0.097
CV (%)	9.90	7.30	8.70	13.50	5.70

Note: Means in the same column bearing different superscripts are significantly different ($p < 0.05$).

feed conversion ratio (FCR) of birds fed the two diets. Throughout the weeks the 60 g (T4) and 40 g (T3) inclusion levels had the lowest values as compared to the 0 and 20 g levels. This condition could be due to the fact that the increasing contents of anti-nutritional factors in the *S. saman* seed meal diets with the increasing levels of substitution accounted for the decrease in WG. Similar trends of decreased WG have been linked to contents of ANFs in the diets by Esonu, Iwu, Opera, and Bamgbose (2000). It is known that broilers WG is strictly affected by dietary energy density in such a way that concentrated fish meal diet promotes high growth as compared to diluted fish meal diets. Hence, it is expected that dilution of the diets with *S. saman* seed meal as occurred in 20 g (T2), 40 g (T3) and 60 g (T4), their WG will reduce significantly compared to 0 g (T1). However, for the fourth and fifth week, there was no significant difference ($p = 0.458$ and $p = 0.219$, respectively) in WG across the four dietary treatments. This may be attributed to the fact that as the week's pass by, the broilers may be getting used to the palatability, the color and other attributes of the experimental diet hence have this insignificant difference ($p > 0.05$) among the treatments at the fifth week. The result of this study accords with reports of Rezaei and Hajati (2016). However, Kamran et al. (2008) indicated that there exists positive phenotype cohesion between growth rate and feed intake or palatability. Wilkinson, Bradbury, Bedford, and Cowieson (2014) also observed that the heave in the appetite of broilers leads to increases in their WG, therefore, the WG of broilers is directly affected by feed intake, genetic potential and other factors.

4.3. Feed conversion ratio

Table 4 presents the results of FCR. The results show that all the dietary levels of *S. saman* seed meal had a significant ($p < 0.001$) effect on FCR of the broiler chicken throughout the five weeks of the experiment. Birds fed 0 and 20 g diets had very close feed/gain ratio with significant difference ($p < 0.001$) throughout the weeks (week one to week five). The superior FCR exhibited by 0 and 20 g dietary levels may, therefore, proved that birds on these dietary levels optimally utilized the feed consumed. However, birds on 0 and 20 g diets differed significantly ($p < 0.001$) from birds fed on 40 and 60 g *S. saman* seed meal from the first till the fifth week of the study. This result may be probably due to the broilers getting adjusted to the taste of the experimental diets. The 0 g (T1) diet enjoyed the highest FCR followed by 20 g (T2) diet with corresponding values of 1.581 and 1.602, respectively, for the first week while 40 g (T3) and 60 g (T4) diets for the first week had values of 2.073 and 2.354 as the worst feed conversion, respectively. The trend continued until the fifth week when the most superior ratio became the 20 g (T2) diet. The FCR decreased among the treatments as the week's passed by (from week one to week five) with 60 g (T4) diet being the least efficient. At the fifth week 0 g (T1), 20 g (T2), 40 g (T3) and 60 g (T4) diets had the corresponding values of 0.754, 0.714, 1.049 and 1.101 which were significantly different ($p < 0.001$) among the four treatments. The above condition could be explained by the absence of anti-nutritional factors in the control diet (0 g) which allowed for effective utilization of nutrients in it and this was responsible for the lowest FCR of birds fed the diet. Also, the increasing contents of anti-nutritional factors in the *S. saman* seed meal diets with the increasing levels of substitution accounted for the increased FCR obtained in birds fed the 20 g (T2), 40 g (T3) and 60 g (T4) inclusion levels. Similar trends were observed by Esonu et al. (2000) with a cultivar of wild cocoyam corms (*Caladium hortilanum*).

Table 5. Sales, variable costs and contribution margin for broiler production per 20 birds in diets with different *S. saman* inclusion levels

Item	T1 (control)	T2 (20 g <i>Samanea saman</i>)	T3 (40 g <i>Samanea saman</i>)	T4 (60 g <i>Samanea saman</i>)
Total Revenue (TR) from 20 birds (Gh¢*)	309.93	320.77	246.50	204.00
Operating cost				
Price per 20 birds at start of the experiment	100.00	100.00	100.00	100.00
Maize	41.61	38.95	35.39	29.91
Fish meal	44.38	38.95	33.03	25.92
Soya bean meal	18.03	15.58	12.98	9.97
Wheat bran	1.78	1.66	1.51	1.28
Dicalcium	6.94	6.49	5.9	4.99
Premix	1.39	1.30	1.18	1.00
Oyster shell	13.87	12.98	11.80	9.97
Salt	3.47	3.25	2.95	2.49
<i>Samanea saman</i>	0.00	2.60	4.72	5.98
Grinding	3.00	4.00	5.00	6.00
Antibiotics	10.00	10.00	10.00	10.00
Vaccine	3.00	3.00	3.00	3.00
Total operating cost (TOC)	247.47	238.76	227.46	210.51
Contribution margin (TR-TOC)/20 birds	62.46	82.01	19.04	-6.51

*\$1 = 3.92 Gh¢.

Kamran et al. (2008) reported that “FCR in well-managed broiler houses should be in a range of 1.9–2.15 or better, depending on the nutrient density, time of year and other factors”. However, Nworgu (2007) reported that broiler FCR in temperate and tropics are between 2 and 2.5 and also when energy levels are high, consumption and the FCR are small and vice versa. According to Zhai, Peebles, Schilling, and Mercier (2016) a good feed conversion would be 2 lb of feed to yield 1 lb (1 lb = 0.454 kg) of live bird weight but anything less than that like FCR under 1.5–1 is great. Therefore, the FCR of the broilers in the present study can be said to be within the normal range. On the other hand, feed efficiency of broilers is affected by bird age, sex, health and environmental temperature, although the major factor is usually diet energy concentration and CP level.

4.4. Contribution margin for broiler fed with *S. saman* seed meal

Contribution margin is the difference between sales revenue and variable cost. This contribution margin contributes towards the payment for fixed cost incurred. Since this project is done at an experimental station it is difficult to capture all the fixed cost to evaluate the profitability; however, contribution margin can be determined once the variable costs are known and sales revenue is determined. Since the study was undertaken at the experimental station it was difficult to capture fixed cost associated with the broiler production in this study. Thus profit cannot be determined however, contribution margin could be used as an indicator of profitability. Contribution margin is TR less TOC. TOC in this study comprises feed, labor, and medication (Table 5). TR is the proceeds from the sale of the broiler chickens after the experiment. The contribution margin for the broiler production per 20 birds was highest for treatment 2 (20 g), amounting Gh¢ 82.01 (1\$ = 3.92Gh¢), it was Gh¢ 62.46 for treatment 1 (0 g), Gh¢ 19.04 for treatment 3 (40 g) and a resulted in a negative margin of Gh¢ 6.51 for treatment 4 (60 g).

5. Conclusions and recommendations

The current study helps in understanding the nutritional versatility of *S. saman* seed meals. This research suggests that *S. saman* seed meal can partly replace fish meal and soybean meal in broiler ration. Hence future strategies can be developed for its optimum utilization. At the end of the experiment, it could be concluded that the treatment 2 (20 g *S. saman* diet) yields the best results in all parameters measured and gross margin. Therefore, *S. saman* seed meal is a valuable protein and mineral supplement for broiler chicken. *S. saman* or rain tree is available in Ghana and is known to produce fruits or pods with seeds which go waste and become a nuisance so they need to use money and effort to clear it when planted at a recreational center.

This study recommends that poultry farmers should form cooperative societies to enable them to procure the *S. saman* seed meal in large quantities so as to further reduce the high cost involved in procuring the meal, especially for individual farmers as the cost can be high looking at laborious work involved in getting the seed out of the pod. Unless there is a market, investors would not invest in machines that can facilitate the removal of seeds from the pods. Thus with co-operatives, there would be a market for the seed meal which would warrant the investment. The poultry farmers should be educated on the advantages of using *S. saman* seed meal as this would reduce the cost of feed and overall production cost.

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Competing Interests

The authors declare no competing interest.

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