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Energy value and digestibility of breadfruit (*Artocarpus altilis*) in broiler diets as partial replacement for Corn (*Zea mays*)

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Abstract The study found that replacing maize with sundried breadfruit meal (SBM) at varying levels were not significantly (P>0.05) affected on the total feed intake, overall feed conversion efficiency, and livability rate of broilers. Similarly, the body weight of Kabir birds was not significantly (P>0.05) affected by SBM at replacement levels of 10% to 30%. The 10% replacement level in broiler diets was found to be equivalent to the control. Additionally, the study showed that SBM was not significantly (P>0.05) affected on digestibility, feed intake, feed conversion efficiency, livability, income over feed and chick cost. The findings suggested that using SBM as a partial replacement for maize in broiler diets at a 10% replacement level resulted to cost savings without compromising performance. The study concluded that feeds with a 10% to 30% replacement level could be given to Kabir birds without compromising their weight gain. By substituting a portion of maize in feeds, andproduction costs were reduced and showed competition between humans and animals for food. Incorporating SBM as a partial replacement for maize in broiler and Kabir bird diets at 10% up to 30% was not significantly (P>0.05) affected on the birds' feed intake, feed conversion efficiency, livability rate, and net income. These findings are supported using SBM as an alternative feed ingredient in poultry production, contributed to sustainable and cost-effective farming practices. Further research is needed to evaluate the economic feasibility of using SBM as a partial substitute for maize in poultry diets.

Keywords: Digestibility, Energy value, Partial replacement, Sundried breadfruit meal

Introduction

Corn is the world's most significant cereal (Shah *et al.*, 2016). Corn accounts for around 77% of corn consumption in developing nations and 44% in industrialized countries, and corn is the primary component of animal feed, accounting for 70%-80% of corn (Yapura, 2021). As a result, competition for corn between humans and animals is unavoidable. Finding a substitute for corn as the primary element in animal feed remains a difficulty to this day. Oso *et al.*

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(2010b) discovered that breadfruit has a high protein and calorie value, making it a suitable replacement for corn in chicken diets. Hundreds of breadfruit cultivars are propagated throughout the Pacific Islands, with traditional culture yielding up to 200 fruits per tree per year and intensive cultivation yielding an average of 330 kg (Ragone, 2006). Although this fruit has been consumed, its demand could be better than that of corn. Breadfruits are produced worldwide, and cultivation is simple due to their adaptability to a wide range of environmental conditions (Ragone, 2006). The fruit was discarded and rotting without anybody understanding that it contributes significantly to animal production as a source of nutrition. For growth and development, broilers require vital nutrients. Feeds provide these nutrients in the form of energy, proteins, vitamins, minerals, and an unexplained growth factor. The cost of feed is thought to be the most expensive aspect of chicken farming. The cost of feed accounts for 75 to 80% of the overall cost of production in broiler production (Rojo, 2004). Breadfruit might be utilized as a suitable feed resource for cattle at 50% supplementation, but it should not be eaten uncooked, especially in mammalian species, as it could cause hemolytic anemia, splenic and hepatic disorders, and other diseases (Aka *et al.*, 2009). Breadfruit is high in protein, carbs, calcium, and other vitamins and minerals (Ragone, 2014). Breadfruit contains 86.27% dry matter, 12.98% crude protein, 4.22% crude fiber, 3.94% ash, and 3870.30 Kcal/kg metabolizable energy, according to Oladunjoye *et al.* (2004).

In addition, Aka *et al.* (2009) found that raw unpeeled sundried breadfruit had a crude protein value of 8.39% when compared to parboiled, roasted, and cooked versions, which had values of 5.6%, 5.08%, and 4.02%, respectively.

Breadfruit is abundant on Ticao Island, but it is not effectively exploited since the residents of the island are unaware of the fruit's economic importance. Breadfruit on Ticao Island has been squandered in recent years owing to degradation, and trees have been chopped down since some feel that there are no benefits to this tree other than serving as sustenance for humans. Humans and animals are battling for corn as a food source to live. On the other side, the food supply is limited, which is why experts are presently looking for ways to alleviate this problem.

The purposes were to determine the energy value and digestibility of sundried breadfruit meal, to determine the growth performance of broilers fed partially replaced sundried breadfruit meal, to assess the profitability of broiler production using partially replaced breadfruit meal, and to determine whether sundried breadfruit meal can partially replace corn as the main ingredient in broiler diets.

Materials and methods

In this study, a two-factor experiment in a Completely Randomized Design (CRD) was used. As experimental birds, one hundred (100) straight-run day-old broiler chicks and one hundred Kabir broiler chicks were employed. These birds were randomized randomly to eight treatments replicated five times. Five birds were assigned at random to each cage that represented a replicate. Treatment A1B1 was diets without breadfruit meal in broiler chicken, A1B2 was diets without breadfruit meal in Kabir chicken, treatment A2B1 was diets with 10% breadfruit meal in broiler chicken, treatment A2B2 was diets with 10% breadfruit meal in Kabir chicken, treatment A3B1 was diets with 20% breadfruit meal in broiler chicken, treatment A3B2 was diets with 20% breadfruit meal in Kabir chicken, treatment A4B1 was diets containing 30% breadfruit meal in broiler chicken and treatment A4B2 was diets containing 30% breadfruit meal in Kabir chicken.

Breadfruit was purchased at Panisijan, Batuan, Daplian, Costa Rica. The fruits were thoroughly washed and dried in the sun for 3 to 5 days until the moisture content reached 14%. Dried breadfruit was crushed and mixed with other feed materials such as yellow corn, soybean meal, rice bran D1 coco oil, limestone, salt, and fish meal using a hammer mill.

The proximate analyses of SBM like DM, CP, EE, P, and Ca were investigated according to Brea *et al.* (2013). The obtained data included body weight, body weight, feed consumption, feed efficiency, livability, and cost and return. In this investigation, total feces were collected to test the digestibility of treatments. Before morning feeds, the feces voided by each broiler throughout the previous 24 hours were carefully collected and weighed to ascertain the actual fecal output before being sent to the laboratory for examination. Before laboratory examination, the collected feces were oven dried to 14% moisture content. The data were statistically analyzed using the analysis of variance of a two-factor factorial experiment in a Completely Randomized Design. Treatment means were compared using Duncan's Multiple Range Test.

Results

Proximate composition of the sundried breadfruit meal (SBM)

Sundried breadfruit meal (SBM) showed greater levels of crude protein (12.98%), crude fiber (4.22%), calcium (0.98%), and phosphorus (0.10%) than regular corn. The gross energy (3870 Kcal), ADF (14.90%), and ether extract (2.02%) values for SBM showed to be an excellent source of energy and

protein in broiler diet formulation. Data revealed that sundried breadfruit meals could substitute a portion of corn in chicken diet formulation to minimize competition and production without impacting growth performance.

Table 1. Composition of the nutrient content of the experimental diets and sundried breadfruit meal

Ingredient (%)	**Treatment**				
	A_1 *(Control)*	**A_2** *(Diet with 10 % sundried breadfruit meal)*	**A_3** *(Diet with 20 % sundried breadfruit meal)*	**A_4** *(Diet with 30 % sundried breadfruit meal)*	**SBM**
Corn, Yellow	43.15	38.84	34.52	30.21	
Soybean, Meal	20.75	20.00	19.55	19.25	
Rice Bran, D1	27.00	28.41	29.25	30.00	
Sundried breadfruit Meal	0.00	4.32	8.63	12.95	
Coco Oil	2.10	1.62	1.23	0.82	
Limestone, Fine	0.81	0.72	0.62	0.51	
Salt	0.20	0.10	0.21	0.27	
Fish Meal	6.00	6.00	6.00	6.00	
Total	100.0	100.0	100.0	100.0	
Determined Analysis					
% Crude Protein	19.35	19.40	19.50	19.70	18.70[1]
ME Kcal/kg	2900.00	2900.00	2900.00	2900.00	3870.00[2]
% Calcium	0.81	0.81	0.81	0.81	0.98[3]
% Available P	0.34	0.35	0.35	0.35	0.20[1]
% Crude Fiber	3.76	3.86	3.95	4.03	4.22[4]
% Lysine	1.07	1.04	1.03	1.01	
% Methionine	0.36	0.35	0.34	0.34	

[1]Oso *et al.* (2010a), [2]Aka *et al*. (2009), [3]Bria *et al.* (2013), [4]Olandoyie *et al*. (2004)

Nutrient digestibility

The nutritional digestibility of sundried breadfruit meals was shown in Table 2. According to the data, using varying degrees of sundried breadfruit meal as a partial replacement for corn had not significantly (P>0.05) influenced the nutritional digestibility of broiler diets. The nutritional digestibility was lowest in chicken beginning diets where corn was supplemented with 10% sundried breadfruit meal (Diets A2B1, A4B2). Furthermore, finisher diets using 10% sundried breadfruit meal as a corn substitute (Diets A2B1, A3B2) had the lowest nutritional digestion.

Table 2. Nutrient digestibility (%) of sundried breadfruit meal

Breed of Chicken	Levels	FEEDS		
		Starter	Finisher	Mean
Broiler	A2B1 (10% SBFM)	77.05	84.45	80.75[a]
	A3B1 (20% SBFM)	81.02	87.91	84.47[a]
	A4B1 (30% SBFM)	88.20	88.06	88.13[a]
	A1B2 (Control)	86.98	91.64	89.31[a]
Kabir	A2B2 (10% SBFM)	74.63	86.04	80.34[a]
	A3B2 (20% SBFM)	84.20	94.03	89.12[a]
	A4B2 (30% SBFM)	87.62	92.57	90.10[a]
	A1B2 (Control)	91.26	95.54	93.40[a]

[a] Means in column with the same letter are not significantly different at (P>0.05)

Apparent metabolizable energy (AME)

Replacing corn with varying quantities of breadfruit meal did not substantially (P0.05) improved the broiler metabolizable energy. Furthermore, this study revealed that substituting corn in broiler diets up to 30% would not impair broiler gross energy intake, which is critical for their growth and development.

Table 3. Apparent metabolizable energy (Kcal) of chicken-fed diets with varying levels of sundried breadfruit meal

Breed of Chicken	Levels	FEEDS		
		Starter	Finisher	Mean
Broiler	A1B1 (Control)	3938.24	3917.33	3927.79[a]
	A2B1 (10% SBFM)	3935.69	3906.45	3921.07[a]
	A3B1 (20% SBFM)	3910.59	3880.17	3895.38[a]
	A4B1 (30% SBFM)	3925.99	3970.00	3948.00[a]
Kabir	A1B2 (Control)	3937.65	3912.84	3925.25[a]
	A2B2 (10% SBFM)	3936.61	3909.63	3923.12[a]
	A3B2 (20% SBFM)	3909.61	3878.08	3893.85[a]
	A4B2 (30% SBFM)	3927.67	3597.60	3762.64[a]

[a] Means in column with the same letter are not significantly different at (P>0.05)

Body weight

The food treatments had a significant (P0.01) effect on the end live weights of the birds. After 35 days of feeding, broiler chicks fed diets containing 20 to 30% sundried breadfruit meal had considerably lower body weight than those in the control group. Furthermore, results indicated that poultry given breadfruit-based diets had lower-end body weight than the control. However, the daily weight of chicken fed 20% and 30% sundried breadfruit meal did not change considerably. The cyclopropane-containing sterol, cycloartenol, which accounted for 12% of the non-saponifiable extract, had been blamed for the deleterious consequences.

Table 4. Average body weight (g) of chicken-fed diets with varying levels of sundried breadfruit meal

Breed of Chicken	**Treatment**	**Feeding Period**		
		Initial	**28 days**	**35 days**
Broiler	A1B1 (Control)	307.16	961.80[a]	1,187.80[a]
	A2B1 (10% SBFM)	339.00	912.20[b]	1,110.40[ab]
	A3B1 (20% SBFM)	297.00	833.60[b]	1,008.00[bc]
	A4B1 (30% SBFM)	345.00	872.60[b]	976.00[c]
Kabir	A1B2 (Control)	120.90	281.95[a]	352.50[a]
	A2B2 (10% SBFM)	144.40	285.40[b]	358.60[ab]
	A3B2 (20% SBFM)	146.00	292.00[b]	350.60[bc]
	A4B2 (30% SBFM)	129.80	239.60[b]	299.20[c]

[a, b, c] Means in column with the same letter are not significantly different at (P>0.01)

Body weight gain

The results showed that the prepared treatments had a substantial (P>0.01) effect on chicken body weight growth after 28 days of feeding. Diets containing 20% and 30% replacement in broiler and Kabir diets considerably lower body weight and increased during all feeding times. A1 (control), A2 (10%), and A3 (20%) were not statistically different from one other. Data also revealed that the control and 10% breadfruit meal levels had the most acceptable indices for this indication, owing to the increased body weight of the broiler at the end of the trial (Table 5). The carcass yield did not change between the control and the 10% breadfruit meal treatment. The results showed that including 10% breadfruit meal in a broiler feed was viable factor.

Table 5. Average body weight gain (g) of chicken-fed diets with varying levels of sundried breadfruit meal

Breed of Chicken	Treatment	Feeding Periods	
		28 days	35 days
Broiler	A2B1 (10% SBFM)	654.64[a]	880.64[a]
	A3B1 (20% SBFM)	573.20[b]	771.40[ab]
	A4B1 (30% SBFM)	536.60[b]	711.00[bc]
	A1B2 (Control)	527.60[b]	631.00[c]
Kabir	A2B2 (10% SBFM)	161.05[a]	231.60[a]
	A3B2 (20% SBFM)	141.00[b]	214.20[ab]
	A4B2 (30% SBFM)	146.00[b]	204.60[bc]
	A2B1 (10% SBFM)	109.80[b]	169.40[c]

[a, b, c] Means in column with the same letter are not significantly different at (P>0.01)

Feed consumption

The results indicated that varying quantities of sundried breadfruit meal in the diets had not significantly (P>0.05) influenced on average feed intake. Data demonstrated that broilers fed diets containing sundried breadfruit meal consumed more feed, although it was not significantly compared to control diets during all feeding times. It revealed that the Kabir consumed more than the broiler.

Table 6. Average feed consumption (g) of chicken-fed diets with varying levels of sundried breadfruit meal

Breed of Chicken	Treatment	Feeding Periods	
		28 days	35 days
Broiler	A2B1 (10% SBFM)	1,280.80[a]	917.60[a]
	A3B1 (20% SBFM)	1,282.36[a]	881.40[a]
	A4B1 (30% SBFM)	1,203.52[a]	756.20[a]
	A1B2 (Control)	1,268.72[a]	779.80[a]
Kabir	A2B2 (10% SBFM)	544.20[a]	330.20[a]
	A3B2 (20% SBFM)	607.88[a]	431.40[a]
	A4B2 (30% SBFM)	705.60[a]	436.20[a]
	A1B2 (Control)	565.20[a]	406.80[a]

[a] Means in column with the same letter are not significantly different at (P>0.05)

Conversion efficiency

The data demonstrated that various quantities of sundried breadfruit meal in bird diets had not significantly (P>0.05) influenced on chicken feed conversion efficiency. Diet A4 with 30% sundried breadfruit meal resulted in higher feed conversion efficiency of broilers.

Table 7. Average feed conversion efficiency (g) of chicken-fed diets with varying levels of sundried breadfruit meal

Breed of Chicken	Treatment	Feeding Period	
		28 days	35 days
Broiler	A2B1 (10% SBFM)	1.97[b]	1.05[c]
	A3B1 (20% SBFM)	2.24[a]	1.14[b]
	A4B1 (30% SBFM)	2.24[a]	1.06[b]
	A1B2 (Control)	2.40[a]	1.26[a]
Kabir	A2B2 (10% SBFM)	3.40[b]	2.07[c]
	A3B2 (20% SBFM)	4.50[a]	3.15[b]
	A4B2 (30% SBFM)	4.85[a]	2.98[b]
	A2B1 (10% SBFM)	5.15[a]	3.71[a]

[a, b, c] Means in column with the same letter are not significantly different at (P>0.01)

The results showed that the efficiency of feed conversion in broiler diets increased with the introduction of treatments. Kabir, on the other hand, had the greatest recorded in feed conversion efficiency, but it was not translated into live weight owing to some depressing aspects. This implies that broiler diets including sundried breadfruit meals may be designed to improve broiler productivity and feed efficiency.

Livability rate

The various quantities of sundried breadfruit in the meals had not significantly affected broiler livability. Mortality did not occur in broilers throughout the trial, but it did occur in Kabir-fed control diets, as indicated in Table 8. Statistical analysis revealed no significant differential impact between treatment means at 5%. The antioxidants in breadfruit were responsible for the 100 percent survivability rates of broilers fed which varied quantities of sundried breadfruit meal. It revealed that altering quantities of sundried breadfruit meals in broiler diets can reduce mortality rates.

Table 8. Average livability rate (%) of chicken-fed diets with varying levels of sundried breadfruit meal

Chicken-fed	Levels	Livability Rate
Broiler	A_1B_1	100.00[a]
	A_2B_1	100.00[a]
	A_3B_1	100.00[a]
	A_4B_1	100.00[a]
Kabir	A_1B_2	98.40[a]
	A_2B_2	100.00[a]
	A_3B_2	100.00[a]
	A_4B_2	100.00[a]

[a] Means in column with the same letter are not significantly different at (P>0.05)

Income over feed and chicks' costs

In broiler, the greatest values were obtained at the 10% level of treatment (Php 225.13). Nonetheless, the therapy containing 20 to 30% sundried breadfruit flour did not vary substantially from the control group in terms of markers. The treatments using 10, 20, and 30% sundried breadfruit flour in Kabir resulted in significant savings as compared to the control for the indicators of feed cost of live weight (Table 9). The control diet had much more productive outcomes. In this case, the cost of feed per bird would be lowered due to an increase in the animal's eventual live weight. For the duration of feeding, the increased cost of the treatments with 10, 20, and 30% sundried breadfruit meal would be inferior to the control.

Table 9. Average income (Php) over feed and chick costs of broilers fed diets with varying levels of sundried breadfruit meal

Cost	A_1B_1	A_2B_1	A_3B_1	A_4B_1
Cost of chick (PHP)	39	39	39	39
Cost of Feed/Kilogram (PHP)				
Booster	34	0.99	1.76	2.75
Starter	33	8.45	14.04	23.24
Finisher	32	5.81	8.89	14.27
Total Feed Consumption/Chick (Kg)				
Booster	0.15	0.15	0.15	0.15
Starter	1.28	1.28	1.20	1.27
Finisher	0.92	0.88	0.76	0.78
Total Cost of Feed (PHP)	76.78	16.073	23.869	41.062
Cost of breadfruit /kg (PHP)	0	30	30	30
Total breadfruit Consumed/chick (kg)	0	0.22	0.39	0.61
Total Cost of breadfruit (PHP)	0	6.6	11.7	18.3
Cost of Vitamin/Medicine (PHP)	20	20	20	20
Total Cost (PHP)	96.78	42.673	55.569	79.362
Return				
Average Body Weight (kg)	2.20	2.06	1.76	1.87
Price/kilogram live weight (PHP)	130	130	130	130
Gross Income (PHP)	286.00	267.80	228.80	243.10
Less Total Cost (PHP)	96.78	42.673	55.569	79.362
Net Profit (PHP)	189.22	225.13	173.23	163.74

Table 10. Average income (Php) over feed and chick costs of Kabir-fed diets with varying levels of sundried breadfruit meal

Cost	A_1B_2	A_2B_2	A_3B_2	A_4B_2
Cost of chick (PHP)	53.00	53.00	53.00	53.00
Cost of Feed/Kilogram (PHP)				
Booster	34.00	0.45	1.04	1.31
Starter	33.00	1.83	4.90	4.87
Finisher	32.00	1.29	3.04	3.57
Total Feed Consumption/Chick (Kg)				
Booster	0.15	0.15	0.15	0.15
Starter	0.54	0.61	0.71	0.56
Finisher	0.33	0.43	0.44	0.41
Total Cost of Feed (PHP)	33.48	1.74	4.97	4.39
Cost of breadfruit/kg (PHP)	0.00	30.00	30.00	30.00
Total breadfruit Consumed/chick (kg)	0.00	0.10	0.23	0.29
Total Cost of breadfruit (PHP)	0.00	3.00	6.90	8.70
Cost of Vitamin/Medicine (PHP)	20.00	20.00	20.00	20.00
Total Cost (PHP)	53.48	24.74	31.87	33.09
Return				
Average Body Weight (kg)	0.65	0.64	0.64	0.58
Price/kilogram live weight (PHP)	200.00	200.00	200.00	200.00
Gross Income (PHP)	130.00	128.00	128.00	116.00
Less Total Cost (PHP)	53.48	24.74	31.87	33.09
Net Profit (PHP)	76.52	103.26	96.13	82.91

Discussion

The study's findings on the nutritional composition of sundried breadfruit meal (SBM) and its effect on broiler diets are consistent with previous research by Aka *et al.* (2009) and Oladunjoye *et al.* (2004) that found breadfruit to be a valuable feed ingredient for livestock. The higher levels of crude protein, crude fiber, calcium, and phosphorus in SBM compared to normal corn make it an excellent source of energy and protein in broiler diet formulation. These results are important as they provide alternative feed sources that can be used to minimize the cost of broiler production.

The study showed that SBM could partially substitute corn in chicken diet formulation without affecting growth performance. This result is consistent with previous studies that used breadfruit as a partial replacement for corn in broiler diets (Bria *et al.,* 2013). However, the nutritional digestibility of broiler

diets was lower in starter diets supplemented with 10% SBM and finisher diets using 10% SBM as a corn substitute. This result is contrary to findings by Oladunjoye *et al.* (2004) and Bria *et al.* (2013) that showed no significant difference in nutrient digestibility in broiler chickens fed breadfruit meal.

The study's findings suggest that substituting corn in broiler diets with up to 30% SBM would not impair broiler gross energy intake, which is critical for their growth and development. This result differs from Bria *et al.* (2013), which found that increasing levels of breadfruit meal in broiler diets reduced the apparent metabolizable energy (AME) content of the diets. The contrasting results may be due to the different levels of SBM used in the two studies. Further research is needed to determine the optimal levels of SBM that can be used as a partial replacement for corn in broiler diets.

The data presented in Tables 9 and 10 of the study indicated that the use of sun-dried breadfruit meals in Kabir and broiler production can result in an increase in income. The use of SBM as a partial replacement for maize in the diet of Kabir chicken resulted in a lower cost of feed per kilogram of weight gain. This result is consistent with findings by Oladunjoye (2005) that showed breadfruit meals to be cost-effective in broiler diets. The use of SBM in the diet of broiler chickens resulted in a higher income per bird, with the group fed a diet containing 30% SBM having the highest income per bird. This result is consistent with findings by Bria *et al.* (2013), which showed that the inclusion of breadfruit meals in broiler diets could improve the economic returns of broiler production.

In conclusion, the study's findings on the nutritional composition of SBM and its effect on broiler diets are consistent with previous research on the nutritional value of breadfruit for livestock. The study's results suggest that SBM can be used as an alternative feed ingredient in broiler diets without compromising broiler performance. Further research is needed to evaluate the economic viability of using SBM as a partial substitute for corn in broiler diets. The data presented in Tables 9 and 10 of the study indicated that the use of SBM can result in cost savings and increased income in Kabir and broiler production. The use of alternative feed ingredients such as SBM in poultry production is essential for sustainable and cost-effective poultry farming.

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