

## Effect of partial replacement of corn with breadfruit (*Artocarpus altilis*) flour on growth performance and meat quality of broiler chickens

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Received: 19<sup>th</sup> April 2020 / Accepted: 13<sup>th</sup> July 2021

### ABSTRACT

**Purpose:** There is a need to explore the use of non-conventional, locally available and cheap energy-rich ingredients to substitute corn in broiler diets as it is used mainly for human consumption in developing countries. Therefore, this study investigated the effect of partial substitution of corn with breadfruit flour (BFF) in broiler diets on growth performances and meat quality in broiler chickens.

**Research Method:** One hundred and eighty day-old straight-run "Cobb 500" broiler chicks (45.92 ± 0.43 g) were randomly allocated into one of three dietary treatments (Corn based basal diet with no BFF [Control], Corn-substituted basal diet with 5% BFF [BFF5], and Corn-substituted basal diet with 10% BFF [BFF10]) with six replications and 10 birds per replicate. Growth parameters including body weights, average daily gain, average daily feed intake, feed conversion ratio, and organ weights and meat quality parameters were determined.

**Findings:** The broilers fed BFF10 significantly ( $P < 0.05$ ) improved the body weight, average daily weight gain, and feed efficiency of broilers for the complete experimental period (d 1-35). Further, the same diet improved ( $P < 0.05$ ) the average daily feed intake of broilers for the starter period (d 1-7) compared to the control diet. Furthermore, broilers fed BFF10 had a heavier ( $P < 0.05$ ) heart, liver and empty intestine than those fed BFF5. Moreover, breast meat of broilers fed BFF10 had a significant ( $P < 0.05$ ) lower crude fat content and CIE a\* value than that of broilers fed other diets.

**Originality/value:** Breadfruit flour would be a suitable non-conventional energy feed source to partly substitute corn in broiler diets up to 10% with improved growth performance and meat quality in broiler chickens.

**Key Words:** Breadfruit flour, corn, growth performance, meat quality, partial substitution

### INTRODUCTION

Dietary energy is quantitatively the most important component in the broiler diet which enhances the performance and production coefficients of broiler chickens and is important in evaluating the nutritional and economical value of the diet (Adekunle *et al.*, 2006; Dairo *et al.*, 2010; Yang *et al.*, 2020). Corn is the superabundant and the predominant energy source in compounded broiler diet due to its relatively higher starch and crude fat contents (Benitez *et al.*, 1999; Abudabos, 2012; Lasek *et al.*, 2012). Nevertheless, the use of corn as a staple human food, and as a major ingredient in

brewing, confectionery and biofuel production has created direct competition regarding the continuous use of corn as the major energy source of poultry diet in developing countries and resulted in an additional cost (Ojewola *et al.*, 2006; Abdulrashid and Agwunobi, 2012). Therefore, non-conventional energy-rich feed ingredients which are locally available,

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less in demand, and relatively lower in cost may be an excellent solution for partial or complete substitution of corn in broiler diets. Consequently, breadfruit has been identified as a potential feedstuff to overcome the constraints of corn used in broiler diets (Atuahene *et al.*, 2002; Chukwukaelo *et al.*, 2018).

Breadfruit (*Artocarpus altilis*) is an underutilized tropical fruit with high energy content. Several studies have emphasized that properly processed breadfruit meal in moderate levels (up to 40%) could be a potential energy source for broilers with no adverse effects on performance and feed efficiency (Ravindran and Sivakanesan, 1995; Adekunle *et al.*, 2006; Oladunjoye *et al.*, 2010). Its fruit is a rich source of energy (3870 kcal kg<sup>-1</sup>) with low crude fat content (3.94%) and contains high-grade protein made out of essential amino acids compared with corn (Liu *et al.*, 2015; Liu *et al.*, 2020; Needham *et al.*, 2020). Besides, studies of Badrie *et al.* (2010) and Jones *et al.* (2011) well-documented breadfruit as a good source of minerals such as Ca, Mg, K, P, Cu, and Fe which are required to ensure the health and productivity of broiler. Moreover, breadfruit is comprised of phenolic compounds such as flavonoids, stilbenoids, and aryl-benzofurans, knowing to possess anti-bacterial, anti-viral, anti-tumour, and cytotoxicity properties (Jagtap and Bapat; 2010; Sikarwar *et al.*, 2014). These findings have supported the claim that breadfruit is an assortment ingredient of high energy with medicinal values for broiler diets. However, broilers should be provided with either cooked breadfruit or breadfruit flour (BFF) due to the presence of anti-nutritional factors including oxalate, tannin, and phytate in its raw form (Adekunle *et al.*, 2006; Oladunjoye *et al.*, 2010). Also, breadfruit is highly perishable in fresh form (Amusa *et al.*, 2002; Oladunjoye *et al.*, 2010).

Breadfruit can be considered as one of the highly productive seasonal crops (16-50 ton/ha) during the fruiting season compared to corn (4.0 ton/ha; Ragone, 2018). Hence, surplus and/or rejected breadfruits could be an excellent alternative energy ingredient in its cooked or powder form to effectively replace corn partially

in broiler feed formulations. To our knowledge, evidence regarding partial replacement of corn with BFF in broiler diets is scarce and yet to be studied thoroughly. Therefore, this study was carried out to elucidate the efficiency of partial substitution of BFF for corn on growth performance and meat quality parameters in broiler chickens.

## MATERIALS AND METHODS

The Research Ethics Committee of the Uva Wellassa University of Sri Lanka has reviewed and approved (UWU/REC/2020/007) the complete experimental procedure of the current study. All birds were reared and cared for, under the guidelines of the Cobb 500® broiler management guide (Cobb-Vantress, 2018a).

### *Preparation of Breadfruit Flour (BFF)*

The selected plant species were identified and authenticated as *Artocarpus altilis* by the National Herbarium, Department of National Botanical Gardens, Peradeniya, Sri Lanka. Breadfruit flour was prepared according to the methodology stated by Liu *et al.* (2020) with slight modifications. Breadfruits were first cleaned thoroughly with fresh water and peeled off. Cores were then cut into small pieces (1.5 cm thickness), blanched at 60°C for 3 sec, and dried indoor to prevent nutritional losses. After that, the dried pieces were sorted and ground to produce a soft and smooth flour. The resultant BFF was finally stored in airtight containers at room temperature for further use. The moisture, crude protein, crude fat and crude ash contents of the BFF used in the present study were 11.59%, 6.29%, 1.76% and 2.55%, respectively.

### *Experimental Design and Animal Care*

A total of 180 day-old straight-run “Cobb 500” broiler chicks with approximately similar body weights (45.92 ± 0.43 g) were randomly allocated into 18 deep litter floor pens (3 m × 3 m) with rice husks as the bedding material in an open-sided house system. Birds were provided with the experimental diets and clean drinking water on an *ad-libitum* basis throughout the experimental period. All the chickens were managed according to the guidelines provided

by the Cobb 500<sup>®</sup> broiler management guide (Cobb-Vantress, 2018a). Floor brooding was performed for 14 days period with 24 hours lighting schedule. The temperature was maintained at 34°C during the brooding period (67±3% Relative humidity) and gradually acclimatized to environment temperature (29±1°C) along with a 24 hours lighting regime. The experiment lasted for 35 days and chickens were observed twice a day for general conditions.

### ***Experimental Diets***

A basal diet was formulated based on corn and soybean meal to meet the nutrient requirements specified in the Cobb 500<sup>®</sup> nutrition specification (Cobb-Vantress, 2018b). Corn in the basal diet was partially replaced with BFF to obtain the experimental diets as; 1) Corn based basal diet with no BFF (Control), 2) Corn-substituted basal diet with 5% BFF (BFF5), and 3) Corn-substituted basal diet with 10% BFF (BFF10). The feeding trial consisted of three phases; starter phase (Day 1-7), grower phase (Day 8-21) and finisher phase (Day 22-35). The compositions of experimental control diets are presented in Table 01 and all the diets were in the mash form.

### ***Growth Performance***

The bodyweight of each bird and feed intake of each replicate was measured weekly for 35 days of the experiment. Using these data, average daily weight gain (ADG) per bird, average daily feed intake (ADFI) per bird, and mortality corrected feed conversion ratio (FCR) were computed in each replicate.

### ***Sample Collection***

Two birds from each replicate were randomly selected and slaughtered by conventional neck cut and exsanguinations for 2 min on d 35. Then the carcasses were de-feathered and eviscerated manually. The weight of each carcass without giblets was measured and the dressing percentage was calculated. The weights of internal organs (i.e., liver, heart, gizzard, and empty intestine) were recorded and expressed in proportion to the live body weight. Carcasses

were then chilled at 4°C for 24 hours, and used for subsequent analyses. Breast fillets from each carcass were dissected separately and trimmed off for visible skin, fat, and connective tissues.

### ***Analyses of Breast Meat Quality***

Proximate composition (moisture, crude ash, crude protein, and crude fat) of breast meat samples was determined according to the standard method of AOAC (2016). Additionally, pH value, cooking loss, water holding capacity (WHC), and surface colour (CIE L\*, CIE a\* and CIE b\*) of breast meat samples were measured according to the methods described by Jayasena *et al.* (2013) and Lakshani *et al.* (2016).

### ***Statistical Analyses***

The complete experiment was conducted according to the completely randomized design and experimental data were analyzed using the one-way ANOVA technique, General Linear Model (GLM) in the SPSS software package (Version 26; IBM SPSS 2019). Significant differences between mean values were determined by using Tukey's multiple range test at a significance level of  $P < 0.05$ .

## **RESULTS AND DISCUSSION**

All birds showed adequate growth performances and remained healthy during the experimental period. Dietary treatments did not affect the mortality of birds and the rate was below 2% during the entire period.

### ***Growth Performances***

The effect of different levels of BFF on the growth performances of broilers raised for 35 d is presented in Table 02. The broilers fed BFF10 improved ( $P < 0.05$ ) the body weight from d 8 to d 35 than those fed control and BFF5 diets. Substitution of corn with BFF at 10% in diets increased ( $P < 0.05$ ) ADG of broilers during the grower, finisher, and complete experimental periods by 1.51%, 6.78%, and 4.62% compared with the control diet and by 1.29%, 4.97%, and 3.44% compared with BFF5 diet, respectively. BFF10 improved ( $P < 0.05$ ) the ADFI of the birds for the starter period (25.81 g/d) which was a 2.67% increment compared to the control diet.

**Table 01. Composition (% , as fed) of the experimental control diet for three phases.**

Ingredients (%)	Feeding phase		
	Starter (1-7 d)	Grower (8-21 d)	Finisher (22-35 d)
Corn	55.82	58.15	60.02
Vegetable oil	1.00	1.30	3.00
Soybean meal 44%	23.92	23.84	19.60
Meat and bone meal	5.56	4.56	5.24
Rice polish	0.00	0.00	3.24
Corn gluten meal 60%	5.00	5.00	0.00
Bakery byproduct meal	5.00	3.64	5.00
Di-calcium phosphate	0.85	0.45	0.80
Lime stone powder	1.20	1.45	1.44
Salt	0.74	0.47	0.48
Sodium bicarbonate	0.00	0.22	0.25
Choline chloride 60%	0.00	0.08	0.05
Mineral pre-mix**	0.20	0.20	0.20
Vitamin pre-mix***	0.04	0.04	0.04
L-lysine 98.5%	0.27	0.20	0.29
DL-Methionine 98.5%	0.26	0.25	0.20
L-Threonine 99%	0.14	0.15	0.15
Calculated Values****			
Metabolizable Energy, kcal/kg	2980	3025	3115
Crude Protein, %	22	20	19
Ca, %	1.00	1.01	1.07
Available P, %	0.34	0.27	0.33
Total Lysine, %	1.33	1.23	1.10
Total Met + Cys, %	0.94	0.91	0.82
Total Thr + Trp, %	1.23	1.19	1.06
Total Val + Arg, %	2.68	2.56	2.21

\* Control- Basal diet; BFF5-Basal diet + 5% BFF; BFF10- Basal diet + 10% BFF

\*\*Supplied per kilogram of total diets: Fe, 80 mg; Zn, 80 mg; Mn 80 mg; Co 0.5 mg; Cu, 10 mg; Se, 0.2 mg; I, 0.9 mg; Mg, 60 mg; K, 1 mg; Na, 0.5 mg.

\*\*\*Supplied per kilogram of total diets: Vitamin A, 24,000 IU; Vitamin D3, 6000 IU; Vitamin E, 30 IU; Vitamin K, 4 mg; Thiamin, 4 mg; Riboflavin, 12 mg; Pyridoxine, 4 mg; Folacine, 2 mg; Biotin, 0.03 mg; Vitamin B8, 0.06 mg; Niacin, 90 mg; Pantothenic acid, 30 mg.

\*\*\*\*The values were calculated according to the values of feedstuffs given in NRC (1994)

**Table 02. Effect of partial replacement of corn with different levels of breadfruit flour in broiler diets on growth performance of broilers for 35 days\*.**

Period	Treatments**			SEM***	P-value
	Control	BFF5	BFF10		
Body weight, g					
Initial	45.93	46.23	45.60	0.427	0.869
Day 7	192.80 <sup>a</sup>	194.40 <sup>ab</sup>	196.33 <sup>b</sup>	0.586	0.014
Day 14	494.00 <sup>a</sup>	497.23 <sup>a</sup>	505.33 <sup>b</sup>	1.901	0.010
Day 21	886.17 <sup>a</sup>	889.40 <sup>a</sup>	900.00 <sup>b</sup>	2.293	0.005
Day 28	1436.60 <sup>a</sup>	1441.70 <sup>ab</sup>	1449.67 <sup>b</sup>	2.157	0.011
Day 35	2009.33 <sup>a</sup>	2032.00 <sup>b</sup>	2099.33 <sup>c</sup>	13.767	< 0.001
Average daily gain, g/d					
Day 1-7	20.98 <sup>a</sup>	21.17 <sup>ab</sup>	21.57 <sup>b</sup>	0.106	0.033
Day 8-21	49.53 <sup>a</sup>	49.64 <sup>a</sup>	50.28 <sup>b</sup>	0.131	0.009
Day 22-35	80.23 <sup>a</sup>	81.61 <sup>b</sup>	85.67 <sup>c</sup>	0.830	< 0.001
Day 1-35	56.10 <sup>a</sup>	56.74 <sup>b</sup>	58.69 <sup>c</sup>	0.396	< 0.001
Average daily feed intake, g/d					
Day 1-7	25.14 <sup>a</sup>	25.44 <sup>ab</sup>	25.81 <sup>b</sup>	0.106	0.005
Day 8-21	64.42 <sup>ab</sup>	64.82 <sup>b</sup>	63.33 <sup>a</sup>	0.276	0.043
Day 22-35	125.04	124.39	125.43	0.221	0.154
Day 1-35	80.81	80.77	80.66	0.074	0.756
Feed conversion ratio					
Day 1-7	1.19	1.19	1.19	0.003	0.870
Day 8-21	1.29 <sup>b</sup>	1.30 <sup>b</sup>	1.25 <sup>a</sup>	0.008	0.006
Day 22-35	1.37 <sup>b</sup>	1.36 <sup>b</sup>	1.34 <sup>a</sup>	0.005	0.005
Day 1-35	1.38 <sup>c</sup>	1.37 <sup>b</sup>	1.32 <sup>a</sup>	0.009	< 0.001

\*Each mean represents values from six replicates (10 birds/replicate)

\*\*Control- Basal diet; BFF5-Basal diet + 5% BFF; BFF10- Basal diet + 10% BFF

\*\*\* Pooled standard error of the mean.

<sup>a-c</sup> Values in a row with different superscripts differ significantly ( $P < 0.05$ ).

Nonetheless, BFF5 improved ( $P < 0.05$ ) ADFI of broiler chickens for the grower period (64.82 g/d) by 2.35% compared to BFF10. Moreover, BFF10 increased ( $P < 0.05$ ) the feed efficiency of broilers by reducing FCR for the grower, finisher, and complete experimental periods by 3.10%, 2.19%, and 4.35% compared to control diet and by 3.85%, 1.47%, and 3.65% compared to BFF5 diet, respectively. Hence, partial replacement of corn in broiler diets with 10% of BFF found to be more effective on the growth performances of broilers than other diets used in the present study. Adekunle *et al.* (2006) has reported improved performances of broilers receiving diets containing breadfruit as a replacement for corn.

Similarly, the results of the present study also showed that the partial replacement of corn with 5-10% of BFF in broiler diets improved the growth performances of broilers. It could be attributed to the fact that improved body weight of broilers fed BFF is due to the favourable amino acid profile of breadfruit, in particular higher content and higher digestibility of glycine, histidine, and lysine that are responsible for the fast growth of birds (Ravindran and Sivakanesan, 1995; Aftab, 2019). Besides, Adekunle *et al.* (2006) has revealed that higher growth and weight gain of broilers can be obtained by providing them with processed BFF compared to a corn-based diet. Processing of raw breadfruit is crucial because the presence of anti-nutritive factors in its raw form lowers the digestion, absorption, and utilization of energy, protein, and specific amino acids through the inhibition of digestive enzymes, thus resulting in poor growth and delayed maturity (Atuahene *et al.*, 2002; Oladunjoye *et al.*, 2010; Brea *et al.*, 2013; Nikmaram *et al.*, 2017).

Interestingly, broilers fed BFF showed a lower ADFI than those fed the control diet in the grower period. An increment in dustiness and powdery nature of feed due to BFF as compared with corn might cause low acceptability, low palatability, and difficulties in eating by broilers (Ravindran and Sivakanesan, 1995; Atuahene *et al.*, 2002). This condition could be partially alleviated either by further processing (pelleting) of the BFF incorporated diets or the

addition of fat to improve texture and reduce the dustiness (Morgan and Choct, 2016). Besides, tannin present in breadfruit (6.06-6.70 mg/kg) also impairs the palatability of feed (Oladunjoye *et al.*, 2010). In agreement with the results of the present study, Valdivié and Alvarez (2003) found an improved feed efficiency by partial replacement of cornmeal with breadfruit meal in broiler diets. The higher fibre content of breadfruit than corn improves the intestinal content and prolonged retention time of feed in the gut which directs to boost nutrient absorption and nutrient transportation through villi ultimately amplifying the feed efficiency in broilers (Jones *et al.*, 2011; Huang *et al.*, 2019; Riber *et al.*, 2020).

### ***Dressing Percentage and Internal Organ Weights***

Dressing percentages (without giblets) and weights of internal organs as affected by partial replacement of corn with different levels of BFF in broiler diets are presented in Table 03. Broilers fed BFF5 had a substantially higher dressing percentage ( $P < 0.05$ ) than those fed the control diet. Besides, the weights of the heart, liver and empty intestine of birds fed BFF10 were significantly heavier ( $P < 0.05$ ) by 15.63%, 9.03% and 8.86% than those of birds fed BFF5 diet, respectively. However, no significant difference in internal organ weights was observed between the birds fed the control diet and those fed corn-substituted diets ( $P > 0.05$ ).

**Table 03. Effect of partial replacement of corn with different levels of breadfruit flour in broiler diets on dressing percentage and internal organ weights of broilers\*.**

Parameter (%)	Treatments**			SEM***	P-value
	Control	BFF5	BFF10		
Dressing percentage	59.69 <sup>a</sup>	62.76 <sup>b</sup>	62.54 <sup>ab</sup>	0.552	0.029
Heart	0.71 <sup>ab</sup>	0.64 <sup>a</sup>	0.74 <sup>b</sup>	0.017	0.025
Gizzard	4.19	4.10	4.49	0.077	0.084
Liver	3.27 <sup>ab</sup>	3.21 <sup>a</sup>	3.50 <sup>b</sup>	0.049	0.030
Empty intestine	8.60 <sup>ab</sup>	8.01 <sup>a</sup>	8.72 <sup>b</sup>	0.128	0.041

\*Each mean represents values from six replicates (10 birds/replicate)

\*\*Control- Basal diet; BFF5-Basal diet + 5% BFF; BFF10- Basal diet + 10% BFF

\*\*\* Pooled standard error of the mean.

<sup>a-b</sup>Values in a row with different superscripts differ significantly ( $P < 0.05$ ).

The results of the current study on dressing percentage and internal organ weights are not in agreement with the findings of Ravindran and Sivakanesan (1995) and Atuahene *et al.* (2002), who reported that these parameters were not affected by breadfruit treated diets. The enlargement of the liver and other internal organs could be attributed to the fact that the presence of anti-nutritive factors in the diet, in particular tannin and oxalate and increased detoxification in the body (Ologhobo *et al.*, 2003; Adekunle *et al.*, 2006; Qorbanpour *et al.*, 2018). Moreover, Aka *et al.* (2009) demonstrated an improvement in heart weight of breadfruit fed albino rats due to the escalated protein deposition, thus, an increment in cardiac muscle mass.

broilers fed BFF10 showed 44.69% and 34.85% decrements ( $P < 0.05$ ) in crude fat content compared to those from broilers fed the control and BFF5 diets, respectively. However, the inclusion of BFF at different levels did not affect ( $P > 0.05$ ) pH, cooking loss, WHC, and CIE L\* values of broiler breast meat. In contrast, CIE a\* value of breast meat from broilers fed BFF10 had a lower value ( $P < 0.05$ ) than those from broilers fed the control and BFF5. Moreover, breast meat from the broilers fed the control diet showed a significantly higher ( $P < 0.05$ ) CIE b\* value than those from broilers fed BFF5 and BFF10.

### **Breast Meat Quality Traits**

The effect of partial replacement of corn with different levels of BFF in broiler diets on proximate composition and quality parameters of broiler breast meat is shown in Table 04 and 05. Accordingly, moisture, ash and crude protein contents were comparable among the treatments ( $P > 0.05$ ). In contrast, breast meat samples from

**Table 04. Effect of partial replacement of corn with different levels of breadfruit flour in broiler diets on proximate composition of broiler breast meat\*.**

Parameter (%)	Treatments**			SEM***	P-value
	Control	BFF5	BFF10		
Moisture	73.78	74.84	74.25	0.431	0.631
Ash	5.30	5.27	5.53	0.143	0.746
Crude fat	3.11 <sup>b</sup>	2.64 <sup>b</sup>	1.72 <sup>a</sup>	0.181	0.001
Crude protein	14.19	16.98	21.00	1.737	0.289

\*Each mean represents values from six replicates (10 birds/replicate)

\*\*Control- Basal diet; BFF5-Basal diet + 5% BFF; BFF10- Basal diet + 10% BFF

\*\*\* Pooled standard error of the mean.

<sup>a-b</sup>Values in a row with different superscripts differ significantly ( $P < 0.05$ ).

**Table 05. Effect of partial replacement of corn with different levels of breadfruit flour in broiler diets on meat quality parameters of broilers\*.**

Parameter	Treatments**			SEM***	P-value
	Control	BFF5	BFF10		
Meat colour					
CIE L*	63.24	62.62	61.41	0.585	0.457
CIE a*	10.72 <sup>b</sup>	10.32 <sup>b</sup>	6.93 <sup>a</sup>	0.574	0.004
CIE b*	14.45 <sup>b</sup>	11.91 <sup>a</sup>	11.96 <sup>a</sup>	0.395	0.004
pH	6.12	5.94	5.86	0.060	0.211
Cooking loss %	24.40	24.50	25.22	0.348	0.611
Water holding capacity %	84.17	85.83	83.61	0.600	0.306

\*Each mean represents values from six replicates (10 birds/replicate)

\*\*Control- Basal diet; BFF5-Basal diet + 5% BFF; BFF10- Basal diet + 10% BFF

\*\*\* Pooled standard error of the mean.

<sup>a-b</sup>Values in a row with different superscripts differ significantly ( $P < 0.05$ ).

Information on the effect of the incorporation of breadfruit into broiler diets on physicochemical parameters of broiler meat is scarce and yet to be elucidated. A recent study by Huang *et al.* (2019) reported that the incorporation of BFF into beef patties enhanced CIE a\* by increasing the myoglobin content of meat. However, the inclusion of BFF in broiler diets has decreased the CIE a\* value of breast meat in the current study. The higher CIE b\* value of breast meat from the broilers fed control diet may be due to the higher yellow pigment content in corn, resulting in more yellowish meat (Smith *et al.*, 2002). The proximate composition of the broiler breast meat was not altered by incorporating BFF in broiler diets in the present study, except the crude fat content. The presence of anti-oxidants and fat-soluble flavonoids in breadfruit reduces the crude fat of broiler meat by suppressing the action of 3-hydroxy-3-methyl-glutaryl-coenzyme A (HMG Co-A) reductase and  $\beta$ -oxidation of long-chain fatty acids in the mitochondria. That could

induce lipid peroxidation along with scavenging hydroxyl radicals, and eventually decreases the fat content in the broiler meat (Jagtap and Bapat; 2010; Tugiyanti *et al.*, 2016; Soifoini *et al.*, 2018). Moreover, Indrasanti and Sumarmono (2016) have reported a decrement in fat content in duck meat due to the tannin contained in the feed. Hence, the observation of the present study on crude fat content can be ascribed to the fact that tannin and other anti-oxidants and fat-soluble flavonoids in BFF reduce the fat content of the broiler breast meat.

## CONCLUSION

In summary, partial replacement of corn in broiler diets with breadfruit flour as an energy feed ingredient improved the growth performances of broilers without adversely impairing breast meat quality up to an inclusion level of 10%.

## REFERENCES

- Abdulrashid, M. and Agwunobi, L.N. (2012). Tannia (*Xanthosoma sagittifolium*) cocoyam as dietary substitute for maize in broiler chicken. *Greener Journal of Agricultural Sciences*. 2(5): 167-171.
- Abudabos, A.M. (2012). Effect of enzyme supplementation to normal and low density broiler diets based on corn-soybean meal. *Asian Journal of Animal and Veterinary Advances*. 7(2): 139-148. DOI: <https://doi.org/10.3923/ajava.2012>
- Adekunle, K.S., Fanimu, A.O., Abiola, S.S. and Akegbejo-Samsons, Y. (2006). Potential of breadfruit meal as alternative energy source to maize in diet of broiler chickens. *The Journal of Poultry Science*. 43(3): 241-249. DOI:<https://doi.org/10.2141/jpsa.43.241>
- Aftab, U. (2019). Energy and amino acid requirements of broiler chickens: keeping pace with the genetic progress. *World's Poultry Science Journal*. 75(4): 507-514. DOI: <https://doi.org/10.1017/S0043933919000564>
- Aka, L.O., Obidike, R.I., Igibokwe, C.O. and Ezema, W.S. (2009). The effect of feeding differently prepared breadfruit (*Artocarpus altilis*) on the hematology, serum biochemistry, live and relative organ weights in Albino rats. *Nigerian Veterinary Journal*. 30(1): 26-34.
- Amusa, N.A., Kehinde, I.A. and Ashaye, O.A. (2002). Bio-deterioration of breadfruit (*Artocarpus communis*) in storage and its effects on the nutrient composition. *African Journal of Biotechnology*. 1(2): 57-60. DOI: <https://doi.org/10.5897/AJB2002.000-010>
- AOAC (Association of Official Analytical Chemists) International. (2016). Official methods of

analysis of AOAC International. 20th Edition. AOAC International, Arlington, Washington D.C, USA.

- Atuahene, C.C., Donkoh, A., Anang, D.M. and Boateng, J. (2002). A note on the use of breadfruit meal (*Artocarpus incisus*) as a feed ingredient for broiler chickens. *Journal of Animal and Feed Sciences*. 11(2): 321-330. DOI: <https://doi.org/10.22358/jafs/67816/2002>
- Badrie, N. and Broomes, J. (2010). Beneficial uses of breadfruit (*Artocarpus altilis*): Nutritional, medicinal and other uses. In: *Bioactive Foods in Promoting Health: Fruits and Vegetables*. (Watson, R.R. and Preedy, V.R. Eds.). Academic Press, San Diego. 491-505. DOI: <https://doi.org/10.1016/B978-0-12-374628-3.00033-5>
- Benitez, J.A., Gernat, A.G., Murillo, J.G. and Araba, M. (1999). The use of high oil corn in broiler diets. *Poultry Science*. 78(6): 861-865. DOI: <https://doi.org/10.1093/ps/78.6.861>
- Brea, O., Ortiz, A. and Elias, A. (2013). Utilization of the fruit meal from the breadfruit tree (*Artocarpus altilis*) in diets for pre-fattening pigs. *Cuban Journal of Agricultural Science*. 47(4): 395-399.
- Chukwukaelo, A.K., Aladi, N.O., Okeudo, N.J., Obikaonu, H.O., Ogbuewu, I.P. and Okoli, I.C. (2018). Performance and meat quality characteristics of broilers fed fermented mixture of grated cassava roots and palm kernel cake as replacement for maize. *Tropical Animal Health and Production*. 50(3): 485-493. DOI: <https://doi.org/10.1007/s11250-017-1457-7>
- Cobb-Vantress, Inc. (2018a). Cobb 500: Broiler Management Guide. <https://www.cobb-vantress.com/assets/5c7576a214/Broiler-guide-R1.pdf> 24.08.2020
- Cobb-Vantress, Inc. (2018b). Cobb 500: Broiler Performance & Nutrition Supplement. <https://www.cobb-vantress.com/assets/Cobb-Files/product-guides/bdc20a5443/70dec630-0abf-11e9-9c88-c51e407c53ab.pdf> 24.08.2020
- Dairo, F.A.S., Adesehinwa, A.O.K., Oluwasola, T.A. and Oluyemi, J.A. (2010). High and low dietary energy and protein levels for broiler chickens. *African Journal of Agricultural Research*. 5(15): 2030-2038.
- Huang, S., Mejía, S.M.V., Murch, S.J. and Bohrer, B.M. (2019). Cooking loss, texture properties, and color of comminuted beef prepared with breadfruit (*Artocarpus altilis*) flour. *Meat and Muscle Biology*. 3(1): 231-243. DOI: <https://doi.org/10.22175/mmb2018.11.0039>
- Indrasanti, D. and Sumarmono, J. (2016). Blood biochemical profile, growth performance, carcass characteristics and meat quality of Mallard and Muscovy ducks fed diet supplemented with bay leaves (*Syzygium polyanthum*). *International Journal of Poultry Science*. 15(1): 21-26.
- Jagtap, U.B. and Bapat, V.A. (2010). *Artocarpus*: A review of its traditional uses, phytochemistry and pharmacology. *Journal of Ethnopharmacology*. 129(2): 142-166. DOI: <https://doi.org/10.1016/j.jep.2010.03.031>
- Jayasena, D.D., Jung, S., Kim, H.J., Bae, Y.S., Yong, H.I., Lee, J.H., Kim, J.G. and Jo, C. (2013). Comparison of quality traits of meat from Korean native chickens and broilers used in two different traditional Korean cuisines. *Asian-Australasian Journal of Animal Sciences*. 26(7): 1038-1046. DOI: <https://doi.org/10.5713/ajas.2012.12684>

- Jones, A.M.P., Ragone, D., Aiona, K., Lane, W.A. and Murch, S.J. (2011). Nutritional and morphological diversity of breadfruit (*Artocarpus, Moraceae*): Identification of elite cultivars for food security. *Journal of Food Composition and Analysis*. 24(8): 1091-1102. DOI: <https://doi.org/10.1016/j.jfca.2011.04.002>
- Lakshani, P., Jayasena, D.D. and Jo, C. (2016). Comparison of quality traits of breast meat from commercial broilers and spent hens in Sri Lanka. *Korean Journal of Poultry Science*. 43(2): 55-61. DOI: <http://dx.doi.org/10.5536/KJPS.2016.43.2.55>
- Lasek, O., Barteczko, J., Borowiec, F., Smulikowska, S. and Augustyn, R. (2012). The nutritive value of maize cultivars for broiler chickens. *Journal of Animal and Feed Sciences*. 21(2): 345-360. DOI: <https://doi.org/10.22358/jafs/66087/2012>
- Liu, Y., Brown, P.N., Ragone, D., Gibson, D.L. and Murch, S.J. (2020). Breadfruit flour is a healthy option for modern foods and food security. *PloS One*, 15(7): 1-19. DOI: <https://doi.org/10.1371/journal.pone.0236300>
- Liu, Y., Ragone, D. and Murch, S.J. (2015). Breadfruit (*Artocarpus altilis*): a source of high-quality protein for food security and novel food products. *Amino acids*. 47(4): 847-856. DOI: <https://doi.org/10.1007/s00726-015-1914-4>
- Morgan, N.K. and Choct, M. (2016). Cassava: Nutrient composition and nutritive value in poultry diets. *Animal Nutrition*. 2(4): 253-261. DOI: <https://doi.org/10.1016/j.aninu.2016.08.010>
- National Research Council. (1994). Nutrient requirements of poultry. 8th edition. National Academies Press, Washington, DC.
- Needham, A., Jha, R. and Lincoln, N.K. (2020). The response of breadfruit nutrition to local climate and soil: A review. *Journal of Food Composition and Analysis*. 88:1-10. DOI: <https://doi.org/10.1016/j.jfca.2020.103451>
- Nikmaram, N., Leong, S.Y., Koubaa, M., Zhu, Z., Barba, F.J., Greiner, R., Oey, I. and Roohinejad, S. (2017). Effect of extrusion on the anti-nutritional factors of food products: An overview. *Food Control*. 79: 62-73. DOI: <https://doi.org/10.1016/j.foodcont.2017.03.027>
- Ojewola, G.S., Opara, O.E. and Ndupu, O. (2006). The substitutional value of cassava meal supplemented and unsupplemented with palm oil for maize in broiler diets. *Journal of Animal and Veterinary Advances*. 5(6): 478-482
- Oladunjoye, I.O., Ologhobo, A.D. and Olaniyi, C.O. (2010). Nutrient composition, energy value and residual antinutritional factors in differently processed breadfruit (*Artocarpus altilis*) meal. *African Journal of Biotechnology*. 9(27): 4259-4263.
- Ologhobo, A., Mosenthin, R. and Alaka, O.O. (2003). Histological alterations in the internal organs of growing chicks from feeding raw jackbean or limabean seeds. *Veterinary and Human Toxicology*. 45(1): 10-13.
- Qorbanpour, M., Fahim, T., Javandel, F., Nosrati, M., Paz, E., Seidavi, A., Ragni, M., Laudadio, V. and Tufarelli, V. (2018). Effect of dietary ginger (*Zingiber officinale Roscoe*) and multi-strain probiotic on growth and carcass traits, blood biochemistry, immune responses and

intestinal microflora in broiler chickens. *Animals*. 8(7):117-127. DOI: <https://doi.org/10.3390/ani8070117>

Ragone, D. (2018). Breadfruit-*Artocarpus altilis* (Parkinson) Fosberg. In: *Exotic Fruits*. Academic Press. 53-60. DOI: <https://doi.org/10.1016/B978-0-12-803138-4.00009-5>

Ravindran, V. and Sivakanesan, R. (1995). Breadfruit (*Artocarpus communis*) meal: Nutrient composition and feeding value for broilers. *Journal of the Science of Food and Agriculture*. 69(3): 379-383. DOI: <https://doi.org/10.1002/jsfa.2740690316>

Riber, A.B. and Tahamtani, F.M. (2020). Motivation for feeding in broiler breeder pullets fed different types of restricted high-fibre diets. *Applied Animal Behaviour Science*. 230:1-10. DOI: <https://doi.org/10.1016/j.applanim.2020.105048>

Sikarwar, M.S., Hui, B.J., Subramaniam, K., Valeisamy, B.D., Yean, L.K. and Balaji, K. (2014). A review on *Artocarpus altilis* (Parkinson) Fosberg (breadfruit). *Journal of Applied Pharmaceutical Science*. 4(8) 91-97. DOI: <https://doi.org/10.7324/JAPS.2014.40818>

Smith, D.P., Lyon, C.E. and Lyon, B.G. (2002). The effect of age, dietary carbohydrate source, and feed withdrawal on broiler breast fillet color. *Poultry Science*. 81(10): 1584-1588. DOI: <https://doi.org/10.1093/ps/81.10.1584>

Soifoini, T., Donno, D., Jeannoda, V., Rakotoniaina, E., Hamidou, S., Achmet, S.M., Solo, N.R., Afraitane, K., Giacomina, C. and Beccaro, G.L. (2018). Bioactive compounds, nutritional traits, and antioxidant properties of *Artocarpus altilis* (Parkinson) fruits: Exploiting a potential functional food for food security on the Comoros Islands. *Journal of Food Quality*. Article ID 5697928, 1-11. DOI: <https://doi.org/10.1155/2018/5697928>

Tugiyanti, E., Setianto, N.A., Harisulistiyawan, I., Susanti, E. and Mastuti, S. (2016). Effect of breadfruit leaf powder (*Artocarpus altilis*) on performance, fat and meat cholesterol level and body immune of male native Tegal duck. *International Journal of Poultry Science*. 15(6): 227-234. DOI: <https://doi.org/10.3923/ijps.2016.227.234>

Valdivié, M. and Alvarez, R. (2003). Note on the use of bread fruit meal (*Artocarpus communis*) in broilers. *Cuban Journal of Agricultural Science*. 37(2): 167-170.

Yang, Z., Pirgozliev, V.R., Rose, S.P., Woods, S., Yang, H.M., Wang, Z.Y. and Bedford, M.R. (2020). Effect of age on the relationship between metabolizable energy and digestible energy for broiler chickens. *Poultry Science*. 99(1): 320-330. DOI: <https://doi.org/10.3382/ps/pez495>