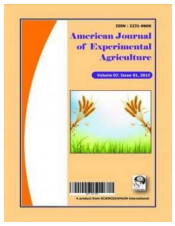

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Replacement Value of Water Soaked Sweet Orange *(Citrus sinensis)* Peel Meal in Broiler Chicken Diet

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Authors' contributions

This work was carried out in collaboration with all the authors. Author OIAO designed the study, supervised its execution and read all drafts of the manuscript. Author LYG carried out the study, and wrote the first draft. Author MAT co-supervised the work. All authors read and approved the final manuscript.

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ABSTRACT

A ten-week two stage experiment consisting of starter and finisher broiler feeding trials was conducted with one hundred and eighty Marshal broiler chicks to determine the replacement value of water soaked Sweet orange (*Citrus sinensis*) fruit peel meal as a substitute for maize. Sweet orange peels were divided into five equal parts, and a part each soaked in water for a duration of 0, 24, 48, 72 and 96 hours, sundried and milled to formulate five (5) test diets T_2, T_3, T_4, T_5, and T_6, respectively, in which the peel replaced maize in the control diet (T_1) at 40% inclusion levels one hundred and eighty birds were randomly allocated to the six dietary treatments each of which had three replicates of ten birds each in a completely randomised design. Significant increases ($P<0.05$) were observed in feed intake, live weight, body weight gain, water intake while, significant decreases ($P<0.05$) were observed in feed conversion ratio, water: Feed ratio and mortality of starter broiler as duration of soaking of orange peels increased from 0 to 96 hours. In the finisher

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phase, significant increases (P<0.05) were observed in feed intake, live weight, body weight gain, whereas, water: Feed ratio decreased significantly (P<0.05) as duration of soaking of sweet orange peel increased from 0 to 96 hours. The study has shown that sweet orange peel when soaked for 96 hour can be used as a replacement for maize in broiler chicken diet at 40% levels while, longer soaking duration is further investigated.

Keywords: Sweet orange peel meal; broiler chicken; growth performance.

1. INTRODUCTION

The unpredictable increase in the cost of conventional ingredients such as maize used in compounding livestock feeds has necessitated intensive investigations in the use of agricultural and agro-based industrial products. The solution to high cost of poultry feed lies in the discovery, processing, and harnessing of non-convectional sources of poultry feedstuffs for which there is little competition from humans [1]. The knowledge of alternative feedstuffs and their levels of inclusion into animal feeds without deleterious effects will go a long way in solving the problem of high cost in poultry production with consequent increase profit margin, increase scale of production, thereby achieving protein availability, improve sustainable intake and high food security [2]. Large quantities of agricultural by-products which are regarded non-conventional feed resources are produced in Nigeria [3]. Some agricultural and agro-industrial by-products available in Nigeria are: Cassava peel meal [4], sweet orange peels [5], mango kernel meal [6] and sweet orange fruit pulp [7]. Unconventional feedstuffs such as cassava root meal, rice bran, sweet potato meal, and sorghum could be used as energy sources to substitute maize, the conventional source, in poultry diets [8]. Sweet orange (*Citrus sinensis*) production in Nigeria is significant [9]. Nigeria produces 3% of fresh citrus in the world, and Africa produces 3,741, 000 tons of different varieties of citrus fruits of which Nigeria contributes 3, 240,000 tons. In Nigeria sweet orange fruit peel is obtained after the exocarp is peeled off and the fruit juice extracted or sucked. Orange fruit peel is available throughout the year even though high production of the fruit is from October through March, and because it is not being put into any productive use and it constitutes environmental challenge pollution because they are indiscriminately disposed. About 30% of the production of citrus fruits (and 40% of orange production) is processed [10], principally to make juice, and results in large quantities of by-products. The main producer of citrus fruit for processing is Brazil (47% of the production), followed by 29% for the USA [10]. In a research work [11], citrus by-products feedstuffs were reported as sources of dietary energy, and use as high energy feed rations that support the growth and lactation in ruminant. It has also been observed that sun-dried peels can replace dietary maize in broiler chicken diet at 20% [12]), and 15% [5] without any adverse effect on performance.

1.1 Objective

The objective of this study was to evaluate the effect of replacement of maize with sweet orange peel meal (SOPM) in the diet of broiler chickens on growth performance.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was carried out at the Poultry unit of the Plateau State College of Agriculture, Garkawa. Garkawa town is located on latitude 8^0 58′E and longitude 9º45′ N, with an elevation of 240m above sea level determined using Global positioning System (GPS) according to [13]. Garkawa is characterized by six months of raining season (May to October) and six months of dry season (November to April).

2.2 Test Ingredient, Collection and Processing

Sweet orange peels were collected from sellers of peeled sweet orange fruit in Garkawa town. They were sun-dried, divided into five (5) equal portions and, soaked in water for 0, 24, 48, 72, and 96 hours. Thereafter, they were each sun-dried and milled to obtain sweet orange peel meals SOP_o, SOP_{24}, SOP_{48}, SOP_{72} and $SOP_{96,}$ respectively. These meals were used to replace 40% maize in the control diet (T_1) both in the broiler starter (Table 1) and finisher (Table 2) to obtain diets T_2, $T_{3,}$ $T_{4,}$ T_5 and T_6, respectively.

Table 1. Ingredients and nutrient composition of starter broiler chick diets containing sweet orange (*Citrus sinensis*) peel meal

Ingredients	Starter broiler diets					
	T_1	T_2	T_3	T_4	T_5	T_6
Maize	54.01	32.41	32.41	32.41	32.41	32.41
SOPM	0	21.60	21.60	21.60	21.60	21.60
SBM	32.41	32.41	32.41	32.41	32.41	32.41
BDG	6.50	6.50	6.50	6.50	6.50	6.50
Blood meal	2.58	2.58	2.58	2.58	2.58	2.58
Bone meal	2.95	2.95	2.95	2.95	2.95	2.95
Oyster shell	0.50	0.50	0.50	0.50	0.50	0.50
Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.30	0.30	0.30	0.30	0.30	0.30
Common Salt	0.25	0.25	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated nutrients						
Metabolisable energy (kcal/kg)	2874.69	2819.28	2824.20	2807.05	2813.12	2798.90
Crude protein (%)	22.88	23.28	23.43	23.59	23.66	23.76
Crude fibre (%)	4.36	8.29	8.61	9.02	9.07	9.43
Ether extract (%)	3.79	3.47	3.52	3.58	3.65	3.56
Lysine (%)	1.44	1.39	1.39	1.39	1.39	1.39
Methionine (%)	0.62	0.57	0.57	0.57	0.57	0.57
Calcium (%)	1.48	1.69	1.75	1.71	1.69	1.75
Phosphorus (%)	0.77	0.71	0.71	0.71	0.71	0.71

T_1 = Control diet, T_2= Broiler starter containing un-soaked sweet orange peels. T_3 = Broiler starter containing SOP soaked in water for 24 hours, T_4 = Broiler starter containing SOP soaked in water for 48 hours, T_5 = Broiler starter containing SOP soaked in water for 72 hours, T_6 = Broiler starter containing SOP soaked in water for 96 hours, SOP = Sweet orange peel, BDG = Brewers dried grain, SBM = Soybean meal, SOPM= Sweet orange peel meal, ME = Metabolisable energy.

**Vitamin-Mineral premix (BIOMIX(R)) will supply per kg diet; Vit. A 500IU; Vit. D_3 888, IU; Vit. E_{12}, 000 mg; Vit. $K_3$15000 mg; Niacin 12000 mg; Pantothenic acid 2000 mg, Biotin 1000 mg; Vit b12 3000mg; Folic acid 15000 mg; Choline chloride 6000 mg, Manganese 1000 mg; Vit. Iron 15000 mg; Zinc 800 mg; Copper 400 mg; Iodine 80 mg; Cobalt 400 mg; Selenium 8000 mg*

2.3 Experimental Animals and Management

One hundred and eighty day-old Marshal Broiler chicks bought from Obasanjo farms, Ogun State were used for the study. They were randomly allocated to six groups with 30 broiler chicks each divided into three replicates with 10 birds per replicate, in a completely randomised design (CRD). The birds were weighed in groups and average weight made similar before they were assigned to their respective dietary treatment groups. The birds were raised on a deep litter system, fed broiler starter *ad libitum* for 5 weeks. At the end of the starter phase the chickens were all mixed together, regrouped into 6 as in the starter phase and fed the broiler finisher *ad libitum* for 5 weeks. The birds were allowed access to water of acceptable quality and routine management procedures were followed. The Performance indices determined for both broiler starter and finisher phases were feed intake, body weight, water intake, whereas, feed conversion ratio (FCR), body weight gain (BWG), water: Feed ratio, protein efficiency ratio (PER) and protein intake were calculated. The cost of every operation was recorded while, feed cost/bird, operational cost and total cost of production per bird were determined as recommended by [14]. The current selling price of lean meat per kilogramme was used and profitability index which shows the net return per Naira (N1.00) invested calculated as:

$$\text{Profitability index (N)} = \frac{\text{Income} - \text{Expenditure}}{\text{Expenditure}}$$

2.4 Statistical Analysis

All the data collected were subjected to analysis of variance [15]. Means were separated where applicable using the Duncan Multiple Range Test [16].

Table 2. Ingredients and nutrient composition of finisher broiler chickens diets containing sweet orange (*Citrus sinensis*) peel meal

Ingredients	Finisher broiler diets					
	T_1	T_2	T_3	T_4	T_5	T_6
Maize	61.52	36.91	36.91	36.91	36.91	36.91
SOPM	0	24.61	24.61	24.61	24.61	24.61
SBM	23.40	23.40	23.40	23.40	23.40	23.40
BDG	8.00	8.00	8.00	8.00	8.00	8.00
Blood meal	2.58	2.58	2.58	2.58	2.58	2.58
Bone meal	2.95	2.95	2.95	2.95	2.95	2.95
Oyster shell	0.50	0.50	0.50	0.50	0.50	0.50
Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.30	0.30	0.30	0.30	0.30	0.30
Common Salt	0.25	0.25	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated nutrients						
Metabolisable energy(kcal/kg)	2952.09	2888.95	2894.56	2875.02	22881.94	2865.74
Crude protein (%)	20.00	20.46	20.63	21.82	20.89	21.01
Crude fibre (%)	4.16	8.63	8.99	9.46	9.52	9.93
Ether extract (%)	3.89	3.52	3.58	3.64	3.72	3.63
Lysine (%)	1.23	1.17	1.17	1.17	1.17	1.17
Methionine (%)	0.59	0.54	0.54	0.54	0.54	0.54
Calcium (%)	1.47	1.71	1.77	1.74	1.70	1.75
Phosphorus (%)	0.75	0.68	0.68	0.68	0.68	0.68

*T_1 = Control diet; T_2= Broiler finisher containing un-soaked sweet orange peel; T_3 = Broiler finisher containing sweet orange peels soaked in water for 24 hours; T_4 = Broiler finisher containing sweet orange peels soaked in water for 48 hours; T_5 = Broiler finisher containing sweet orange peels soaked in water for 72 hours; T_6 = Broiler finisher containing sweet orange peels soaked in water for 96 hours. BDG = Brewers dried grain, SBM = Soybean meal, SOPM= Sweet orange peel meal, ME = Metabolisable energy *Vitamin-Mineral premix (BIOMIX$^{(R)}$) will supply per kg diet; Vit. A 500IU; Vit. D_3 888, IU; Vit. E_{12}, 000 mg; Vit. $K_3$15000 mg; Niacin 12000 mg; Pantothenic acid 2000 mg, Biotin 1000 mg; Vit b12 3000 mg; Folic acid 15000 mg; Choline chloride 6000 mg, Manganese 1000 mg; Vit. Iron 15000 mg; Zinc 800 mg; Copper 400 mg; Iodine 80 mg; Cobalt 400 mg; Selenium 8000 mg*

3. RESULTS AND DISCUSSION

3.1 Starter Broiler Chicks Performance

The growth response of starter broiler chicks to the experimental diets is presented in Table 3. The result obtained showed that the diets produced significant effect ($P<0.05$) on the performance of the chicks in all growth indices evaluated. The mean daily feed intake increased significantly as the duration of soaking sweet orange peels in water increased from 0 to 96 hours and at 96 hours of soaking the feed intake of the starter broiler was not significantly different ($P>0.05$) from the control. Sweet orange peel meal has been reported to have some amounts of saponin and tannin [17] which by nature confer bitter and astringent taste on feed materials, but processing methods like soaking and its duration cause reduction.

It appears that soaking of sweet orange peel for long duration improved its feed value with a consequent palatability enhancement reflected in the feed intake of the birds at longer soaking duration of peels. The decreased final body weight of the chicks fed sweet orange peel meal diets compared to the starter broiler on the control group may be due to the higher fibre levels in the sweet orange peel meal based diets which can impose a limitation on nutrient utilization. However, among the orange peel based diets, it was observed that the chicks became heavier as duration of soaking of orange peels increased. The increased mean body weights of the chicks on diets containing the orange peel as duration of soaking increased in spite of increased fibre level can be attributed to higher protein content of these diets. Significant trend in body weight gain of broiler chicks in the sweet orange peel based-diet groups was observed to be similar to that of the final weight,

as the duration of soaking increased from 0 to 96 hours. This is an evidence of consistent growth rate of the birds in these diet groups during the broiler starter phase. The feed conversion ratio of the birds on the SOPM based diets was significantly higher ($P<0.05$) than the feed conversion ratio of the birds in the control. This suggests reduced utilization of dietary nutrients, even though the feed conversion ratio values were within the acceptable range of 2.00-5.00 for chicks as recommended by [18]. The water consumption pattern of the broiler chicks showed that replacement of maize with sweet orange peel stimulated higher water consumption. This may be partly due to higher protein levels in the SOP diets which may stimulate higher water intake for its utilization. Higher dietary fibre in the sweet orange peel based diets may also have contributed to this pattern of water intake. Water: Feed ratio tended to reduce as the duration of soaking the SOP increased. Broiler chicks in SOP-based diets had significantly higher ($P<0.05$) rate of water consumption than chicks in the control partly as a requirement to mitigate the effect of bitter taste of saponin, which has been found to be present in orange peels. The protein efficiency ratio showed that the birds fed the maize-based diet utilized dietary protein more efficiently than those in the groups fed SOP-based diets. Mortality recorded during the starter phase was significant ($P<0.05$) across the treatment groups. This was observed when there was a sudden sharp change in weather condition from dry cold harmattan to dry hot weather. This mortality is thus attributed to the inability of the broiler chicks to contain the adverse inclemency of weather.

3.2 Finisher Broiler chickens Performance

The effect of experimental diets containing water soaked sweet orange peel meal on the performance of broiler finisher chickens is shown on Table 4. Means of final live weight, daily feed intake, daily body weight gain, water to feed ratio, protein efficiency ratio, protein intake and mortality varied significantly ($P<0.05$) among the experimental groups, while feed conversion ratio and daily water intake did not vary significantly ($P>0.05$) as the duration of soaking of the SOP incorporated in the diets increased. Daily feed intake per bird progressively increased from 101.70 to 148.05 g. Soaking is likely to have enhanced the nutritive potential of SOP and consequently its maize replacement value which was transferred into the test diets. The least feed intake of 101.70 g/day recorded by the birds fed diet T_2 which contained the un-soaked sweet orange peel shows that processing beyond sun-drying is required for SOP to optimally exploit its potential as a feed resource in broiler chicken production.

The average final body weight of 2287.50 g for the finisher chickens fed diet T_1 (control) was significantly ($P<0.05$) higher than the average final body weight of chickens fed diets T_2, T_3, T_4, T_5, and T_6 which varied from 1327.50 g to 1866.67 g. However, it was observed that, the longer the soaking duration of the orange peels the significantly ($P<0.05$) heavier the chickens. It is thus apparent that soaking could be a viable option to biochemically manipulate the internal environment of SOP to make it a valuable feed resource for maize replacement feeding programme development in broiler production.

The body weight gain of the birds was observed to follow a similar pattern as the final body weight. Soaking for up to 96 hours seems beneficial because the mean daily body weight gain of 35.76 g for chickens fed diet T_6 (diet containing orange peel soaked in water for 96 hours) was significantly ($P<0.05$) higher than for others SOP-based diets groups containing SOP soaked for lesser time duration. Irrespective of the treatment groups, feed conversion ratio and daily mean water intake did not differ significantly ($P>0.05$). The observation in the later is opposite of the variation in water consumption in the starter phase. As the birds advanced in age as in finisher phase, their physiology matures and is better able to adapt to and accommodate the chemical constituents of the sweet orange peel.

The result of water-to-feed ratio of finisher broiler chickens significantly decreased as the duration of soaking of the orange peels increased. This is similar to the water: Feed ratio for starter broiler chicks. The result showed that less water is consumed per gram feed intake at higher soaking duration of the peels. The study revealed that the birds on the SOP treatment groups were unable to utilize the protein in their feed as efficiently as the birds in the control group (T_1) even though the feed intake by the birds fed diets T_5 and T_6 SOP based diets were significantly higher. A possible reason for this may be the higher dietary crude fibre in the SOP based diets which could have impaired the utilization of the dietary protein. Mortality recorded was significantly different ($P<0.05$) among treatment groups. Except for T_3, mortality did not exceed

10% in any other group. The mortality may have been caused by heat stress since the finisher phase overlapped with the month of March which is usually the peak of the hot season, during which maximum temperature can rise up to 39ºC.

Table 3. Effect of experimental diets on growth performance of starter broiler chicks

Performance indices	Experimental diets						
	T_1	T_2	T_3	T_4	T_5	T_6	SEM
Initial live weight (g/)	42.67	43.00	42.67	42.67	42.67	43.00	0.10
Final body weight (g/bird)	660.33^{a}	394.44^{d}	483.33^{c}	505.00^{bc}	500.00^{bc}	550.00^{b}	20.12
Daily body weight gain (g/bird)	17.65^{a}	10.04^{d}	12.59^{c}	13.21^{bc}	13.07^{bc}	14.49^{b}	0.58
Daily Feed intake (g/bird)	49.13^{ab}	34.44^{c}	45.64^{b}	49.58^{a}	47.40^{ab}	49.90^{a}	1.36
Feed conversion ratio	2.78^{a}	3.44^{b}	3.62^{b}	3.77^{b}	3.67^{b}	3.44^{b}	0.09
Daily water intake (ml/bird)	98.30^{c}	106.35^{b}	118.08^{a}	113.00^{a}	114.45^{a}	118.76^{a}	1.87
Water: feed ratio (ml/g)	2.00^{d}	3.10^{a}	2.59^{b}	2.28^{c}	2.41^{bc}	2.38^{bc}	0.09
Protein efficiency ratio	1.71^{a}	1.34^{bc}	1.19^{c}	1.19^{a}	1.40^{a}	1.35^{bc}	0.05
Protein intake (g/bird)	10.32^{a}	7.54^{c}	10.59^{a}	11.06^{a}	9.33^{b}	10.70^{a}	0.03
Mortality (%)	8.79^{c}	13.33^{ab}	16.67^{a}	10.00^{b}	6.67^{c}	6.67^{c}	0.98

$^{a, b, c, d}$ *Means on the same row with different superscripts are significantly different (P<0.05), SEM = Standard error of mean. T_1 = Control diet; T_2 = Broiler finisher containing unsoaked sweet orange peel; T_3 = Broiler finisher containing sweet orange peels soaked in water for 24 hours; T_4 = Broiler finisher containing sweet orange peels soaked in water for 48 hours; T_5 = Broiler finisher containing sweet orange peels soaked in water for 72 hours; T_6 = Broiler finisher containing sweet orange peels soaked in water for 96 hours*

Table 4. Effects of experimental diets on performance of finisher broiler chickens

	Experimental diets						
Performance indices	T_1	T_2	T_3	T_4	T_5	T_6	SEM
Initial live weight (g/bird)	616.67	615.00	615.00	623.33	620.00	615.00	1.36
Daily feed intake (g/bird)	126.71^{bc}	101.70^{d}	121.10^{c}	128.00^{bc}	133.84^{b}	148.05^{a}	3.53
Final live weight (g/bird)	2287.50^{a}	1327.20^{c}	1578.89^{c}	1589.72^{c}	1563.89^{c}	1866.67^{b}	79.34
Daily BWG (g/bird)	47.74^{a}	20.35^{c}	27.54^{c}	27.61^{c}	26.97^{c}	35.76^{b}	2.27
Feed conversion ratio	2.67	3.99	4.41	4.67	4.88	4.27	0.25^{s}
Daily water intake (ml/bird)	394.53	380.23	391.87	395.39	378.88	391.91	2.67
Water:feed ratio (ml/g)	3.11^{bc}	3.75^{a}	3.24^{b}	3.09^{bc}	2.83^{c}	2.65^{d}	0.09
Protein efficiency ratio	1.83^{a}	0.90^{c}	1.24^{b}	1.07^{bc}	1.07^{b}	1.13^{bc}	0.08
Protein intake (g/bird)	26.05^{b}	22.69^{c}	22.26^{c}	25.76^{b}	25.17^{b}	31.74^{a}	0.78
Mortality (%)	10.00^{ab}	10.00^{ab}	13.33^{a}	10.00^{ab}	3.33^{c}	6.67^{b}	0.93

$^{a, b, c, d}$ *Means on the same row with different superscripts are significantly different (P<0.05), SEM = Standard error of mean. T_1 = Control diet; T_2 = Broiler finisher containing unsoaked sweet orange peel; T_3 = Broiler finisher containing sweet orange peels soaked in water for 24 hours; T_4 = Broiler finisher containing sweet orange peels soaked in water for 48 hours; T_5 = Broiler finisher containing sweet orange peels soaked in water for 72 hours; T_6 = Broiler finisher containing sweet orange peels soaked in water for 96 hours*

Table 5. Economic analysis of broiler chicken fed sweet orange peel meal diets

	Diets						
Indices	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**SEM**
Cumulative feed intake/bird (kg)	6.15b[c]	4.76[d]	5.84[c]	6.22[bc]	6.34[b]	6.93[a]	0.17
Final live weight/bird (g)	2287.50[a]	1327.20[c]	1578.89[c]	1589.72[c]	1563.89[c]	1866.67[b]	79.34
Fed cost/bird (₦)	533.12[a]	334.06[c]	419.03[b]	446.16[b]	424.25[b]	506.40[a]	
Operational cost (₦)	152.74	152.74	152.74	152.74	152.74	152.74	-
Cost of DOC/bird (₦)	190.00	190.00	190.00	190.00	190.00	190.00	-
Total cost of production/ bird (₦)	875.86	676.80	761.77	788.90	766.99	849.14	-
Selling price/live bird (₦)	1883.33[a]	1062.67[c]	1226.67[c]	1253.33[c]	1233.33[c]	1460.00[b]	63.71
Profitability index (₦)	1.15	0.57	0.61	0.59	0.61	0.72	-

[a,b,c,d] *Means on the same row with different superscripts are significantly different (P<0.05). SEM=standard error of mean.*

T_1 = Control diet; T_2 = Broiler finisher containing unsoaked sweet orange peel; T_3 = Broiler finisher containing sweet orange peels soaked in water for 24 hours; T_4 = Broiler finisher containing sweet orange peels soaked in water for 48 hours; T_5 = Broiler finisher containing sweet orange peels soaked in water for 72 hours; T_6 = Broiler finisher containing sweet orange peels soaked in water for 96 hours. ₦ = Naira, DOC = day old chick

3.3 Economic Cost of Broiler Chicken Production

The cost of production of broiler chickens using sweet orange peel meal based diets is presented in Table 5 above. The cumulative feed intake increased steadily as duration of soaking sweet orange peels increased. The control diet had higher feed cost over the SOP based diets while, increase in cumulative feed intake also caused increase in feed cost per bird as the soaking duration increased. However, it was observed that the control diet (T_1) and the sweet orange peel meal diet group (T_6) containing peel soaked for 96 hours were not significantly different (P>0.05). Total cost of production chicken fed sweet orange peel meal based diets ranged from ₦676.80 to ₦849.14 which is lower compared to the control diet with ₦875.86. Broiler chicken fed the control diet had the highest selling price. The selling price/bird in the sweet orange peel meal based diets increased as the duration of soaking increased. This was also reflected in the profitability index of ₦1.15 for the control group and, ₦0.57 to ₦0.72 for the sweet orange peel meal based diets.

4. CONCLUSION

The study showed that water can be applied to soak sweet orange peels for the biochemical manipulation of the peels to improve the nutritional value of this potential maize replacement feed ingredient in broiler chicken feeding.

5. RECOMMENDATION

There is need for longer durations than 96 hours, experimented in this study to be investigated on the growth rate of broiler chickens.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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