



Growth Performance and Carcass Characteristics of Broilers Fed Diets Containing Various Duration of Water Soaked Sweet Orange Peels

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Authors' contributions

This work was carried out in collaboration among all authors. Author OIAO designed the study. Author AOA carried out the experiment, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors CDT and FGK managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted with one hundred and eighty (180) unsexed day old broiler chicks of Arbor acre strain to investigate the effect of feeding diets supplemented with water soaked sweet orange peel meal (SOP) on the performance and carcass characteristics of broiler chicken. The broiler chickens were randomly distributed into six (6) dietary treatments of 30 birds per treatment which were further distributed into three (3) replicates of 10 birds per replicate from day old, in a completely randomized design. Six dietary treatments were formulated such that, T1 which is control was maize based. In diets 2, 3, 4, 5 and 6, sweet orange peels replaced maize at various duration of water soaked, 0, 24, 48, 72 and 96 hours respectively and incorporated at 30% inclusion. Data were collected on feed intake and weekly weight gain. Six (6) birds were randomly selected per treatment starved over night, weighed and sacrificed by cervical dislocation for carcass analysis. Result reveals significant ($p < 0.05$) difference in daily feed intake, there was no significant ($p > 0.05$) difference on final weight and daily weight gain. The result of carcass

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characteristics showed no significant ($p>0.05$) difference in carcass cut and internal organs. It can be concluded that supplementing broiler diets with water soaked sweet orange peels had no detrimental effects on the performance and carcass characteristics.

Keywords: Broiler; performance; carcass; sweet orange peels.

1. INTRODUCTION

The animal protein intake in most developing countries including Nigeria is predominantly characterized by inadequate protein intake in both quantity and quality. [1] reported inadequate animal protein intake of 9 grams per caput in Nigeria compared to the daily requirement of 35grams per caput recommended by [2]. This shortage is as a result of high prices of animal protein [3]. The most critical challenge facing livestock production in Nigeria, most especially non-ruminants is the cost of feed making and unavailability of the conventional feedstuffs. According to [4] feed cost accounts for 70-80% of the total recurrent cost of production of poultry. [5] indicated that feed accounts for 66% or more of the total cost of broiler production and a shift to alternative sources of ingredients especially non-conventional sources may help especially when the ingredients are of less competition and are sufficiently available. [6] reported that developing the poultry industry is the fastest means of bridging the protein deficiency gap prevailing in most tropical countries. This is technically possible because birds are able to adapt to most areas of the world, have a short generation time and high rate of productivity. [7] stated that a poultry enterprise can produce meat within seven weeks and has the first egg produced within eighteen weeks of the first chick being hatched.

Expansion of the poultry industry depends to a large extent on the availability of good quality feed in sufficient quantity and at affordable price. This is particularly true of the intensive poultry enterprises whose performance depends almost entirely on the use of balanced concentrate ration [8]. The scarcity of conventional sources of protein and energy is largely responsible for the present high price of finished feed. In order to salvage this situation, and to keep livestock industry viable and profitable and also to improve the animal protein intake, livestock nutritionists have continued tirelessly to search for alternative feedstuffs. These alternative feedstuffs must be readily available and less competitive by man and industries [9]. Sweet orange fruit (*Citrus*

sinensis) production is significant in Nigeria with heavy direct consumption due to inadequate capacity of industries to convert the fruit to juice, concentrate and canned fruits [10]. The sweet orange peel is obtained from the pericarp of orange fruit following the preparation (processing) of the fruit for direct consumption of the juice. The peel is removed with the aid of sharp knife or razor mostly by orange vendors. The peels are found mostly in large quantities indiscriminately after each day's sales on streets, drainage system and refuse dumps causing environmental pollution. These sweet orange fruit peels according to [11] contain some similarities with maize in the quantitative values of protein and metabolisable energy. Its crude protein and metabolisable energy contents are 10.73% CP and 3988.7 kcal ME/kg respectively, as against 9.00% CP and 3432 kcal ME/kg for maize. This proximate composition highlights the potential of sweet orange fruits peels as a feed resource capable of replacing maize. The sweet orange peels has also been reported to be safe and recommended for inclusion in broiler chicken diets [10].

2. MATERIALS AND METHODS

2.1 Description of Experimental Site

The study was conducted in Osgood farm Welfare quarters Makurdi. Makurdi is the capital of Benue State and is located on longitude $8^{\circ} 37'$ East and latitude $7^{\circ} 41'$ North, Annual rainfall ranges from 609.9 mm to 1219.8 mm, the temperature ranges from 25.6°C to 39.6°C and the relative humidity is about 21% to 85% [12].

2.2 Preparation of Test Ingredients

Sweet orange fruit (*Citrus sinensis*) peels (SOP) the test material were collected from orange vendors within Makurdi metropolis who usually peel the orange fruit before selling to consumers.

The collected sweet orange peels (SOP) were divided into five (5) equal parts, one part each was soaked in water for 0, 24, 48, 72, and 96

hours to obtain five different treated test ingredients. All the peels were separately sun-dried on concrete floor until they attained about 10% moisture level. They were milled and coded SOP₀, SOP₂₄, SOP₄₈, SOP₇₂, and SOP₉₆, respectively and used to replace maize in the control diet (CD) at 30% level to obtain test diets coded as SOP₀D, SOP₂₄D, SOP₄₈D, SOP₇₂D, SOP₉₆D, respectively.

2.3 Experimental Birds and Management

One hundred and eighty (180) day old broiler (Arbor Acre) chickens were balanced for weight and randomly assigned to six treatments in a completely randomized design. Each treatment was divided into 3 replications of 10 birds each. The study lasted for 70 days. The birds were

raised in a deep litter half-walled house, having its upper half covered with wire mesh. Feed and clean cool water were supplied to the birds *ad libitum*. Heat was supplied using charcoal and kerosene stove. Newcastle (I/O) vaccine was given at day old, gumboro vaccine was administered at 14 days, and newcastle vaccine (lasota) in drinking water was given at 21 days, as recommended by National Veterinary Research Institute, Vom, Nigeria. Anti-stress (Vitalyte) was given before and after vaccinations and coccidiostat were administered via drinking water every other week against coccidiosis. Antibiotics were also given to all the birds for five days after the second week of commencement of the feeding trial. The litter material was maintained dry throughout the period of the experiment.

Table 1. Gross composition of broiler finisher diet (g/kg)

Experimental Diets

Ingredients	CD	SOP ₀ D	SOP ₂₄ D	SOP ₄₈ D	SOP ₇₂ D	SOP ₉₆ D
Maize	57.23	40.06	40.06	40.06	40.06	40.06
Sweet orange peel	—	17.17	17.17	17.17	17.17	17.17
Groundnut cake	31.32	31.32	31.32	31.32	31.32	31.32
Brewer dried grain	5.00	5.00	5.00	5.00	5.00	5.00
Blood meal	1.50	1.50	1.50	1.50	1.50	1.50
Bone meal	2.50	2.50	2.50	2.50	2.50	2.50
Oystershell	1.50	1.50	1.50	1.50	1.50	1.50
*premix	0.25	0.25	0.25	0.25	0.25	0.25
Common salt	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	0.10	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100	100

Calculated values

ME(Kcal/Kg)	2954.33	2987.84	2996.44	3004.95	3015.02	3012.17
Crude protein (%)	21.87	18.81	20.12	20.08	20.21	19.69
Crude fibre (%)	6.00	8.25	15.75	6.75	3.50	6.00
Crude fat (%)	5.25	3.75	3.50	3.25	4.50	3.25
Calcium (%)	1.55	1.55	1.55	1.55	1.55	1.55
Phosphorus (%)	0.79	0.74	0.74	0.74	0.74	0.74
Methionine (%)	0.29	0.26	0.26	0.26	0.26	0.26
Lysine (%)	0.75	0.71	0.71	0.71	0.71	0.71

SOP= Sweet orange peel meal CD= Control diet. SOP₀D= Diet containing test ingredient not soaked in water. SOP₂₄D= Diet containing test ingredient soaked in water for 24hrs. SOP₄₈D= Diet containing test ingredient soaked in water for 48hrs. SOP₇₂D= Diet containing test ingredient soaked in water for 72hrs. SOP₉₆D= Diet containing test ingredient soaked in water for 96 hrs

*0.25 kg of Premix supplied the following: Vitamin A 1500 IU, Vitamin D 300 IU, Vitamin E 300 IU, Vitamin K 0.25 g, Thiamine (B₁) 0.2 mg, Riboflavin (B₂) 0.6 mg, Pantothenic acid 1.00 mg, Pyridoxine(B₆) 0.4999 mg, Niacin 4.00 mg, Vitamin B₁₂ 0.002 mg Folic acid 0.10 mg, Biotin 0.008 mg, Choline chloride 0.05 g, Antioxidant 0.0125 g, Manganese 0.0096 g, Zinc 0.006 g, Copper 0.0006 g, Iodine 0.00014 g, Selenium 0.024 mg, Cobalt 0.004 mg

2.4 Growth Performance Parameters

Initial and final weights of birds in each replicate group were taken at the start and end of the trials in addition to weekly weights. Weekly weight gain was determined by difference between weight of the birds for the present and the previous weeks. Total weight gain was calculated by working the difference between the final and initial weights. Feed intake was determined by taking the initial weight of the feed for each replicate before serving the birds and the feed left over at the end of the week to calculate feed intake by difference. Feed conversion ratio (FCR) was calculated as the ratio of feed intake to the corresponding live body weight gain of the birds.

$$\text{FCR} = \text{Feed intake} / \text{Body weight gain.}$$

2.5 Carcass Characteristics

Carcass evaluations were done at the termination of feeding trials. The birds were deprived of feed but given water for 18 hours prior to carcass evaluation. A bird was carefully selected per replicate such that its weight was similar to the average weight of the replicate group and processed according to standard procedure [13]. Their fasted live weights were taken before slaughter. They were slaughtered by severing the jugular vein, dipped in hot water and defeathered as recommended by [14]. Carcass cuts namely breast, back, neck, wing, thigh and drumstick were weighed. Internal organs namely gall bladder, heart, crop, liver, gizzard, proventriculus, pancreas, kidney, and lungs.

The visceral organs were expressed as percent live weight using the formula:

$$\text{Visceral parts} = \frac{\text{weight of organs}}{\text{Live weight}} \times 100$$

3. RESULTS

Performance of broiler finisher chickens in the feeding trial is shown on Table 2. Final live weight, daily weight gain and daily water intake were not significantly ($p > 0.05$) affected by the dietary treatments. Feed intake, feed conversion ratio, protein efficiency ratio and protein consumed were however, significantly ($p < 0.05$) affected by the dietary treatments among the treatment groups. The only significant difference ($p < 0.05$) in feed intake was between the birds in the control group which was 81.53 g and birds in

SOP₀D, SOP₄₈D and SOP₉₆D which were 69.80 g, 70.77 g and 69.26 g respectively. The feed intake of birds in SOP₂₄D and SOP₇₂D which were 74.02 g and 76.94 g respectively were not different ($p > 0.05$) from the feed intake of the control group. It was observed that the least feed consumed was by the chickens in SOP₉₆D and that feed intake was not significantly different in the SOP based dietary groups. The broiler chickens fed diets with sweet orange peel meal had a significantly superior ($p < 0.05$) FCR ranging from 2.41 to 2.63 compared with the FCR of 2.67 recorded by the chickens in the control group except the SOP₇₂D treatment that presented the same result as the control (CD). Protein consumed was significantly affected ($p < 0.05$) with birds in the control group consuming highest (18.12), while birds on the diets with sweet orange peel not water soaked (SOP₀) having the least (13.13). The broiler chickens in the SOP diet groups had significantly lower ($p < 0.05$) protein efficiency ratio of 1.98 to 2.21 compared with protein efficiency ratio of 1.68 obtained in the control treatment which was the best. The mortality recorded was varied between 0 to 6.67%.

The carcass characteristics of broiler chickens fed diets containing various duration of water soaked sweet orange peel meal is as shown in Table 3.

The diets had significant effect ($p < 0.05$) on dressed carcass weight, while dressed weight expressed as percent of live weight (%LW) gave the dressing percent which was not significantly different ($p > 0.05$). Breast, back, neck, wing, thigh, drumstick, abdominal fat expressed as percentage dressed weight were not significantly affected ($p > 0.05$) by the diets. The dressed weight of the chickens in the control group was 1800.00 g and the highest but not significantly different ($p > 0.05$) from the dressed weights of 1666.67 g, 1783.33 g, 1743.33 g and 1683.33 g for SOP₀D, SOP₂₄D, SOP₄₈D and SOP₇₂D, respectively. The dressed weight of the chickens in the SOP₉₆D which was 1566.67 g was the least and significantly lower ($p < 0.05$) than the dressed weight for the control group.

The effect of SOP based diets on internal organs namely: gall bladder, heart, crop, liver, empty gizzard, pancreas, proventriculus, kidney, lungs and spleen expressed as percentage of live weight (%LW) are presented in Table 4. None of these organs parameters varied significantly ($p > 0.05$) among the dietary groups.

Table 2. Performance characteristics of finisher broiler chickens fed diets containing various duration of water soaked sweet orange peel meal**Experimental Diets**

Performance indices	CD	SOP ₀ D	SOP ₂₄ D	SOP ₄₈ D	SOP ₇₂ D	SOP ₉₆ D	SEM
Initial live weight (g/bird)	43.33	41.67	41.67	41.67	43.33	43.67	1.70 ^{ns}
Final live weight (g/bird)	2133.33	2021.33	2070.00	2018.33	2049.33	1939.67	77.80 ^{ns}
Daily weight gain (g/bird)	30.48	28.87	29.57	28.83	29.28	27.71	1.02 ^{ns}
Daily feed intake (g/bird)	81.53 ^a	69.80 ^b	74.02 ^{ab}	70.77 ^b	76.94 ^{ab}	69.26 ^b	1.21 [*]
Feed conversion ratio	2.67 ^c	2.41 ^a	2.51 ^{ab}	2.46 ^{ab}	2.63 ^{bc}	2.50 ^{ab}	0.06 [*]
Protein efficiency ratio	1.68 ^c	2.21 ^a	1.98 ^b	2.03 ^b	1.98 ^b	2.03 ^b	0.05 [*]
Protein consumed (g)	18.12 ^a	13.13 ^d	14.89 ^{bc}	14.23 ^{bcd}	15.48 ^b	13.65 ^{cd}	0.54 [*]
Daily water intake (ml)	190.48	183.15	199.57	188.28	200.41	191.65	4.19 ^{ns}
Mortality (%)	0	3.33	6.67	3.33	3.33	3.33	-

^{*}($P < 0.05$) Significant difference; ^{a,b,c,d} Means in the same row with different superscripts are significantly different ($p < 0.05$); ^{ns}= Not significant ($p > 0.05$); SEM= Standard Error of Means; CD= Control diet, SOP₀D = Diet containing test ingredient not soaked in water. SOP₂₄D = Diet containing test ingredient soaked in water for 24 hrs. SOP₄₈D = Diet containing test ingredient soaked in water for 48 hrs. SOP₇₂D = Diet containing test ingredient soaked in water for 72 hrs. SOP₉₆D = Diet containing test ingredient soaked in water for 96 hrs

Table 3. Carcass characteristics of broiler chickens fed diets containing various duration of water soaked sweet orange peel meal**Experimental Diets**

Carcass indices	CD	SOP ₀ D	SOP ₂₄ D	SOP ₄₈ D	SOP ₇₂ D	SOP ₉₆ D	SEM
Live weight (g)	2296.67 ^{ab}	2183.33 ^{ab}	2396.67 ^a	2333.33 ^{ab}	2283.33 ^{ab}	2066.67 ^b	82.46 [*]
Dressed weight (g)	1800.00 ^a	1666.67 ^{ab}	1783.33 ^{ab}	1743.33 ^{ab}	1683.33 ^{ab}	1566.67 ^b	67.65 [*]
Dressing percentage	78.48	76.69	74.40	74.75	73.65	75.68	2.27 ^{ns}
Carcass parts (%Dressed weight)							
Breast	30.85	31.12	31.90	29.54	33.38	30.10	2.26 ^{ns}
Back	13.53	12.68	14.04	13.59	13.56	13.73	0.94 ^{ns}
Neck	7.53	6.90	7.05	6.66	6.96	7.00	0.63 ^{ns}
Wing	10.74	10.63	10.84	11.13	11.32	11.03	0.92 ^{ns}
Thigh	14.29	14.05	16.29	15.87	14.87	15.81	0.70 ^{ns}
Drumstick	14.48	12.65	14.04	14.37	12.91	13.80	0.51 ^{ns}
Abdominal fat	1.19	0.78	1.16	1.04	0.93	1.23	0.30 ^{ns}

^{*}($p < 0.05$) significant difference; ^{a,b} Means in the same row with different superscripts are significantly different ($p < 0.05$); ^{ns}= Not significant ($p > 0.05$) SEM = standard error of mean DW= Dressed weight; CD= Control diet, SOP₀D = Diet containing test ingredient not soaked in water. SOP₂₄D = Diet containing test ingredient soaked in water for 24 hrs. SOP₄₈D = Diet containing test ingredient soaked in water for 48 hrs. SOP₇₂D = Diet containing test ingredient soaked in water for 72 hrs. SOP₉₆D = Diet containing test ingredient soaked in water for 96 hrs

4. DISCUSSION

Growth performance characteristics of finisher broiler chickens fed diets containing various duration of water soaked sweet orange peel meal: The treatment effect on none of the mean final body weight, weight gain and daily weight gain was significant among the dietary groups. It thus implied that irrespective of duration of soaking the sweet orange peels in water which in this study varied from 0 hr to 96

hrs, the performances of finisher broiler in the control group was not superior to the performance of the finisher broiler in the SOP based diets. This suggests that the diets containing SOP supported daily growth of the chickens as much as the maize based diet did. Performance of broiler birds are said to be good if they attain market weight of 1.6 to 1.8 kg on average at 8 or 10 week of age [5]. The mean live weights in this study were therefore satisfactory. Feed intake varies significantly

among the dietary treatment with birds on the control recording the highest feed intake (81.53 g). However, it was observed that birds on the experimental diets statistically had similar feed intake comparable with the control. The average feed intake obtained in this study was however lower than the average daily feed consumption range of 135.98 g to 160.89 g reported by [11] when the same test ingredient (SOP) was used to replace dietary maize. This difference could be due to the differences in strain of broiler chicken used, the duration of each study and the season the studies were conducted. The FCR obtained in this study was within the range of 2.57 to 2.88 reported by [15] and comparatively better than the 2.83 to 3.59 (DM) reported by [11]. These differences do not matter much since they fall within FCR range of 2 to 5 recommended by [5] as normal for broiler chickens. Protein efficiency ratio (PER) varied significantly among the treatments. However, birds on water soaked peels from 24 hrs to 96 hrs had similar PER. This implies that the duration of soaking the peels in water did not affect the utilization and absorption of protein in the diets. The PER obtained in this study was higher than 1.46 to 1.58 reported by [16] the difference could be attributed to the processing method of the test diets. There was no significant difference among the treatment groups on daily water intake. This implies that maize replacement in broiler diet with SOP of varying duration of water soaking from 0 hr to 96 hrs at 30% level of inclusion did not have any influence on water intake. This agrees with the

report of [11] and [16] who reported a non-significant effect on the performance of broiler chickens at 20% when maize was replaced by SOP. Mortality recorded could not be linked to feed poison since past reports on sweet orange peel meal have recorded zero mortality even at higher percentages of maize replacement [17]. More so, the fact that mortality also occurred in the control is a proof to the fact that feed poison may not be the cause of the mortality.

Carcass Characteristics of finisher broiler chickens fed diets containing various duration of water soaked sweet orange peel meal:

The effect of the live weight and dressed weight revealed that there were significant differences among the treatment groups. However, it was observed that the values for birds on experimental diets (SOP) were comparable to control. This implies that the feather development process in broiler chickens was not affected by the incorporation of SOP in their diets. The live weights are comparable with 1.85 kg to 2.58 kg reported by [11] and higher than 1.03 kg to 1.25 kg reported by [18]. The dressing percentage value of 73.65 to 78.48% in this trial are higher than 66.19 to 69.76% [11] and 56.56 to 60.14% [15]. Dressing percent may vary due to the parts of the birds that have developed better. None of the carcass parts evaluated in this study were significantly affected by the dietary treatments. This shows that the diets did not result in a statistical variation in these carcass parameters evaluated.

Table 4. Effect of diets containing duration of water soaked sweet orange peel meal on internal organs of finisher broiler chickens (%LW)

Experimental Diets

Internal organs	CD	SOP₀D	SOP₂₄D	SOP₄₈D	SOP₇₂D	SOP₉₆D	SEM
liver	1.79	1.69	1.66	1.76	1.65	1.87	0.07 ^{ns}
Empty gizzard	1.98	2.34	1.95	1.97	1.96	1.96	0.12 ^{ns}
Pancreas	0.26	0.28	0.30	0.24	0.27	0.25	0.03 ^{ns}
Proventriculus	0.55	0.43	0.55	0.52	0.51	0.48	0.07 ^{ns}
Heart	0.48	0.37	0.40	0.47	0.48	0.45	0.06 ^{ns}
Kidney	0.55	0.58	0.52	0.50	0.53	0.50	0.05 ^{ns}
Lungs	0.62	0.54	0.52	0.55	0.57	0.54	0.04 ^{ns}
Spleen	0.10	0.11	0.10	0.11	0.10	0.11	0.02 ^{ns}
Crop	0.37	0.38	0.41	0.42	0.41	0.38	0.40 ^{ns}
Gall bladder	0.08	0.08	0.10	0.07	0.10	0.10	0.02 ^{ns}

ns = Not significant ($p > 0.05$); SEM = Standard Error of Means; LW = Live weight; CD = Control diet, SOP₀D = Diet containing test ingredient not soaked in water.

SOP₂₄D = Diet containing test ingredient soaked in water for 24 hrs. SOP₄₈D = Diet containing test ingredient soaked in water for 48 hrs. SOP₇₂D = Diet containing test ingredient soaked in water for 72 hrs. SOP₉₆D = Diet containing test ingredient soaked in water for 96 hrs

None of the visceral organs was significantly affected among the dietary treatments in terms of their individual weights relative to their corresponding live weights expressed in percent. Internal organs such as gall bladder and the liver would vary by way of enlargement if some of the diets contain poisonous substances. The situation where significant differences did not occur implies that the SOP did not introduce poisonous substances in the diets [19]. Similarity among treatment groups for empty gizzard and proventriculus suggests that though fibre contents of SOP based diets seemed to be higher, it did not affect these organs. This condition is normal since calculated crude fibre for all the diets did not exceed the 5% level recommended by [20]. Abnormal blood circulation would cause variation in the size of the heart [21]. Non-significant difference among the treatment groups for heart (percent live weight) indicated a normal blood circulation among all the dietary groups. The pancreas is the site for production of many of the digestive enzymes. There was no significant difference in percent pancreas weight among the treatments. This suggests that digestion especially in the small intestine was not obstructed in any form as a result of the test ingredient (SOP) inclusion in the diets.

5. CONCLUSION AND APPLICATION

1. Water soaked sweet orange peel meal improved the performance of broiler chicken and also resulted into comparable performance with the control.
2. The carcass characteristics showed that using water soaked sweet orange peels up to 96 hours do not have any negative effects on the primer cuts.
3. Farmers can include water soaked sweet orange peels in the diets of their broilers for improved performance and carcass quality.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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