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Research Article

Response of Broiler Chickens to Diets Containing Varying Levels of Rumen Filtrate Fermented Wheat Offal

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Abstract

Background and Objective: Wheat offal is one of the abundant AIBs whose application is limited in monogastric animals due to poor nutritional value. Fermentation improves the nutritional value of feedstuff. This experiment was conducted to evaluate rumen filtrate fermented wheat offal as (RUFFWO) a feed ingredient in the diet of broiler chickens. **Materials and Methods:** Six diets were formulated to meet the nutritional requirement of broiler chickens at the starter and finisher stages using RUFFWO at 0, 5, 10, 15, 20 and 25% of the diets. As 180 days old broiler chicks were randomly weighed and allotted to six treatment groups of 30 birds each, respectively. Each treatment was divided into three replicates of 10 birds each in a Completely Randomized Design (CRD). Data on the feed intake, body weight gain feed conversion ratio, protein efficiency ratio and cost-benefit were generated and analyzed. **Results:** The result of the experiment revealed a significant ($p<0.05$) decrease in feed intake, body weight gain and final weight of broiler chickens with an increase in dietary RUFFWO at the starter phase. Feed conversion ratio and mortality were significantly lower in the RUFFWO group compared to the control at the finisher phase. Feed cost and cost/kg gain were higher in the RUFFWO group at the starter phase. No significant effect was found at the finisher phase. **Conclusion:** It was concluded from this study that broiler chickens can tolerate up to 25% fermented wheat offal without detrimental effects on performance. As 20% inclusion of RUFFWO is recommended for broiler chickens at the finisher stage.

Key words: Rumen filtrate fermented wheat offal, broiler chickens, growth performance, total feed cost, total weight gain, cost per gain

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Protein deficiency is a major cause of malnutrition and the problem will become worse with further increases in the world population[1]. Nigeria is the most populous country in Africa. The expanding population has led to a corresponding increase in demand for food, especially protein of animal origin. Intensive production of highly reproductive animals with short generation intervals such as poultry, pigs and rabbits have been suggested as some of the strategies for addressing the problem. However, the incessant high prices of feed ingredients have been a major factor limiting the development of commercial poultry enterprises[2]. This is because monogastric animals cannot utilize fibrous feed materials and must rely on food grains (concentrates) usually consumed by man for their nourishment. This situation has created keen competition with humans for available food grains making it increasingly difficult to supply cereal grains to the livestock industry. Efforts to address the escalating price of feed ingredients for poultry include the use of cheaper feed ingredients especially non-conventional feedstuff (NCF) that are cheaper, readily available and have low and less direct nutritional significance to man. The most common NCFs considered are agro-industrial by-products (AIBs) such as grain offals, palm kernel meal and brewers' dried grains among others. Wheat offal (WO) is one of the abundant AIBs whose application is limited in monogastric animals due to poor nutritional value. Reports have portrayed wheat offal as a byproduct that could replace some portion of maize in the chicken diet[3]. However, wheat offal contains anti-nutritional factors (ANF) known as nonstarch polysaccharides (NSP). The NSPs have been implicated as a factor depressing nutrient digestibility, absorption, availability and efficient utilization in monogastric animals. This is because they are not efficiently degraded by the conditions and digestive enzymes in the gastrointestinal tract of monogastric animals. Nutritionists have identified various processing methods to enhance the utilization of AIBs like WO, they include the use of exogenous enzymes and more recently, the application of microbiological fermentation and biotechnology applications.

Fermentation is an effective means of breaking down anti-nutrients and increasing the nutritive value of AIBs[4]. On the other hand, rumen contents and rumen liquor are by-products that are left after ruminant animals are slaughtered. It is projected that simulating rumen fermentation (*in vitro*) of wheat offal with rumen liquor will perhaps reduce the fiber portion in the wheat bran and increase the bioavailability of nutrients to the bird. According to Aro *et al*.[5], the application of solid-state fermentation to enhance the nutritional worth of AIBs has not been comprehensively studied through animal trials[5]. Moreover, there is insufficient information on the treatment of wheat bran with rumen liquor except for the work of Adesua and Onibi[6], who indicated the possibility of upgrading the feeding value of these by-products by a simple, inexpensive and easily adaptable technique. Therefore, the objective of this study was to evaluate the effect of including rumen filtrate fermented wheat offal (RUFFWO) on the performance of broiler chickens.

MATERIALS AND METHODS

Location of the study: The study was conducted from January to March, 2023 at the Department of Animal Sciences, Poultry Unit of the Teaching and Research Farm, University of Maiduguri. The area is located between Latitude 11°85 and 12°N and Longitude 13°16 and 14°E and at an Altitude of 325 m above sea level. It falls within the Sahel Savannah Region characterized by the long dry season (October to May) and short duration of rainfall (June to September) which varies from 300 to 700 mm per annum. Mean temperature ranges from 33-40°C (April-May) from the lowest (23-28°C) from December to January.

Sourcing, processing and preparation of experimental material: Wheat offal (WO) and other ingredients such as maize, soybean, fish meal, bone meal and mineral vitamin premix to be used for the experiment were purchased from a local market in Maiduguri. Fresh cattle rumen content was collected immediately after the slaughter at the Maiduguri abattoir and was immediately filtered through a sieve. The residue was discarded and the filtrate was collected. Equal weight of the filtrate and wheat offal were measured and thoroughly mixed. The mixture was immediately compacted into a fermentation vat, the mouth of which was sealed with polythene material and tightly closed with the covers to create the anaerobic conditions for the fermentation at room temperature for two weeks. At the end of the fermentation period, the vat was opened and the fermented wheat offal was removed and sundried for two to three days and securely stored until required for compounding the diets.

Experimental birds and their management: A total of 180 broiler chicks were purchased from a reputable hatchery and used for the experiment. On arrival, the chicks were brooded for one week using a kerosene stove as a source of heat. The chicks were thereafter weighed individually and randomly assigned to various treatment groups. The birds were also vaccinated against Gumboro and Newcastle diseases at the age of two and three weeks. Other routine husbandry management practices were duly observed. The experiment lasted for seven weeks. The study was conducted in line with the animal welfare act and does not violate or infringe on the right of the animals used in the experiment.

Experimental diets and design: The rumen filtrate fermented wheat offal (RUFFWO) was used to formulate six diets for the starter and finisher phases. During the phases, RUFFWO was included at 0, 5, 10, 15, 20 and 25% of the diets. These were designated as T1 (0% RUFFWO), T2 (5% RUFFWO), T3 (10% RUFFWO), T4 (15% RUFFWO), T5 (20%) and T6 (25% RUFFWO), respectively. The birds were randomly weighed and allotted to six treatment groups of 30 birds each. Each treatment was divided into three groups of 10 birds per replicate in a Completely Randomized Design (CRD). Feeding and watering were *ad libitum*. The birds were weighed at the onset of the experiments and thereafter every week feed intake was recorded daily. The composition and calculated analysis of the experimental diets were presented in Table 1 and 2.

Measurement of response criteria

Feed intake: This was determined as the difference between the quantity of feed given and the leftover per group.

Body weight gain: This was determined as the difference between the mean live weight of the current week from the mean live weight of the preceding week.

Feed conversion ratio (FCR): This was determined as the ratio between the quantity of feed consumed and body weight gain for each treatment group.

Protein efficiency ratio (PER): This was determined as the ratio between weight gain and protein intake during the experiment.

Cost-benefit: Feed cost per kilogram was obtained from the cost of various feed ingredients used in the feed preparation using prevailing market prices. Feed cost per kilogram live weight gain was obtained by multiplying feed cost per kilogram by the feed conversion ratio.

Statistical analysis: Data collected were subjected to Analysis of Variance (ANOVA) (SPSS 13.0) at 0.05% significance. Treatment means were separated using Duncan's Multiple Range Test (DMRT).

Table 1: Composition and calculated analysis of the experimental broiler starter diets

	Level of rumen filtrate fermented wheat offal (RUFFWO) inclusion (%)					
Ingredients (%)	0	5	10	15	20	25
Maize	45.00	45.00	44.00	40.00	39.00	37.00
Full-fat-soya bean	40.00	39.00	33.00	31.00	25.00	22.00
RUFFWO	00.00	05.00	10.00	15.00	20.00	25.00
Wheat offal	06.00	02.00	02.00	01.00	01.00	00.00
Fish meal	05.00	05.00	06.00	07.00	08.00	08.50
Bone meal	03.00	03.00	03.00	03.00	03.00	03.00
Common salt	00.30	00.30	00.30	00.30	00.30	00.30
*Min-Vit premix	00.40	00.40	00.40	00.40	00.40	00.40
Lysine	00.10	00.10	00.10	00.10	00.10	00.10
Methionine	00.20	00.20	00.20	00.20	00.20	00.20
Palm oil	00.00	00.00	01.00	02.00	03.00	03.50
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis (%)						
Crude protein	23.27	23.14	23.06	23.15	23.00	23.00
Crude fibre	03.69	03.87	03.26	03.53	03.71	03.37
Calcium	01.43	01.40	0 1.43	01.45	01.46	01.42
Phosphorous	00.77	00.72	00.86	00.73	00.75	00.76
Lysine	01.16	01.33	01.36	01.36	01.36	01.35
Methionine	00.53	00.59	00.58	00.67	00.67	00.64
ME (kcal kg^{-1})	2817.97	2812.43	2826.71	2832.61	2834.53	2811.60

ME: Metabolizable energy, *1 kg of mineral-vitamin premix supplies, vitamins A 4,000,000.00 IU, vitamin D3 800,000.00 IU, vitamin E 9,200.00 mg, vitamin K3 800 mg, vitamin B1 1200 mg, vitamin B2 20000 mg, niacin 22000 mg, pantothenic acid 3,000 mg, vitamin B61 200.00 mg, vitamin B12 6.0 mg, folic acid 300 mg, biotin 24 mg, choline chloride 120,0000 mg, manganese 16,000 mg, iron 40000 mg, zinc 32000 mg, copper 1, 200.00 mg, iodine 400 mg, cobalt 80 mg, selenium 80.00 mg and anti-oxidant 500.00 mg

Table 2: Composition and calculated analysis of experimental broiler finisher diets

	Level of rumen filtrate fermented wheat offal (RUFFWO) inclusion (%)					
Ingredients (%)	0	5	10	15	20	25
Maize	55.00	54.00	53.00	52.00	49.00	46.00
Full fat soya bean	26.00	22.00	20.00	18.00	15.00	12.00
RUFFWO	00.00	05.00	10.00	15.00	20.00	25.00
Wheat offal	08.00	06.00	03.00	01.00	00.00	00.00
Fish meal	03.00	04.00	05.00	05.00	06.00	06.00
Blood meal	02.00	02.00	02.00	02.00	02.00	02.00
Bone meal	04.00	04.00	04.00	04.00	04.00	04.00
Common salt	00.30	00.30	00.30	00.30	00.30	00.30
*Min-Vit premix	00.40	00.40	00.40	0.400	00.40	0.400
Lysine	00.10	00.10	00.10	00.10	00.10	00.10
Methionine	00.20	00.20	00.20	00.20	00.20	00.20
Palm oil	01.00	02.00	02.00	02.00	03.00	04.00
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis (%)						
Crude protein	20.30	20.05	20.07	20.00	19.98	20.00
Fibre	03.21	03.36	03.34	03.34	03.35	03.35
Calcium	01.19	01.24	01.26	01.26	01.28	01.30
Phosphorous	00.85	00.76	00.77	00.77	00.61	00.73
Lysine	01.14	01.13	01.14	01.11	01.06	01.08
Methionine	00.53	00.57	00.55	00.58	00.61	00.60
ME (kcal kg^{-1})	2926.33	2934.60	2952.17	2929.10	2926.93	2967.80

ME: Metabolizable energy, *1kg of mineral-vitamin premix supplies, vitamins A 4,000,000.00 IU, vitamin D3, 800,000.00 IU, vitamin E 9,200.00 mg, vitamin K3 800 mg, vitamin B1 1200 mg, vitamin B2 20000 mg, niacin 22000 mg, pantothenic acid 3,000 mg, vitamin B61,200.00 mg, vitamin B12 6.0 mg, folic acid 300 mg, biotin 24 mg, choline chloride 120,0000 mg, manganese 16,000 mg, iron 40000 mg, zinc 32000 mg, copper 1, 200.00 mg, iodine 400 mg, cobalt 80 mg, selenium 80.00 mg and anti-oxidant 500.00 mg

RESULTS AND DISCUSSION

Effect of dietary RUFFWO on growth performance of broiler chickens: The effect of feeding RUFFWO on the productive performance of broiler chickens at the starter and finisher phases of growth was presented in Table 3. A significant difference ($p<0.05$) was observed in daily feed intake, daily weight gain, total weight gains and final live weight, at the starter phase. There was, however, no significant difference ($p\geq0.05$) in the feed conversion ratio. At the finisher phase, however, a significant difference ($p<0.05$) was found only in the feed conversion ratio.

Daily feed intake: For the starter phase, chickens fed a diet containing 0% RUFFWO recorded the highest ($p<0.05$) feed intake (70.64 g/b). The value was statistically similar to 65.02, 64.29, 66.21 and 64.47 (g/b) obtained for chickens on 5, 10, 20 and 25% RUFFWO. Those fed 15% RUFFWO recorded the least value (62.73 g/b). The value was, however, similar to values observed in chickens on 5-25% RUFFWO. The trend revealed a tendency to decrease feed intake in the RUFFWO groups compared to the control. Lower feed intake in chickens on diet four (15% RUFFWO) could be related to higher morbidity observed in the group which might have a depressed appetite. The findings of this study concur with the reports of Olaifa *et al.*[7], who showed a significant reduction in daily feed intake of broiler chickens fed a diet containing graded levels of rumen filtrate fermented cassava peel meal. Mandey *et al.*[8] reported lower feed intake in chickens fed rumen content. The findings of Ajayi and Ajao[9] showed decreased feed intake in chickens fed max grain-supplemented corn cob meal. Similarly, Atapattu and Silva[10] reported lower feed intake in broiler chickens fed rice bran compared to the control. Furthermore, relatively lower FI in the RUFFWO groups compared to the control could be a result of the dark color of the RUFFWO which discourages the chicks from feeding as the selection of feed particles was noted in the groups. Alternatively, it could be due to the inability of the chicks to completely break down the high level of RUFFWO in the diets as the gastro-intestinal tract was not well developed to process fibrous material at that stage of growth.

Daily weight gain: The result from this study showed significantly higher daily weight gain in chickens on 0 and 5% RUFFWO (34.41 and 34.97 g/b). The value is statistically similar to values obtained for chickens fed 10, 20 and 25% RUFFWO (33.44, 32.28 and 31.33 g/b). Chickens on 15% RUFFWO had the lowest weight gain (30.13 g/b). This is also similar to values obtained for chickens on 10, 20 and 25% RUFFWO. The trend in this study showed a reduction in daily weight gain with an increase in RUFFWO inclusion. The findings of this study concur with the reports of Olaifa *et al.*[7], who showed a significant reduction in daily weight gain of broiler chickens fed a diet containing graded levels of rumen filtrate fermented cassava peel meal. Atapattu and Silva[10] reported lower weight in broiler chickens fed rice bran and sawdust compared to the control. Lower weight gain observed in chickens RUFFWO could be related to lower feed intake observed in the group.

Feed conversion ratio: The findings of this study revealed no significant difference ($p>0.05$) between the treatment groups for feed conversion ratio at the starter phase. A significant difference ($p<0.05$) was, however, found between the groups at the finisher phase. Chickens with the highest RUFFWO inclusion (25%) had the best FCR (1.77). The value was similar to values recorded for chickens on 5, 10, 15 and 20% RUFFWO. The worst FCR was found in chickens on the control diet 2.20. The value is also similar to values obtained for chickens on 5,10 and 15% RUFFWO. The observation in this study concurs with the findings of Elmasry *et al.*[4], who reported better FCR in the group fed fermented wheat bran compared with the control. Lawal *et al.*[11] also reported that *Aspergillus niger* fermentation of wheat offal resulted in significant improvement in the FCR of broiler chickens at the finisher phase. Similarly, the reports of Kpehe *et al.*[12] also showed better FCR in rabbits fed rumen filtrate fermented rice offal compared to the control. Better FCR observed in chickens in RUFFWO groups could be related to relatively higher weight gain (73.23 to 76.2 g) observed in the groups fed RUFFWO than the control (68.26 g). It could also be related to the fermentation of the wheat bran which is reported to enhance nutrient availability[4]. Alternately, Better FCR in the RUFFWO groups may be because solid-state fermentation of AIBs enhances digestion, promotes secretion of digestive enzymes and reduces endogenous losses in the gastrointestinal tract which enhances the efficiency of feed utilization by the birds. Furthermore, a significant difference was observed in the weight of the proven triculus between the control and the 25% RUFFWO group. This may also suggest some extra muscular and enzyme activities in the organ required to process the high fiber content of the feed which perhaps resulted in enhanced digestion and efficiency of feed utilization. Similarly, better FCR at the finisher phase could be an indication that the RUFFWO-based diets, are more efficiently utilized at the finisher than the starter phase.

Protein efficiency ratio (PER): The PER showed no significant difference ($p\geq0.05$) among the groups for the starter phase. A significant difference ($p\leq0.05$) was, however, observed at the finisher phase. The PER tended to increase with an increase in dietary RUFFWO. Chickens fed 20 and 25% RUFFWO diet had the highest PER (4.03 and 4.02). The values are statistically similar to values obtained in chickens fed 5-15% RUFFWO diets (3.64-3.83). The least PER (3.29) was found in chickens in the control group. The value is also, similar to values recorded in chickens fed a 5-15% RUFFWO diet. The protein efficiency ratio is an indicator of the quality of dietary protein, as it reflects its availability for tissue deposition[13]. Better BWG and FCR observed in chickens on the RUFFWO groups could be related to the PER. The findings of the study indicate that the RUFFWO group efficiently utilized the protein consumed to maximize production which resulted in high body weight gain. Similarly, better FCR at the finisher phase could be an indication that RUFFWO based diets, are more efficiently utilized at the finisher than the starter phase.

Final live weight: The final live weight for the starter phase was highest ($p<0.05$) in chickens fed a diet containing 5% RUFFWO (838.48 g). The value was similar to values obtained for chickens fed diets containing 0, 10, 20 and 25% RUFFWO. Chickens on diet four (15% RUFFWO) had the lowest final weight (735.56 g). The value was again, similar to values obtained for chickens on 0, 10, 20 and 25% RUFFWO (825.56, 807.14, 784.81 and 763.85 g, respectively). The trend revealed a tendency to lower the final weight in the RUFFWO groups compared to the control. The findings of this study concurred with the reports of Olaifa *et al.*[7], who showed a significant reduction in the final weight of broiler chickens fed a diet containing graded levels of rumen filtrate fermented cassava peel meal. The observation in chickens in RUFFWO groups could be related to lower feed intake and daily weight gain observed in the group. No significant difference ($p>0.05$) between the treatment for final weight at the finisher phase.

Mortality: The findings of this study revealed no significant difference ($p>0.05$) between the treatment for mortality at the starter phase. At the finisher phase, however, a significant difference ($p<0.05$) between the treatment groups was observed. Chickens fed a diet containing 20% RUFFWO had the least mortality (3.33 %). The value is similar to 9.70-13.70% recorded for chickens on 5, 10, 15 and 25% RUFFWO. The highest mortality was found in chickens in the control group (20.74 %). The trend revealed better survivability in chickens in the treatment groups than in the control. Studies conducted by Elmasry *et al.*[4] showed no mortality and health disorders in broiler chicks with 10% fermented wheat bran.

Table 3: Effect of dietary rumen filtrate fermented wheat offal (RUFFWO) on productive performance of broiler chickens

	Treatments/level of RUFFWO inclusion (%)						
Parameters	T1 (0)	T2 (5)	T3 (10)	T4 (15)	T5 (20)	T6 (25)	SEM
Starter phase (1-4 weeks)							
Initial weight (g)	102.93	104.01	104.91	102.90	106.86	105.82	0.75^{ns}
Feed intake (g/b/day)	70.64^{a}	65.02^{ab}	64.29^{ab}	62.73^{b}	66.21^{ab}	64.47^{ab}	0.82*
Daily weight gain (g)	34.41^{b}	34.97^{b}	33.44^{ab}	30.13^{a}	32.28^{ab}	31.33^{ab}	0.51*
Feed conversion ratio	2.05	1.86	1.93	2.08	2.05	2.05	0.03^{ns}
Protein efficiency ratio	1.39	1.46	1.41	1.27	1.41	1.38	0.03^{ns}
Final weight (g)	825.56^{ab}	838.48^{a}	807.14^{ab}	735.56^{b}	784.81^{ab}	763.85^{ab}	10.96*
Mortality (%)	12.121	6.061	9.091	12.121	12.121	6.061	1.43^{ns}
Finisher phase (5-7 weeks)							
Feed intake (g/b/day)	148.18	136.89	143.96	144.86	138.64	134.87	1.83^{ns}
Weight gain (g/b/day)	68.26	73.23	74.99	74.89	77.44	76.20	1.27^{ns}
Feed conversion ratio	2.20^{b}	1.87^{ab}	1.92^{ab}	1.93^{ab}	1.80^{a}	1.77^{a}	0.04*
Protein efficiency ratio	3.29^{a}	3.64^{ab}	3.80^{ab}	3.83^{ab}	4.03^{b}	4.02^{b}	0.07
Final weight (g)	2258.93	2376.30	2381.94	2308.14	2411.11	2363.97	24.24^{ns}
Mortality (%)	20.74^{a}	9.70^{ab}	9.70^{ab}	13.70^{ab}	3.33^{b}	11.80^{ab}	1.86*

^{a,b}Means on the same row having different superscripts are significantly different ($p \leq 0.05$), SEM: Standard error of mean, *Significantly different ($p \leq 0.05$) and ^{ns}Not significantly different ($p \geq 0.05$)

Table 4: Cost-benefit analysis of broiler chickens fed diets containing RUFFWO

	Level of RUFFWO inclusion (%)						
Parameters/treatments	T1 (0)	T2 (5)	T3 (10)	T4 (15)	T5 (20)	T6 (25)	SEM
Starter phase (1-4 weeks)							
Initial weight (g)	102.93	104.01	104.91	102.90	106.86	105.82	0.75^{ns}
Final weight (g)	825.56^{ab}	838.48^{a}	807.14^{ab}	735.56^{b}	784.81^{ab}	763.85^{ab}	10.96*
Total weight gain (g)	722.62^{a}	734.47^{a}	702.23^{ab}	632.65^{b}	677.96^{ab}	658.02^{ab}	3.04*
Total feed intake (kg)	1.98^{a}	1.82^{ab}	1.80^{ab}	1.76^{b}	1.85^{ab}	1.80^{ab}	0.02*
Feed cost (N kg^{-1})	287.90^{a}	287.33^{a}	294.26^{ab}	314.54^{ac}	320.03^{c}	321.28^{c}	10.81*
Total feeding cost (N)	640.90	610.55	628.75	641.09	694.62	664.52	10.21^{ns}
Cost kg^{-1} gain (N)	591.96^{a}	536.44^{a}	569.19^{ab}	656.25^{b}	657.40^{b}	661.11^{b}	12.79*
Finisher phase (5-7 weeks)							
Initial weight (g)	825.56^{ab}	838.48^{a}	807.14^{ab}	735.56^{b}	784.81^{ab}	763.85^{ab}	10.96*
Final weight (g)	2258.93	2376.30	2381.94	2308.14	2411.11	2363.97	24.24^{ns}
Total weight gain (g)	1433.37	1537.81	1574.81	1572.58	1626.30	1600.13	26.68^{ns}
Total feed intake (g)	3111.73	2874.70	3023.05	3042.07	2911.46	2832.33	38.47^{ns}
Feed cost (N kg^{-1})	294.38^{ab}	303.28^{ab}	303.38^{ab}	290.00^{a}	310.51^{ab}	316.08^{b}	3.01*
Total feeding cost (N)	916.06	871.06	914.88	882.20	903.52	895.59	11.66^{ns}
Cost kg^{-1} gain (N)	651.04	567.86	581.11	560.88	557.09	560.68	14.95^{ns}

^{a,b,c}Means on the same row having different superscripts are significantly different ($p<0.05$), SEM: Standard error of mean, *Significantly different ($p \leq 0.05$) and ^{ns}Not significantly different ($p \geq 0.05$)

Tsado and Akinwolere[13] also revealed the highest mortality (24.45%) in the control group compared to groups fed rumen filtrate fermented shea nut. Lower mortality in chickens in the RUFFWO groups could be an indication of the superiority in health status and/or defense mechanism of the chickens to disease stress as the chickens suffered from the Newcastle disease outbreak. Furthermore, feeding fermented feed stimulates the proliferation of beneficial bacteria which competitively exclude pathogenic bacteria by occupying strategic attachment sites in the gut mucosa and or producing bacteriostatic or bactericidal compounds hostile to competitors giving some advantage to the chickens in the treatment group over the control group in term of health status[14].

Cost-benefit analysis of broiler chickens fed diets containing RUFFWO: Cost-benefit analysis of broiler chickens fed diets containing RUFFWO at the starter and finisher phases are presented in Table 4. A significant ($p<0.05$) difference was observed for total feed intake, total weight gain, feed cost and cost per kg weight gain at the starter phase. There was, however, no significant ($p>0.05$) difference in total feed cost. Expect feed cost, no significant ($p>0.05$) difference was found in all the parameters measured at the finisher phase.

Total weight gain: For the starter phase, total weight gain was lowest ($p<0.05$) in chickens on 15% RUFFWO (632.65 g). The value is similar to values obtained for chickens on 10, 20 and 25% RUFFWO (702.23, 677.96 and 658.02 g). Chickens on the control and 5% RUFFWO diet had the better total weight gain (722.62 and 734.47 g). Also, the values were similar to values found in chickens on 10, 20 and 25% RUFFWO (702.23, 677.96 and 658.02 g). Total weight gain followed the same trend as daily weight gain. Observation in chickens RUFFWO could be related to lower feed intake and daily weight gain observed in the groups.

Total feed intake: Total feed intake was found to be highest ($p<0.05$) in chickens on the control diet (1.98 kg). The value was similar to values found in chickens on 5, 10, 20 and 25% RUFFWO. The group fed 15% RUFFWO had the lowest feed consumption (1.76 kg). The value was also similar to 1.82, 1.80, 1.85 and 1.80 kg recorded for chickens on 5, 10, 20 and 25% RUFFWO. The trend in total feed intake also followed a similar trend with daily feed intake.

Feed cost: For the starter phase, feed cost was highest ($p<0.05$) in chickens fed diets containing 20 and 25% RUFFWO (320.03 and 321.28 N kg^{-1}). Chickens on 15% RUFFWO had values (314.54 N kg^{-1}) that were similar to values recorded for chickens in the control group and those on 20 and 25% RUFFWO diets. The least value was found in the group fed 0 and 5% RUFFWO (287.90 and 287.33 N kg^{-1}). A significant difference ($p<0.05$) was also observed between the groups for feed cost at the finisher phase. Again chickens with the highest RUFFWO inclusion (25%) had the highest cost of feed 316.08 N kg^{-1}. The value was, however, similar to values obtained for chickens on 0, 5, 10 and 20% RUFFWO (294.38-310.51 N kg^{-1}). The least cost of feed was found in chickens on 15% RUFFWO (290.00 N kg^{-1}). The findings of this study were similar to the findings of Elmasry *et al.*[4], who earlier reported lower feed costs for chickens fed fermented wheat bran compared to the control. The high cost of feed in chickens in the RUFFWO group could be attributed to increased inclusion and the high cost of palm oil used to boost the energy level of the diets. It was earlier noted in this study that the fermentation of wheat offal did not improve its energy content as was expected. It may also be related to the increased cost of wheat offal at the time of the experiment.

Cost per kilogram weight gain: For the starter phase, cost per kilogram weight gain was highest ($p<0.05$) and similar in chickens on 15, 20 and 25% RUFFWO (656.25 657.40 and 661.11 N). Chickens on 15% RUFFWO had a value (569.19 N) that was similar to values obtained for chickens on 0, 5, 10, 15, 20 and 25% RUFFWO. The control and 5% RUFFWO groups had the least cost per kilogram weight gain (591.96 and 536.44). The trend in this study reveals increasing cost per gain as the level of RUFFWO increased. There was, however, no significant difference in cost per unit gain at the finisher phase. The observation in this study could be related to higher feed cost and poorer weight gain recorded for the groups coupled with a lack of significant effect in feed conversion ratio.

The findings of this study imply that with fermentation, low-quality AIBs such as wheat offal could be utilized in broiler chickens. Rumen filtrate contains thousands of different microbial species. One of the limitations of the study is the inability to identify the chief microbial species that were responsible for improving the nutritional quality of wheat offal and the subsequent performance of the chickens. Future studies on these microbial species could assist in identifying, isolating and production of favorable species for commercial use.

CONCLUSION

It has been shown from this study that chickens fed diets containing up to 25% RUFFWO performed as well as those fed the control diet at the starter phase. At the finisher phase, however, chickens in the RUFFWO groups performed better than the control group. It was also shown that dietary RUFFWO improves feed conversion ratio, Protein efficiency ratio and survivability. It was concluded from this study that RUFFWO could be incorporated into the diets of broiler chickens up to 25% level without adverse effects on growth performance, total feed cost and cost per gain. Thus, can assist in lowering the cost of broiler production and in lessening the feed/food competition. As 20% RUFFWO is recommended in the broiler diets for better productivity.

SIGNIFICANCE STATEMENT

This study has shown that with fermentation, wheat offal can be included in the diets of broiler chickens up to 25% without adverse effects on productive performance. It has shown that chickens on RUFFWO diets had comparable growth performance as those fed a control diet at the starter phase. However, chickens on 20% inclusion of RUFFWO performed advantageously to those on the control diet at the finisher stage. Thus, the 20% inclusion of RUFFWO provides several benefits such as improved feed conversion ratio, Protein efficiency ratio and mortality and can reduce the quantities of conventional ingredients used as energy and protein sources (like maize and soybeans) in poultry feed formulations. Therefore, relax the food/feed competition between humans and mono gastric animals for available grains.

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