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Research Article

Evaluation of Processing Methods of Rubber (*Hevea brasiliensis*) Seed Meal for Use as a Feed Ingredient for Broiler Chickens

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ABSTRACT: A 42-d study was conducted to determine the effect of different processing methods of rubber seed meal (RSM) which include soaking, cooking, toasting and fermentation as substitute for soybean meal on performance, apparent nutrient digestibility, relative organ weight and carcass qualities of broiler chickens. Three hundred, 1-day old Arbor acre broiler chicks were randomly allotted to five dietary treatments containing the four different processed RSM (soaked, cooked, toasted and fermented RSM) and control diet without RSM, with five replications of twelve birds each in a completely randomized design. Proximate composition revealed that the fermented RSM had higher crude protein content, and hydrogen cyanide (HCN) concentration recorded lowest in the cooked RSM than other processed RSM. Birds fed cooked and fermented RSM recorded higher weight gain and feed intake with better feed efficiency than those on toasted and soaked RSM group compared to the control group. The cost/kg weight gain of birds fed cooked and fermented RSM diets was lower than those fed control, soaked and toasted RSM diets. With the exception of crude protein digestibility which was lower in the group fed SRSM, apparent nutrient digestibility variables were similar among the control and other processed RSM diets. Carcass and organ variables were better compared among the control, cooked and fermented RSM groups. Conclusively, cooking and fermentation tend to improve the nutritive potentials of rubber seed than soaking and toasting. Birds fed cooked and fermented RSM maintained superior performance and better carcass qualities at higher savings in terms of cost/kg gain.

Keywords: Broilers, carcass, nutrient digestibility, performance, processing, rubber seed

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Kauçuk Tohumu Küspesi (*Hevea brasiliensis*)'nin Etlik Piliçler için Yem Maddesi Olarak Kullanımında Üretim Yöntemlerinin Değerlendirilmesi

ÖZ: Etlik piliçlerde soya küspesi yerine ikame olarak, ıslatma, pişirme, ezme ve fermantasyon gibi farklı üretim yöntemleri kullanılarak üretilen kauçuk tohumu küspesinin (KTK) performans, zahiri besin madde sindirilebilirliği, nispi organ ağırlıkları ve karkas kalitesi üzerine etkilerini saptamak için 42 günlük bir çalışma yürütülmüştür. Araştırmada 1 günlük yaşta 300 adet Arbor acre broyler civcivler, 4 farklı metotla (ıslatma, pişirme, ezme ve fermente) üretilen KTK içeren ve KTK içermeyen kontrol grubu olmak üzere, her birinde 12 civciv bulunan 5 tekerrürlü, 5 deneme grubuna rastgele yerleştirilmiştir. Diğer işleme metotları ile karşılaştırıldığında Weende analizleri açısından yalnızca ham protein düzeyi fermente KTK'da daha yüksek iken, hidrojen siyanid düzeyi pişmiş KTK'da en düşük bulunmuştur. Kontrol grubu ile karşılaştırıldığında pişmiş ve fermente KTK ile beslenen piliçlerde canlı ağırlık ve yem tüketimi daha yüksek bulunmuştur. Ayrıca kontrol, ezilmiş KTK ve ıslatılmış KTK gruplarından daha iyi yemden yararlanma oranı elde edilmiştir. Pişmiş ve fermente KTK ile beslenen piliçlerde maliyet/kg canlı ağırlık artışı kontrol grubu, ıslatılmış KTK ve ezilmiş KTK ile beslenen gruplardan daha düşük olmuştur. Islatılmış KTK ile beslenen grupta daha düşük olan ham protein sindirilebilirliği dışında, zahiri besin madde sindirilebilirliği değerleri kontrol ve diğer işlenmiş KTK grupları arasında benzer bulunmuştur. Karkas ve organ parametreleri kontrol, pişmiş ve fermente KTK gruplarında daha iyiydi. Sonuç olarak, pişirme ve fermantasyon kauçuk tohumunun besin değerlerini ıslatma ve ezmeye göre iyileştirmiştir. Pişmiş ve fermente KTK ile beslenen piliçler daha iyi performans ve maliyet/kg ağırlık kazancı ile birlikte daha iyi karkas kalitesi göstermişler.

Anahtar Kelimeler: Etlik piliç, karkas, besin madde sindirilebilirliği, performans, işleme, kauçuk tohumu

INTRODUCTION

The importance of increased livestock production in developing countries cannot be overemphasized. The populace need for foods with high biological values such as meat and eggs has become inevitable (1). Animal breeders, nutritionists and poultry producers have roles to play in order to ensure that affordable protein is produced for the ever growing population of the developing countries. However, the escalating cost of production involved as a result of high cost and competition with man and industry for conventional ingredients has not made this possible (2, 3). Recently, animal production is focused at minimizing cost of production and increasing profit without adverse effect or setback on the product produced for the consumer or the public (4, 5). The rising price of livestock feeds and the scarcity of conventional proteins and energy concentrates for the formulation of feeds have forced the animal nutritionists in developing countries to search for attractive, cheaper and readily available protein and energy sources (6, 7). One agro-product of interest is the rubber (*Hevea brasiliensis*) seeds which are very abundant in the Nigeria, where rubber is produced for domestic purposes and for export; thus, the seeds are usually discarded causing environmental hazards (8, 9). The seed meal has been reported to have higher contents

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of digestible nutrients than some conventional seed meals and is highly promising as further protein supplements in livestock and animal diets (9, 10, 11). Previous authors (12, 13) reported on the amino acid composition of rubber seed meal (RSM) showing high contents of arginine, valine and leucine and moderate contents of phenylalanine, threonine and lysine and low content of histidine. Despite its potential as a protein source, the presence of a toxic factor, cyangenic glucoside in seed has been an obstacle to its utilization as a feedstuff (14, 15). This is because the enzymatic hydrolysis of the glycosides by endogenous enzymes occur when the plant tissues is damaged either mechanically or otherwise, thereby liberating hydrocyanic acid (HCN) which is a deadly poison (1, 16). In order for the seed to have a wider acceptability in poultry production, scientists have recommended different methods of processing to reduce the toxic glycoside such as soaking, fermentation and heat treatment (17, 18). However, the information regarding the effect of utilization of the processed RSM in poultry diets is limited. Therefore, this present study was undertaken with the aim to evaluate the effect of differently processing methods of the rubber seed on performance, nutrient digestibility, carcass quality and relative organ weights of broiler chickens.

MATERIALS and METHOD

Study Area

The experiment was performed at the Poultry Unit of the Teaching and Research Farm of the Department of Animal Production Technology, Federal College of Wildlife Management, New-bussa, Niger State, Nigeria.

Source and Processing of Rubber Seed

The experimental rubber seeds were procured from a rubber plantation in Ovia South-West Local Government Area of Edo state, Nigeria. All the raw seeds were collected fresh and divided equally into 4 batches and processed differently. First batch were soaked in cold water inside a closed metal drum for 72 hours followed by draining of the water and sun-drying for 5 days; second batch were cooked in water at temperature of $100^{o}C$ for 45 minutes, drained of the water and sun-dried for 5 days. Third batch were toasted using a metallic frying pan for 45 minutes and the fourth batch were subjected to anaerobic fermentation for 72 hours. All the processed rubber seeds were separately hammer-milled prior to experimental diet formulation to produce the respective meals as soaked RSM (SRSM), cooked RSM (CSRM), toasted RSM (TRSM) and fermented RSM (FRSM).

Experimental Diets

Four experimental diets both for starter (0-21 days) and grower (22-42 days) phases were formulated with the different processed RSM. Diet 1 was purely corn-soybean based (control diet) while the different processed RSM (SRSM, CRSM, TRSM and FRSM) quantitatively replaced soybean meal in the control at 30% dietary level as diet 2, 3, 4 and 5 respectively at both starter and grower stages. The ingredient composition of the experimental starter and grower basal diets is shown in Table 1 and 2 respectively.

Experimental Birds and Management

Use and care of birds and procedures adopted on this study were approved by the Animal Ethics Committee of the Federal College of Wildlife Management, New bussa before the commencement of the experiment. Three hundred (300) 1-day old *Arbor acre* broiler chicks were used for the experiment. The birds were weighed and randomly allotted to each of the five dietary treatments consisting of five replicates with twelve birds each in a completely randomized design. The experiment lasted for 42 days. Each experimental group was offered its corresponding diet *ad-libitum* and they were given free access to clean water. The birds were raised in a deep litter system using wood shavings as litter material in an open sided poultry facility.

Data Collection

A weighed quantity of feed was supplied weekly and left-over was weighed. Feed intake was determined by difference between feed served and the left over. Birds were weighed weekly and weight gain calculated by difference between two consecutive weighing. Feed conversion ratio (FCR) was calculated as the ratio of the feed consumed to the weight gain. The prevailing market prices of feed ingredients at the time of the present study were used to calculate the cost of feed per kilogram.

Metabolic Cage Trial

At the end of the feeding trial, two broilers from each replicate pen were selected randomly for metabolic cage evaluation. The birds were acclimatized for two days before collection of excreta in the cages. Excreta collection was taken daily for a period of five days. Total collection per replicate were pooled, weighed, dried, ground, and representative samples were taken to determine their nutrient compositions. The result was used to calculate the apparent nutrient digestibility coefficient.

Carcass and Organ Evaluation

Three birds were randomly selected from each replicates. Live weight and carcass weight were taken immediately after slaughter. Defeathering follows after dipping in hot water at 70°C for 10 minutes. The cut-parts and visceral organs were manually removed and their weights were taken using electronic sensitive balance and expressed as percentage of the dressed weight.

Chemical Analysis

The differently processed RSM and excreta samples were analyzed for proximate composition according the procedure of AOAC (19). The cyanide contents of the different processed RSM were also analyzed according to alkaline titration method of AOAC (19).

Statistical Analysis

All the data collected was subjected of one-way analysis of variance (ANOVA) using the GLM procedure of SAS (20) for windows software. Tukey test was applied to compare means at P<0.05 level of significance.

Table 1 Ingredients and nutrient composition of experimental diets for starters birds (1-21d)

Feed ingredients	Control	SRSM	CRSM	TRSM	FRSM
Maize	58.50	57.50	57.50	57.50	57.50
Soybean meal	33.00	23.05	23.05	23.05	23.05
Rubber seed meal (RSM)	0.00	9.90	9.90	9.90	9.90
Fish meal	4.00	5.00	5.00	5.00	5.00
Di Calcium Phosphate	2.50	2.50	2.50	2.50	2.50
Limestone	1.00	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25	0.25
Vitamin-Premix[1]	0.25	0.25	0.25	0.25	0.25
DL-Methionine 99%	0.25	0.30	0.30	0.30	0.30
L-lysine HCL 78.9%	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Nutrient composition					
ME (Kcal/kg)	3171.60	3140.80	3163.70	3112.50	3180.60
Crude Protein (%)	23.75	22.86	22.36	22.45	23.26
Crude fat (%)	5.34	6.12	6.23	6.17	6.08
Crude fiber (%)	4.67	4.43	4.78	4.85	4.13

SRSM: Soaked rubber seed meal, CRSM: Cooked rubber seed meal, TRSM: Toasted rubber seed meal, FRSM: Fermented rubber seed meal. [1]Vitamin mineral premix provided (per kg of diet): Vitamin A, 5000 I.U., Vitamin D_3 1000,000 I.U., Vitamin E 15,000 mg; Vitamin K_3, 100 mg; Vitamin B_1, 1,200 mg; Vitamin B_2, 2,400 mg Biotin, 32 mg; Vitamin B_{12}, 10 mg; Folic acid, 400 mg; Choline chloride, 120,000 mg; Manganese, 40,000 mg; Iron, 20,000 mg; Zinc 18,000 mg; Copper, 800 mg; Iodine, 620 mg; Cobalt, 100 mg; Selenium 40 mg.

Table 2 Ingredient composition of experimental diets for grower birds (22-42d)

Feed ingredients	Control	SRSM	CRSM	TRSM	FRSM
Maize	65.50	64.50	64.50	64.50	64.50
Soybean meal	26.00	18.15	18.15	18.15	18.15
Rubber seed meal (RSM)	0.00	7.80	7.80	7.80	7.80
Fish meal	4.00	5.00	5.00	5.00	5.00
Di Calcium Phosphorus	2.50	2.50	2.50	2.50	2.50
Limestone	1.00	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25	0.25
[1]Premix	0.25	0.25	0.25	0.25	0.25
DL-Methionine 99%	0.30	0.30	0.30	0.30	0.30
L-lysine HCL 78.5%	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Nutrient composition					
ME (Kcal/kg)	3278.76	3281.96	3288.76	3211.96	3240.80
Crude Protein (%)	20.38	19.71`	19.24	19.37`	20.15
Crude fat %	6.03	6.39	6.83	6.09	6.43
Crude fiber %	5.77	5.33	5.45	5.33	5.77

SRSM: Soaked rubber seed meal, CRSM: Cooked rubber seed meal, TRSM: Toasted rubber seed meal, FRSM: Fermented rubber seed meal, [1]Vitamin mineral premix provided (per kg of diet): Vitamin A, 5000 I.U., Vitamin D_3 1000,000 I.U., Vitamin E 15,000 mg; Vitamin K_3, 100 mg; Vitamin B_1, 1,200 mg; Vitamin B_2, 2,400 mg Biotin, 32 mg; Vitamin B_{12}, 10 mg; Folic acid, 400 mg; Choline chloride, 120,000 mg; Manganese, 40,000 mg; Iron, 20,000 mg; Zinc 18,000 mg; Copper, 800 mg; Iodine, 620 mg; Cobalt, 100 mg; Selenium 40 mg.

RESULTS and DISCUSSION

Proximate Composition of Fresh and Processed Rubber Seed Meal

The result of proximate composition analysis of fresh and differently processed RSM is presented in Table 3. The moisture content of the raw RSM (4.60%) after undergone the different processing methods was observed to be within the range of values (3.8 – 9.2%) reported by earlier researchers (14, 21, 22). This implies that the moisture content of processed RSM were low enough to be less susceptible to microbial attacks and also will exhibit longer shelf-life characteristic. The CP value of the fresh RSM (33.25%) obtained in this present study was within the range (26 – 34% CP) as reported in literature (9, 21, 23). After processing the seeds, cooking, soaking and toasting reduced the crude protein content of the RSM while fermentation method enhanced its value. The higher CP value of the fermented RSM is in accordance with the result of Ukpebor et al. (14) who reported that increase in protein level is attributable to the utilization of lipid and carbohydrate components of the RSM as carbon sources. However, the marginal drop in CP level observed in both cooked and soaked RSM may be probably due to the fact that cooking and soaking enhances degradation which is associated with solubilization and leaching of some nitrogenous compounds into the processing water (24, 25). The amount of crude fiber was lower in fermented RSM than the values obtained in soaked, cooked and toasted RSM. Values for ether extract and ash were lower in the processed seed meals than the fresh seed indicating that some of these nutrient elements may have been lost during processing of the seeds. Consequently, The energy content of the fresh RSM (4149.14 kcal ME/kg)which falls within the range of values (3850.84 – 4402.73 kcal ME/kg) reported by previous authors (13, 21, 23) was slightly higher in both fermented and cooked RSM than soaked and toasted RSM.

Hydrogen Cyanide Composition of the Fresh and Processed Rubber Seed Meal

Table 4 shows the composition and percentage reduction of hydrogen cyanide (HCN) in the different processed rubber seeds. The result showed that the HCN content of the fresh RSM (315 mg/kg) was lower than the values reported by Okafor and Anyawu (1) and Sharma et al. (22) as 391.60 and 415.10mg/kg respectively but higher than the values as reported by Batel et al. (26) and Eka et al. (15) as 263 and 186 mg/kg respectively. According to previous authors (27, 28), cyanogenic glycoside concentrations can vary widely as a result of genetic and environmental factors, location, season and soil factors. Moreover, reduction in the level of hydrogen cyanide (HCN) was effective with the adopted processing methods and this revealed that cyanide level in the fresh seed decreased by 49.99%, 65.63%, 80.27% and 85.69% for soaking, toasting, fermentation and cooking respectively. The higher level of cyanide reduction obtained in the boiled and fermented processed rubber seeds was in agreement with the reports of earlier researchers (14, 17, 22) who confirmed that heat treatments and fermentation tends to reduce the concentration of HCN in RSM and makes them nutritionally less active.

Performance Characteristics and Cost Implications

The results of the average final weight, average feed intake, average weight gain, feed conversion ratio (FCR) and feed cost per kg gain are presented in Table 5. The average initial weight ranged between 43.79 – 44.82g and did not differ significantly (P>0.05) across the treatment groups. There was a significant difference (P<0.05) in average final weight and daily average weight gain across the treatments. Birds fed cooked RSM and fermented RSM diets recorded similar (P>0.05) body weight gain with those on the control diets but higher (P<0.05) than those fed soaked and toasted RSM diets. The depression in weight gain was most severe in the birds fed soaked RSM than the toasted RSM group. Average feed intake of the birds among the dietary treatments differed significantly (P<0.05) with birds on soaked RSM diet having the lowest feed consumption followed by those on toasted RSM group, whereas both cooked and fermented RSM have comparable (P>0.05) intake with those on the control group. Feed conversion ratio (FCR) was significantly (P<0.05) influenced by the dietary treatments. FCR was higher (P<0.05) in the birds fed soaked and toasted than those that received control, cooked RSM and fermented RSM diets. CRSM and FRSM diets compared favorably with the control group and were lower (P<0.05) than birds fed TRSM and SRSM diets. The poor feed efficiency of birds on soaked and toasted RSM diet is reflected by their low feed consumption and weight gain in this group. The marked reduction in performance of the birds observed with soaked and toasted RSM based diet could be a reflection of the stringent requirement of essential nutrient due to limitation imposed on them by the presence of residual hydrocyanic acid (HCN) as a result of incomplete detoxification. Cyanogenic glycoside on hydrolysis yield toxic hydrocyanic acid (HCN) and cyanide ions inhibit several enzyme systems, reduce growth through interference with certain essential amino acid and thus depressed the utilization of protein (29). It is noteworthy that deleterious factors such as cyanogens when present in animal feed could lead to growth depression as a result of depletion of amino acids of the body when ingested (30, 15). This could be explained due to sulfur-containing amino acids are needed for cyanide detoxification resulting in a condition akin to amino acid imbalance and hence reduced protein synthesis (1, 14). Poor feed efficiency of birds in soaked RSM diet group may be due to the reduced intestinal absorption of amino acids which might be caused by the interference from the residual effect of HCN, consequently leading to reduced protein utilization (22). Nevertheless, cooked RSM were better detoxified followed by fermented RSM relative to other processing methods, which perhaps explains the significant (p<0.05) improvement in growth rate and feed efficiency similar to the maize-soybean control diet. These improvements could be attributed to better protein absorption, higher palatability and availability of the amino acids in the diets due to inactivation of the residual anti-nutritional factors especially HCN (31). The feed cost per kilogram was highest for birds fed control diet (93.43₦/kg) but reduced among the processed RSM diets having the same value as 73.56₦/kg, because of the equal percentage inclusion level of RSM in the experimental diets. Feed cost per kilogram of the dietary treatments decreased with the inclusion of processed RSM due to the higher margin between the market prices and demand of soybean meal compared to RSM. This cumulatively made the cost per kilogram weight gain produced in the control group to be higher (P<0.05) than the processed RSM. The result obtained in this present study is in agreement with the reports of earlier authors who reported that unconventional potential plant protein sources such as RSM will reduce cost of production with better returns (32, 21). Moreover, birds on cooked and fermented RSM produced lower (P<0.05) cost of feed per kilogram weight gain relative to other dietary treatments due to moderate feed cost, favorably weight gain and improved feed efficiency.

Table 3 Proximate composition of raw and different processed Rubber Seed Meal (RSM)

Parameters	Fresh RSM	SRSM	CRSM	TRSM	FRSM
Moisture (%)	4.80	5.01	5.17	4.60	5.60
Crude protein (%)	33.25	30.68	30.37	32.65	34.48
Ether extract (%)	22.27	20.14	20.52	20.77	20.35
Crude fiber (%)	5.61	4.54	4.04	5.25	3.81
Ash (%)	5.34	4.51	5.08	5.17	5.12
NFE (%)	33.53	40.13	40.09	36.16	36.24
ME kcal/kg	4226.66	4193.13	4207.36	4176.18	4212.67

Table 4 Effect of processing techniques on reduction of hydrogen cyanide (HCN) level in rubber seed

Processing methods	mg/kg HCN	% reduction of HCN
Raw	315.89	-
Soaking	167.45	46.99
Cooking	45.21	85.69
Toasting	108.56	65.63
Fermentation	62.34	80.27

Table 5 Growth performance and cost implications of broilers fed differently processed rubber seed meal (RSM) based diets.

Parameters	Control	SRSM	CRSM	TRSM	FRSM	SEM
Initial weight g/bird	43.82	44.72	44.82	43.61	43.79	0.92
Final weight g/bird	2291.76^{a}	1795.65^{d}	2203.11^{ab}	2005.34^{c}	2166.23^{b}	44.06
Daily weight gain g/bird	53.52^{a}	41.69^{c}	51.39^{a}	46.71^{b}	50.53^{a}	1.61
Daily feed intake g/bird	76.07^{a}	70.28^{c}	74.49^{a}	72.89^{b}	73.93^{ab}	1.10
FCR	1.42^{c}	1.69^{a}	1.45^{bc}	1.56^{b}	1.46^{bc}	0.06
Feed cost/kg (₦*)	98.43	73.56	73.56	73.56	73.56	-
Feed cost/kg gain (₦*)	139.90^{a}	124.01^{b}	106.63^{c}	114.80^{c}	107.62^{c}	4.10

$^{a, b, c}$Mean values on the row with different superscripts are significantly different (P<0.05). *Naira (N) to US Dollars is 254:1.

Table 6 Nutrient digestibility coefficients of broiler chickens fed different processed rubber seed meal (RSM)

Parameters	Control	SRSM	CRSM	TRSM	FRSM	SEM
Dry matter (%)	71.76	70.55	71.45	72.96	72.76	1.87
Crude protein (%)	74.65^{a}	55.86^{c}	72.54^{a}	67.54^{b}	70.07^{ab}	2.12
Crude fiber (%)	43.97	40.08	43.47	42.17	44.20	2.10
Ether extracts (%)	75.86	71.07	76.56	74.07	74.87	7.14
NFE (%)	64.78	62.90	64.55	63.91	66.02	1.80

$^{a, b, c}$ Mean values on the same row with different superscripts are significantly different (P<0.05)

Table 7 Carcass traits and prime cut parts of broiler chickens fed differently processed rubber seed meal (RSM) based diets

Parameters	Control	SRSM	CRSM	TRSM	FRSM	SEM
Live weight g/bird	2211.39^{a}	1879.45^{c}	2162.18^{ab}	1989.63^{b}	2159.86^{a}	28.02
Dressing weight g/bird	1651.50^{a}	1300.63^{c}	1619.20^{a}	1409.13^{b}	1629.06^{a}	17.98
Dressing %	74.68^{a}	69.20^{b}	74.89^{a}	70.85^{b}	75.46^{a}	0.86
Breast cut %	12.04^{a}	8.98^{c}	11.97^{a}	10.07^{b}	11.46^{a}	0.56
Thigh cut %	10.47^{a}	6.13^{c}	10.20^{a}	7.38^{b}	9.40^{a}	0.54
Drumstick cut %	14.50^{a}	9.86^{c}	13.93^{ab}	10.91^{c}	12.89^{b}	0.31
Wing cut %	7.58	6.19	7.38	6.42	6.98	0.70
Back cut %	7.56	6.97	7.51	7.15	7.41	0.30
Abdominal fat %	1.60	1.88	1.75	1.91	1.77	0.16

^{abc} Means within the same row with different superscripts are significantly different (P<0.05).

Table 8 Organ weights (g) expressed as a percentage dressed weight of differently processed rubber seed meal (RSM) in broilers diet (0 – 42 days)

Parameters	Control	SRSM	BRSM	TRSM	FRSM	SEM
Liver	2.22^{b}	3.34^{a}	2.27^{b}	3.14^{a}	2.12^{b}	0.41
Gizzard	4.54	5.01	4.26	4.16	5.05	0.46
Heart	0.91	0.79	0.86	0.83	0.85	0.08
Kidney	0.86^{b}	1.59^{a}	0.91^{b}	1.43^{a}	0.96^{b}	0.22
Proventiculus	0.69	0.74	0.76	0.81	0.78	0.07
Intestine	3.28	3.15	4.09	3.68	3.47	0.51
Spleen	0.16	0.12	0.18	0.11	0.15	0.04

^{ab} Means within the same row with different superscripts are significantly different (P<0.05).

Nutrient Digestibility

The result of apparent nutrient digestibility of birds fed different processed rubber seed meal is shown in Table 6. Statistical analysis showed that except for crude protein (CP), other nutrient variables did not differ significantly (P>0.05) among the control and different processed RSM diets. CP digestibility was lower (P<0.05) in birds fed soaked RSM (55.86%) diet while birds fed diets containing cooked RSM (72.54%) and fermented RSM (70.07%) were similar (P>0.05) with those on control diet (74.65%). The lower CP retention of birds fed soaked RSM diet could be attributed to the presence of residual HCN due to ineffectiveness of soaking to completely inactivate the effect of this anti-nutrient in the seeds. This observation is accordance with the report of Amaefule and Nwagbara (33) that soaking of legume seeds is less efficient in the removal of anti-nutritional substances. Residual cyanide has been reported to depress protein digestibility because dietary methionine could be mobilized via the rhodanese pathway for cyanide detoxification to the innocuous thiocyanate (34). In such circumstances, dietary protein quality is compromised, resulting in poor protein digestibility hence poor protein utilization (35). The improved protein digestibility of the birds in cooked and fermented RSM groups may be associated with the beneficial effect of cooking and fermentation, which enhanced the nutritional value of rubber seeds (36).

Carcass Qualities

Table 7 shows the carcass traits of broiler chicken fed various processed RSM based diets. The carcass characteristics of the birds were significantly (P<0.05) affected by the dietary treatments. The birds on the control group have the highest (P<0.05) live body weight and dressed weight which was similar to those on cooked and fermented RSM group. Lower (P<0.05) live body and dress weight was recorded in the group fed soaked RSM diet followed by the toasted RSM group. Dressing percentage was within the range of 75.46% to 69.20%, where the birds on fermented RSM group had the highest (P<0.05) mean value and those on soaked RSM diet gave the lowest value. The lower (P<0.05) dress weight of broilers fed the soaked RSM diets followed by those on toasted RSM diet resulted from their smaller live weight, since the surface area and the weight determine the amount of feathers and visceral organs required respectively (37). The inferior carcass growth response observed in birds fed soaked RSM diet could be attributed to inhibitory activity of the residual toxic factors on nutrient utilization which were unable to be inactivated by soaking (38, 39). The percent weight of drumstick, thigh and breast were comparable (P>0.05) among the control, cooked RSM and fermented RSM group and this may be an indication that boiling and fermentation of the rubber seeds have a positive influence on the carcass yield of the broiler chickens as reflected by their higher dressed percentage, indicating better edible portion of live weight contrary to inedible offals (40). Besides, the reduction in cyanide concentration by cooking and fermentation is an indication of enhanced efficiency of protein utilization in the birds, which can be assessed by its availability for tissue disposition (22). Since improved carcass yield is an indication of the quality and utilization of the ration (41), it would seem that birds on cooked and fermented RSM diets efficiently utilized their feed as evidenced by their higher (P<0.05) dressed weight, breast, thigh and drum stick cuts weight comparable to the control group. However, the poorer carcass yield shown by soaked RSM group could be due to impairment in utilization of nutrients attributed to residual cyanide activity (35).

Relative Organ Weights

The relative organ weights expressed as percentage dressed weight of broilers chickens fed different processed RSM are shown in Table 8. The results showed that with the exception of liver and kidney, all other parameters evaluated were not significantly (P>0.05) affected by the different processing methods. The control group has a comparable liver weight with both cooked and fermented RSM groups and were lower (P<0.05) compared to the toasted and soaked RSM group. Liver size is known to increase in response to several factors, especially deficiencies of protein and amino acids, associated with residual ANFs which have the ability to interfere with normal production of liver protein, impairing liver function and generating hypertrophic effect, resulting in an increase in liver weight (31, 34). The mean values obtained for weight of kidney were higher (P<0.05) in birds fed soaked and toasted RSM diets than in other dietary treatments. The increase in kidney weight is in agreement with the findings of Ologhobo et al, (42) who attributed the observation to the fact that the key enzyme in cyanide detoxification (Rhodenase) is located mainly in the kidney and therefore, the increase in the enzyme activity might have led to an increase in the weight of the kidney. Liver and kidney are known to be the major detoxification organs and an increase in activities of these organs due to detoxification of residual anti-nutrients, hence will lead to an enlargement in the weights of these organs (43). Thus, lower (P<0.05) relative liver and kidney weights of birds fed diets containing cooked and fermented RSM than those on soaked and toasted RSM diets is in confirmation to the effect of the degree of percentage reduction of HCN by the adopted processing methods.

CONCLUSION

The results of this study revealed that cooking and fermentation were effective in improving the nutritive value of rubber seed meal, hence caused substantial reduction in the level of anti-nutritional factors especially hydrogen cyanide contained in the seeds followed by toasting while soaking was observed to be less effective. Therefore, birds fed cooked and fermented RSM diets showed improvement in feed intake, weight gain, feed conversion ratio, crude protein digestibility and carcass qualities at higher saving in terms of cost per weight gain.

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