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Performance of broiler chicken fed diets containing mango (*Mangifera indica*) fruit reject pulp mixed with maize offal

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Abstract

A number of alternative feedstuff that are affordable and profitable for use in developing countries for animal feeding have been identified and reported. However, some of these alternative feedstuff have low nutrient density, and some with high nutrient density are difficult to process and or preserve. However, it is reported that two different alternative feedstuff could be mixed to improve the nutrient density of the mixture, and be preserved better at the same time. Mango fruit reject pulp has high energy content but cannot be easily sundried and preserved alone, except a carrier is involved. Four (4) experiments were conducted to determine the proximate composition and energy content of mango fruit reject pulp-maize offal mix meal (MFRP-MO); effects of MFRP-MO on growth performance and economics of productions for starter and finisher broiler chickens, carcass characteristics, internal organs and gastro-intestinal tract (GIT) morphometry of finisher broiler chickens. Mango fruit rejects pulp-maize offal mix meal (MFRP-MO) partially replaced maize at 0, 20, 40, 60, and 80% respectively to produce diets coded T1 (0%), T2 (20%), T3 (40%), T4 (60%), T5 (80%), and T1(0%). One hundred and eighty (180) day-old Marshall broiler chicks were grouped into five, with each group replicated three times and a replicate contained 12 birds in completely randomized design (CRD); which were exposed to the diets in a feeding trial that lasted for 28 and 49 days for starter and finisher phases respectively. MFRP-MO contained 9.63% CP, 68.38% NFE and 3320. 41kcal/kg ME. Results of mean growth performance parameters for starter and finisher phases declined from 40% and 20% MFRP-MO respectively on parameters including final weight, daily weight gain and FCR. Economic indices were better at 80% MFRP-MO mix replacement of maize; the cost per kg weight gain steadily declined. Percentage feed costs were 32.36 to 39.92% and 53.50 to 62.75% for starter and finisher respectively. The dress percent, major carcass cuts and internal organs were not significantly different. With the exception of large intestine length, which was not significantly different ($p<0.05$), caeca and small intestine varied in opposite directions: small intestine decreased, while caeca increased as MFRP-MO mix increased. It was concluded that 20% replacement of maize by MFRP-MO mix was optimal for both starter and finishing broiler chickens' growth but 60% was more economical and 60% MFRP-MO mix was recommended.

Keywords: mango fruit, maize offal, growth, carcass, economics, internal organs

Introduction

Fruits by-products are reported to contain high nutrients than other by products because such by-products sometimes retain their nutrients though no longer suitable for human consumption (Orayaga *et al*., 2017). Among the fruits' by-products, mango has received attention in the recent time, with successful on-farm processing and incorporation into animal diets (Orayaga *et al*., 2016; Orayaga and Sheidi, 2018; Orayaga and Apeaule, 2018). Mango fruit reject meal is gotten from rejected mango fruits that are not over ripe; which are usually processed by slicing, sun-drying and milling, and have been used successfully in broiler chicken (Orayaga *et al*., 2015), quail (Orayaga and Apeaule, 2018; Orayaga and sheidi, 2018), rats (Orayaga *et al*., 2016), and rabbit (Orayaga, 2016; Orayaga *et al*., 2018) diets. Mango fruit reject could be obtained in large amounts because world mango production figure (39m tones) is quite high (FAO, 2014) and the waste arising from mango fruit processing is high (50%); rejected mango fruits inclusive. Contributing further to the abundance of mango fruit waste is the fact that many developing countries do not have the requisite technology to convert the fruit to processed-products for a longer shelf life, resulting to huge losses during its peak production season. Orayaga (2016) reported that mango fruits are rejected for many reasons: bruises, infestations, activities of birds, children attack on the fruits, premature fruit-fell because of wind, and poor taste fruits of a tree stand for whatever reason. This rejected fruits litter the ground during its season causing a negative environmental pollution.

The on-farm technology of slicing and sun-drying rejected half-ripe has been successful in the tropics (Orayaga *et al*., 2015; Orayaga *et al*., 2017). However, applying the same technology and techniques to over-ripe rejected mango fruit could not produce the desired product as was with the half-ripe mango fruit. Nevertheless, an on-farm technology of using a carrier reported by Ikurior (1995) could work. In his report, brewers' yeast slurry, which could not be easily sun-dried was successfully dried when cassava peel meal served as a carrier to the yeast slurry. A carrier such as maize offal is both cheap and available (Makinde and Soniaya, 2011; Onakpa *et al*., 2011). Maize offal is a by-product of maize processing industries, including starch and ethanol production and production of maize-based foods. While maize bran theoretically consists of the coating removed in the early stages of processing, the maize offal sold for livestock feeding is usually a mixture of the bran fraction and other pieces of maize grain that detach from the grain in the course of processing and is therefore a very loose defined product of highly variable composition (Kalscheur *et al.,* 2012). This maize offal contains about 2500Kcal ME/kg and a crude protein percentage of 11 (Aduku, 2004). This energy is low compared to maize. This is because maize offal has higher level of fibre than maize (NIAS, 2019). Mango fruit reject pulp on the other hand has high energy density with low fibre content (Orayaga and sheidi, 2018). Mixing mango reject pulp with maize offal has the potential of increasing the energy density of the mixture by lowering the fibre content of maize offal and increasing the nitrogen-free extract; making the mixture have the energy equivalent of maize should appropriate combination be done.

The aim of the study was therefore to investigate the effect of mixing mango fruit reject pulp with maize offal on the nutrient characteristics of the mixture and effect on performance of broiler chickens.

Materials and methods

Experimental site

The study was carried out in Makurdi town, the capital of Benue state which is located on latitude 7° 43' and Longitude 80 3' E (Google map, 2019). The Benue floodplain is between 0 m to 100m above sea level. The area is warm, characteristic of tropical climate with a minimum temperature of 24.20 + 1.40°C and maximum temperature of 36.33 + 3.70°C (TAC, 2011). From February through April, temperatures may reach 35°C to 40°C in Makurdi town. Rainfall is between 508 and 1016mm, and the relative humidity is between 39.50 + 2.20 and 64. 00 + 4.8% and mean wind speed of 2.47 knot/second North-East (TAC, 2011).

Preparation of mango fruit reject pulp-maize offal mix meal

The well-ripe mango fruit rejects (Plate 1), test ingredient, were collected free of monetary cost from mango tree stands and waste sites of fruit markets around Makurdi town with no consideration to particular variety in its season; onset of March and May ending. The composite comprised of different varieties; exotic and local mango fruits rejects were collected and cleaned using dry piece of cloth. The pulp (Plate 2) was manually extracted after the peels were removed and brushed the pulp into a container. The extracted pulp was kneaded with the palms of the hand, thoroughly and evenly mixed with maize offal (Dusa) in a ratio of 1:1 w/w. The mixture was sun dried for three days by spreading it on polyethylene sheets and frequently breaking the lumps by scrubbing in between the palms to obtain an even mixture until moisture of less than 10% was achieved (Plate 3). The sun dried material was stored in polyethylene bags and kept safe to the time it was used. Before the mango fruit rejects pulp-maize offal mix (MFRP-MO) was incorporated into the broiler chicken diets, it was first milled using corn milling machine to obtain mango fruit rejects pulp-maize offal (MFRP-MO) meal, which was subjected to proximate analysis using standard procedures (AOAC, 2015).

The preparation of experimental diets

Five diets were prepared in which MFRP-MO mix partially replaced maize at 0, 20, 40, 60, and 80% respectively to produce diets T1 (0%), T2 (20%), T3 (40%), T4 (60%), T5 (80%), and 0% served as control (table 1 and 2).



Plate 1: MFR **Plate 2: MFRP** **Plate 3: MFRP-MO**

MFR = mango fruit rejects; MFRP = mango fruit reject pulp; MFRP-MO = mango fruit reject-maize offal mix

Table 1: Composition of MFRP-MO based diets for starter broiler chicks

Ingredient (%)	Replacement levels of MFRP-MO				
	T1	T2	T3	T4	T5
	0%	20%	40%	60%	80%
Maize	52.50	42.00	31.50	21.50	10.50
MFRP-MO	0.00	10.50	21.00	31.50	42.00
Soyabean Meal	35.50	35.50	35.50	35.50	35.50
BDG	5.00	5.00	5.00	5.00	5.00
Blood Meal	3.00	3.00	3.00	3.00	3.00
Bone Ash	3.00	3.00	3.00	3.00	3.00
Common Salt	0.25	0.25	0.25	0.25	0.25
Methionine	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20
VMP	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated Nutrients					
Energy (MEkcalkg^{-1})	2845.25	2790.00	2782.01	2767.43	2750.45
Crude Protein	24.11	24.23	24.28	24.40	24.50
Crude Fibre	3.81	4.10	4.40	4.50	5.01
Ether Extract	3.74	4.21	4.50	4.70	5.23
Methionine	0.60	0.63	0.63	0.63	0.64
Lysine	1.33	1.34	1.34	1.35	1.35
Calcium	1.30	1.33	1.40	1.44	1.49
Phosphorous	0.80	0.83	0.85	0.90	0.92

MFRP-MO= Mango fruit reject pulp-maize offal mix, VMP= vitamin-mineral premix, BDG= brewers' dried grain

Table 2: Composition of MFRP-MO based diets for finisher broiler chickens

Ingredient (%)	Replacement levels of MFRP-MO				
	T1	T2	T3	T4	T5
	0%	20%	40%	60%	80%
Maize	60.05	47.93	36.03	24.02	12.01
MFRP-MO	0.00	12.12	24.02	36.03	48.04
Soyabean Meal	28.00	28.00	28.00	28.00	28.00
BDG	6.00	6.00	6.00	6.00	6.00
Blood Meal	2.00	2.00	2.00	2.00	2.00
Bone Ash	3.00	3.00	3.00	3.00	3.00
Common Salt	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20
VMP	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated Nutrients					
Energy (MEkcalkg^{-1})	2954.22	288.02	2870.80	2858.05	2846.40
Crude Protein	21.01	21.03	21.08	21.13	21.15
Crude Fibre	4.00	4.13	5.05	5.40	5.90
Ether Extract	3.75	4.00	4.45	4.80	5.03
Methionine	0.56	0.56	0.57	0.57	0.58
Lysine	1.20	1.22	1.22	1.23	1.1.23
Calcium	1.35	1.37	1.40	1.45	1.49
Phosphorous	0.80	0.82	0.85	0.86	0.88

MFRP-MO= Mango fruit reject pulp-maize offal mix, VMP= vitamin-mineral premix, BDG= brewers' dried grain

Table 3: Effects of MFRP-MO based diets on growth performance of starter broiler chicks

Parameter (g)	Replacement levels of MFRP-MO					SEM	P
	T1 0%	T2 20%	T3 40%	T4 60%	T5 80%		
Initial weight	44.44	44.81	44.44	44.44	44.81	-	-
Final weight	1055.56[a]	970.37[ab]	912.59[bc]	875.00[c]	853.52[c]	27.36	0.00
ATWG	1011.12[a]	925.56[ab]	868.15[bc]	830.56[c]	808.7[c]	27.39	0.00
ADWG	36.10a	33.06a	31.01bc	29.6c	28.88c	0.98	0.00
ATFI	1692.96	1654.08	1637.04	1615.85	1637.96	51.59NS	0.93
ADFI	60.46	59.07	58.46	59.09	58.49	2.34NS	0.87
FCR	1.67[c]	1.79[bc]	1.89[b]	1.99[a]	2.02[a]	0.05	0.00
ADPI	14.51	14.18	14.03	14.72	14.04	0.56NS	0.87
PER	2.49	2.33	2.21	2.03	2.06	0.08NS	0.01
PCE	1.69	1.65	1.64	1.65	1.64	0.05NS	0.94

[abcd] means on the same row with different superscript is significantly different($p<0.05$), SEM= standard error of mean, NS= not significant, P= probability level, MFRP -MO=mango fruit reject pulp -maize offal mix, ATWG= average total weight gain, ADWG= average daily weight gain, ADFI= average daily feed intake, FCR= feed conversion ratio, ADPI= average daily protein intake, PER= protein efficiency ratio, PCE= protein conversion efficiency

Table 4: Effects of MFRP-MO based diets on growth performance of finisher broiler chickens

Parameter (g)	Replacement levels of MFRP-MO					SEM	P
	T1 0%	T2 20%	T3 40%	T4 60%	T5 80%		
Initial wt	44.44	44.81	44.44	44.44	44.81	-	-
Final wt	2215.88[a]	1979.35[b]	1961.48[b]	1830.16b[c]	1746.67[c]	46.37	0.000
ADWG	44.31[a]	39.48[b]	39.12[b]	35.76[c]	34.73[c]	0.80	0.000
ADFI	97.84	95.20	94.64	93.71	94.80	1.25 NS	0.264
FCR	2.21[c]	2.41[b]	2.42[b]	2.62[a]	2.73[a]	0.04	0.000
ADPI	20.55	19.99	19.87	19.68	19.91	0.26 NS	0.264
PER	2.16[a]	1.98[b]	1.97[b]	1.81[c]	1.75[c]	0.03	0.000
ATWG	2171.44[a]	1934.54[b]	1917.04[b]	1752.38[c]	1701.85[c]	39.21	0.000

[abc] means on the same row with different superscript is significantly different($p<0.05$), SEM= standard error of mean, P= probability level, NS= not significant, MFRP -MO=mango fruit reject pulp -maize offal mix, ADFI=average daily feed intake, FCR= feed conversion, ADPI= average daily protein intake, ATWG= average total weight gain

Table 5: Effects of MFRP-MO based diets on economics of production of starter broiler chicks

Parameter (N)	Replacement levels of MFRP-MO					SEM	P
	T1 0%	T2 20%	T3 40%	T4 60%	T5 80%		
CKgD	136.62	126.53	116.44	106.89	96.27	-	-
CFC	231.31[a]	211.28[ab]	195.12b[c]	182.54[cd]	166.27[d]	6.61	0.00
CPDC	220	220	220	220	220	-	-
Other costs*	128	128	128	128	128	-	-
Total cost	578.67[a]	558.64[ab]	542.48b[c]	529.81[cd]	513.63[d]	6.62	0.00
CKgG	229.03	228.78	225.40	219.35	205.55	5.81 NS	0.82
Revenue	844.45[a]	776.29[a]	730.07[ab]	684.15[b]	578.67[ab]	50.09	0.03
Profit	265.78[a]	217.65[ab]	187.59[b]	170.19[b]	169.19[b]	18.14	0.01
C-B ratio	2.18	2.59	3.03	3.20	3.05	8.98 NS	0.14
%FC	39.92[a]	37.82[ab]	35.95[bc]	34.45[cd]	32.36[d]	0.74	0.00
%DC	38.05[d]	39.38[cd]	40.57[bc]	41.53[ab]	42.84[a]	14.76	0.00
%other cost	22.03[d]	22.79[cd]	23.48[bc]	24.04[ab]	24.80[a]	8.54	0.00

[abcd] means on the same row with different superscript is significantly different($p< 0.05$), SEM= standard error of mean, P= probability level, NS= not significant CKgD= cost per kg diet, CFC= cost of feed consumed, CKKG= cost per kg gain, C -B = cost-benefit, FC= feed cost, DC=day -old cost, MFRP -MO=mango fruit reject pulp -maize offal mix, o ther costs*= cost of housing, litter material, feeders, drinkers and medication

Table 6: Effects of MFRP-MO based diets on economics of production o finisher broiler chickens

Parameter (N)	Replacement levels of MFRP-MO					SEM	P
	T1	T2	T3	T4	T5		
	0%	20%	40%	60%	80%		
Cost kg^{-1} diet	131.81	117.87	104.89	90.38	76.56	-	-
CFC	654.87[a]	590.48[b]	539.89[c]	490.98[d]	447.33[e]	7.22	0.000
CPDC	220	220	220	220	220	-	-
Other costs	168.66	168.66	168.66	168.66	168.66	-	-
Total cost	1043.53[a]	979.14[b]	938.55[c]	879.64[d]	835.99[e]	7.22	0.000
Cost kg^{-1}gain	301.93[a]	305.36[a]	281.79[b]	280.41[b]	262.82[c]	4.11	0.000
Revenue	1773.33[a]	1584.00[b]	1568.00[b]	1437.33[c]	1394.67[b]	30.85	0.000
Profit	741.81a	604.86[b]	639.45[b]	557.69[b]	558.67[b]	36.02	0.003
C-B ratio	1.41	1.63	1.45	1.59	1.50	0.06 NS	0.155
%FC	62.75[a]	60.30[b]	58.14[c]	55.81[d]	53.50[e]	0.32	0.000
%day-old cost	21.09[e]	22.47[d]	23.69[c]	25.01[b]	26.32[a]	0.18	0.000
%other costs	16.16[e]	17.23[d]	18.16[c]	19.18[b]	20.18[a]	0.14	0.000

[abc] means on the same row with different superscript is significantly different(p< 0.05), SEM= standard error of mean, P= probability level, NS= not significant, CFC= cost of feed consumed, CKKG= cost per kg gain, C -B = cost -benefit, FC= feed cost, DC=day-old cost, MFRP-MO=mango fruit reject pulp-maize offal mix

Table 7: Effects of MFRP-MO based diets on carcass characteristics of finisher broiler chickens

Parameter (%)	Replacement levels of MFRP-MO					SEM	P
	T1	T2	T3	T4	T5		
	0%	20%	40%	60%	80%		
Fasted wt (g)	2200.00[a]	1950.00[b]	1966.67[b]	1800.00[c]	1750.00[c]	47.14	0.00
Bled wt	96.19	94.85	94.91	95.31	92.56	1.82 NS	0.53
plucked wt	92.75	91.18	92.40	90.88	87.07	1.82 NS	0.32
Evisc. wt	82.96[a]	79.94[ab]	81.78[ab]	76.75[b]	77.18[b]	0.83	0.01
Dressed wt	75.12	69.19	74.60	68.68	75.99	1.38 NS	0.26
Breast	27.93	25.81	28.38	26.31	27.84	0.79 NS	0.53
Thigh	11.81	10.78	11.01	11.04	10.81	0.40 NS	0.51
Drum stick	11.40[a]	10.59[ab]	10.42[ab]	9.81[b]	9.58[b]	0.29	0.01
Back	9.86	9.74	9.53	8.31	8.86	0.44 NS	0.14
Neck	5.53	5.43	5.46	5.05	5.24	0.46 NS	0.93
Wing	7.98	8.40	8.71	8.65	8.90	0.37 NS	0.46
Shank	3.89	3.89	3.43	4.17	3.78	0.25 NS	0.54
Head	2.26	2.19	2.17	2.29	2.07	0.24 NS	0.72

[abc] means on the same row with different superscript is significantly different(p< 0.05), SEM= standard error of mean, P= probability level, NS= not significant, MFRP-MO=mango fruit reject pulp-maize offal mix

Table 8: Effects of MFRP-MO based diets on internal organs and GIT morphometry of broiler chickens

Parameter (%)	Replacement levels of MFRP-MO					SEM	P
	T1	T2	T3	T4	T5		
	0%	20%	40%	60%	80%		
Gizzard	1.62	1.94	1.92	1.68	1.83	0.34	0.54
Liver	1.95	1.66	1.73	2.08	1.91	0.24	0.14
Lungs	0.52	0.60	0.50	0.45	0.61	0.27	0.60
Spleen	0.19	0.53	0.15	0.17	0.17	0.21	0.86
Pancrease	0.22	0.23	0.24	0.28	0.29	0.13	0.19
Gall	0.17	0.21	0.21	0.20	0.20	0.54	0.83
Kidney	0.43	0.35	0.26	0.32	0.35	0.29	0.42
Proventriculus	0.34	0.43	0.37	0.47	0.40	0.20	0.35
Heart	0.43	0.43	0.33	0.39	0.38	0.12	0.10
GIT	250.13	263.23	253.13	239.80	235.43	11.95	0.52
Small intestine	80.77[a]	79.97[ab]	79.17[ab]	76.37[c]	77.83[bc]	0.56	0.20
Large intestine	4.97	5.00	4.90	5.10	4.73	0.39	0.87
caeca	14.30[c]	15.03[c]	15.97[bc]	18.47[a]	17.47[ab]	0.44	0.00

[abc] means on the same row with different superscript is significantly different(p< 0.05), SEM= standard error of mean, P= probability level, MFRP-MO=mango fruit reject pulp-maize offal mix

Experimental procedure, design and management of birds

A total of 180 day-old Marshall Broiler Chicks were obtained from Zartech Hatchery Farm in Jos, Plateau State, Nigeria for the study. Prior to the arrival of the birds, the poultry house was thoroughly cleaned, washed and disinfected using detergents and izal solution. The feeders and drinkers were likewise washed and disinfected for optimum hygienic environment. On arrival, the chicks were all weighed using electronic digital scale and randomly allocated to five dietary treatments having 3 replicates each and each of the replicate had 12 birds, in a completely randomized design (CRD). The day-old chicks were brooded for a period of three weeks, according to standard procedures (Oluma, 2011), and data was collected concurrently. The birds were raised in a deep litter half-walled house, having its upper half covered with wire mesh. Feed and water were served *ad libitum* throughout the experimental periods; 28 days at starter and 49 days; day-one to end of experiment. Routine medications and vaccinations were carried out to ensure proper health of the birds. The birds were all vaccinated against Newcastle disease with the use of lasota vaccine in lime water intra-occularly at day one, then against infectious bursal disease (Gumboro) with the use of Gumboro vaccine which was administered orally (in drinking water) at day 14 and finally lasota was given at day 21 orally through drinking water as recommended by NVRI VOM (2019).

Data collection on growth performance

Data for initial live weight of the birds were taken by weighing birds before introducing them to the experimental diets. Subsequently, weekly live weight and feed intake were recorded while daily weight gain and daily feed intake were determined by dividing their totals against the number of days that the feeding trial was conducted; 28 for starter phase and 49 days for finisher phase. At the end of the experiment, the total feed intake and the total weight gain were calculated and the feed conversion ratio was determined by dividing the total feed intake by the weight gain,

Economics of production

Economic parameters namely cost per kg diet, cost due to feed consumed, other costs (cost of drinkers, feeders, hosing, drugs, litter, source of heat), cost per kg gain, total cost, revenue, benefit, cost/benefit ratio, percentage feed cost, percentage day old cost, and percentage other costs were determined as outlined by Orayaga *et al*. (2015).

Carcass evaluation

Carcass yield: Prior to the termination of the experiment, three chickens per treatment, one per replicate, having the weight of the replicate's average were fasted of feed for 18hrs. After that, the animals were bled and the carcass evaluated as described by Aduku and Olukosi (2000) and the Canadian Meat Inspection Agency (2017). Carcass was separated into the cuts namely breast, thigh, drum stick, wing and back; offals namely shank, head and fats and internal organs including heart, liver, spleen, gall, pancrease, gizzard, proventriculus, lungs and kidney. The gastro-intestinal tract (GIT) morhometry components; small intestine, large intestine, and caeca, were also examined.

All parts were weighed using a sensitive digital scale.

Data analysis

Data generated were subjected to analysis of variance using statistical software [SPSS, 2004], which was configured to automatically separate means that were significant. Data in percentages were first transformed using arcsin transformation before subjecting them to statistical analysis.

Results and discussion

Results of the proximate constituents of MFRP-MO showed that it contained 5.54% moisture, 9.63% crude protein, 5.05% crude fibre, 6.56% ether extract, 4.84% ash, and 68.38% nitrogen free extract. Metabolizable energy; calculated from the proximate components using the formula of Pauzenga (1989) was 3320.41 kcal/kg ME. The 9.63% CP of MFRP-MO mix was similar to that of maze, whole grain (9%) as reported by NIAS (2019), while the energy was lower than 3420 kcal/kg in maize (Aduku, 2004) but similar to 3300 kcal/kg reported by NIAS (2019;). The high protein content of the mixture is not likely the consequence of mixing maize offal,12% CP, (Aduku, 2004) and mango fruit reject pulp, 3.8% CP, (Orayaga and Sheidi, 2018) but most probably an interplay of microbes inoculated via chance, which multiplied during the drying period, increasing the CP of the mixture. Chance fermentation has also been reported to increase crude protein level in feed materials (Orayaga *et al*., 2015). The mixture had higher fat and fibre in comparison to maize; but lower than that of maize offal. It is expected as such, since maize offal has higher fat and fibre, when mixed with mango fruit reject pulp with lower fat and fibre, the mixture had these proximate constituents in-between; being above mango fruit reject pulp and below maize offal. This mixture by chemical composition has the potential to replace maize in broiler chicken diets. Result of growth performance of the broiler chicks is presented in Table 3 and that of the finisher broiler chicken is in table 4. For the starter phase, daily feed and protein intakes and protein efficiency ratio (PER) were not significantly different ($P>0.05$) among treatment groups. Average final body weight, daily body weight gain and FCR were however significantly lower ($P<0.05$) from T3 (40% MFRP-MO) upward. The final body weight of 28-days chicks was higher than 436.22g to 564.93g reported by Orayaga *et al.* (2015) when broiler chicks were fed diets containing mango fruit reject meal and 725g final weight reported by Ekenyem *et al.* (2006) when broiler chicks were fed with commercial diets. Comparing this growth performance result to previous reports, the performance of the birds was undoubtedly high across the treatment groups. Though the diets were all sufficient in protein and some other essential nutrients, as the level of MFRP-MO increased, ME decreased. This is likely the reason why growth performance parameters of Final weight, weight gain and FCR declined with increase in MFRP-MO. It is also likely that nutrient utilization was reduced by increase in fibre occasioned by increase in MFRP-MO. High fibre is implicated for reduced utilization of nutrients by monogastric animals (Aduku, 2004). In another perspective, Orayaga *et al.* (2018) opined that in as much as mango fruit is known to convert its acids to sugars at ripening, this biochemical process is effective when normal ripening takes place. For rejected mango fruits, ripening does not always follow the normal process, making even the seemingly overripe mango fruit to retain most of the acids in large amounts; the reason it still tastes sour and could cause lesser performance of the chicks as some of these acids are anti-nutritional. Sour taste alone may not be an impediment to feed intake of broiler chickens but somehow, these acids; some been anti-nutritional, may have affected feed utilization; which is why the FCR though within a very good range across the treatments, steadily declined significantly. Even the feed intake, though not significantly affected; tended to decline steadily.

Just like the starter phase, Final weight, weight gain and FCR declined with increase in MFRP-MO at the finisher phase including PER which did not vary at the starter phase. The decline became stronger at the finisher phase; from 20% and above, leaving the control superior to the rest of the treatment groups. Feed and protein intakes were not significantly different (P>0.05) as in the starter phase. The broiler chickens's taste may not have been affected by the test material resulting to similar consumption across treatment groups.

The stronger significant difference at the finisher level suggest that increase in fibre might not be the reason for variation in performance since finisher birds should handle fibre better than starter (Orayaga *et al*., 2016). Presence of acids becomes more culpable, most likely because more of the acids which were anti-nutritional, were consumed more in quantity, thereby imparting more conspicuously on them. As stated concerning the general performance of the starter, the decline in weight performance of the finisher broiler chickens did not discount the usefulness of the test material since it also supported growth such that birds could attain above 1.6kg in seven weeks; a table weight for birds of eight weeks (Oluyemi and Robberts, 2000), and even much better than some previous reports. Finisher broiler weight of 1746.67g to 2215.88g in this study were still superior to 1549.70 to 1715.24g reported by Makinde and Soniaya (2011) when broiler chickens were fed diets containing maize bran-blood meal mixture, and 1308.43g to 1752.84g reported by Nnenma *et al*. (2006). These results were similarly reflected in respective weight gains and FCR.

Economics of production as presented in table 5 showed a steady reduction in cost per kg diet as MFRP-MO increased in diet. The cost of feed consumed, total cost, revenue, profit, % feed cost, % day old cost and % other costs were significantly different (P<0.0); cost of feed consumed, total cost, profit and percentage feed cost declined from 40%, revenue declined from 60% and percentage day-old and other costs increased right from 20% MFRP-MO. Cost per kg gain and cost-benefit ratio were not significantly different (P>0.05) among treatment groups. However, they both followed definite patterns with the former steadily declining as the latter steadily increased; which could not be ignored as chance happening. The steady decline (significant or not on analysis of variance) is an indication that inclusion of the MFRP-MO lowers the cost of feeding birds. This agrees with previous reports on the use of many other non-conventional feedstuff which reduce cost of feeding animals (Orayaga *et al*., 2018). Although the profit also steadily declined, the decline in cost outweighed the decline in profit as shown by steady decline in cost per kg gain, which is an indicator of good economics of utilization of the diets by the animal in translating the feed cost to meat value; forming the basis for profitability. The revenue as function of weight of the birds is expected to decline since the weight of the birds declined with increased MFRP-MO. Percentage feed cost of 32.36 – 39.92% is similar to the report of Orayaga *et al.* (2018) but lower than 70% and above reported (Aduku, 2004). This may not be unconnected to the nature of the enterprise; the chick enterprise, whose larger cost components are the cost of chicks itself and brooding (Orayaga *et al*. 2015). Moreso, a new scenario of increased cost of day-old chicks in Nigeria has made the cost distribution in the enterprise to shift more toward acquiring the day-old chicks than to feeding. At the finisher level, all economic parameters subjected to analysis of variance were significantly different (P<0.05) among treatment groups, except cost-benefit ratio which was similar across treatment groups (Table 6). The cost of feed consumed, total cost, revenue, profit, % feed cost, % day old cost and % other costs were significantly different (P<0.0); cost of feed consumed, total cost, revenue, profit and percentage feed cost reduced from 20% MFRP-MO level, while the cost kg-1 gain reduced from 40% MFRP-MO. Explanations on the starter phase hold for the finisher. However, the percentage feed cost was higher at the finisher phase compared to the starter phase and agreed with previous reports (Orayaga *et al*., 2015), though still lower than 70 -80 percent reported by Aduku (2004). The profit was high across treatment group irrespective of the significant decline. The result of carcass yield is presented on Table 6. Final weight, eviscerated weight, and drum stick were significantly lower (P<0.05); final weight at 20%, eviscerated and drum stick weights at 60% MFRP-MO respectively. Bled, plucked, dressed and the rest of the carcass cuts percentages were not significantly affected (p>0.05) by the dietary treatments. Mean final weights in this report were within broiler chicken table weight range of 1750.00g to 2200g, reported by Oluyemi and Robert (2000). The dressing percent of 75.99 to 68.68% agrees with the report of Aduku and Olukosi (2000), similar with the report of Orayaga *et al.* (2016) and superior to 66.37 to 70.19% reported by Tuleun *et al.* (2011) when broiler chickens were fed diets containing mucuna seed meal. Dressing percentage is affected by weight of birds, plane of nutrition, pre-slaughter activities and dressing method (Aduku and Olukosi, 2000). Since other factors that affect dressing percentage were kept constant except the diet composition, it no doubt that the diet had effect on carcass characteristics- eviscerated and drumstick weights. Disproportionate growth, which favours the growth of some parts at the expense of other parts, could be caused by diet (Hubbard, 2006) and a situation where only eviscerated and drumstick weights were significantly different means carcass parts were largely unaffected by diets – MFRP-MO levels in diets.

Internal organs relative weights were not significantly affected among the dietary treatments groups (Table 8). Internal organs such as gall bladder and the liver would vary in size (enlargement) if diets contain poisonous substances. No significant differences imply that the MFRP-MO mix did not introduce poison in the diets and the anti-nutritional levels were tolerable to the birds. Orayaga *et al*. (2018) had reported the presence of anti-nutritional factors in mango fruit reject meal and depressed performance of broiler chickens fed diets containing this material above 10%. The effect of mango fruit reject in whatever form on the internal organs is scarce. Non-significant difference among treatment groups for empty gizzard and proventriculus suggests that though fibre contents of MFRP-MO based diets seemed to be a little higher, it did not affect these organs, which would have enlarged if extra load of grinding was put on them. Abnormal blood circulation occasioned by dietary factors would cause variation in the size of the heart (Frandson, 1986). 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. Gastro-intestinal tract morphometry results are presented in Table 8. GIT length and large intestine were not significantly different (p>0.05) across treatment groups. GIT lengths in this study which ranged from 235.43cm to 263.23cm were higher than the GIT lengths of 197.5cm to 213.5cm reported by Oluremi *et al*. (2010) when 30% maize was replaced with Sweet Orange peel Meal in the diets of broiler chicken but similar to 245cm to 265cm reported by Orayaga *et al.* (2016). Non-significant difference means that the dietary effects on the GIT and large intestine were the same. Significant differences occurred in the relative small intestine length and caeca length in a reversed order; small intestine increased with MFRP-MO while caeca decreased as MFRP-MO increased.

Conclusion

The study showed that mango fruit reject pulp and maize offal could be mixed together to produce an alternative feedstuff in chicken feeding. It also showed that the nutrient composition of the mixture is better than either maize offal or mango fruit reject pulp alone considering energy and protein contents. It was concluded that 20% replacement of maize by MFRP-MO was optimal for both starter and finishing broiler chickens' growth but 60% was more economical and 60% MFRP-MO mix was recommended.

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