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Response of broiler chickens fed mango (*Mangifera indica*) fruit reject pulp-maize offal mix (MRFP-MO) based diets

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ABSTRACT

A seven-week study was conducted to determine the effect of mango fruit reject pulp-maize offal mix meal on growth performance, carcass characteristics, internal organs, gastrointestinal tract (GIT) morphometry, economics of production, flock uniformity and digestibility of nutrients by broiler chickens. Mango fruit reject pulp-maize offal mix meal partially replaced maize at 0, 5, 10, 15 and 20% in the diets of broiler chickens, respectively; represented as T1, T2, T3, T4, and T5 accordingly. One hundred and eighty (180) day-old Marshall broiler chicks were grouped into five, and each group was replicated three times while each replicate had 12 birds, in a Completely Randomized Design (CRD). The result of the feeding trial showed no significant difference (P >0.05) on growth performance parameters, digestibility of nutrients and economics of production. The Coefficient of Variation was less than 10. The carcass yield, internal organs and GIT morphometry all showed no significant difference (P >0.05). It was concluded that mango fruit reject pulp-maize offal mix meal can replace maize up to 20% in broiler chicken diet without negative influence on growth performance, nutrient digestibility, carcass yield, internal organs, flock uniformity and economics of production.

Keywords: carcass, digestibility, economics, growth, mango waste

INTRODUCTION

Poultry production as a livestock subsector plays an important role in the human economy through the provision of food and wealth creation through job provision for our teeming population (Alders et al., 2019). Poultry is the second most widely eaten type of meat worldwide and it provides nutritionally beneficial food containing high quality protein and a low proportion of fats (Glats, 2004). The chicken is unarguably identified as the livestock species that could be raised to easily close up the protein intake gap of less than 10 g per caput per day as against the FAO recommendation of 35g per caput per day between people in advanced world and developing countries (FOA, 2020). Broilers chickens are particularly selected and bred for large-scale, efficient meat production. They are noted for having very fast growth rates, a high feed conversion efficiency, low capital on investment due to small size as compared to large animals, and low levels of activity that make them easy to handle. Modern commercial broilers are bred to reach a slaughter-weight of about 2 kg (4.4 lb) in only 5 to 7 weeks (Robinson et al., 1993).

According to Anosike et al. (2018), the poultry sector is characterized by relatively faster growth in consumption and market volume than many other agricultural livestock sub-sectors. Despite the fast-growing trade and importance of poultry production, broiler chicken inclusive, the sector is plagued by a myriad of challenges; the feed problem being the most crucial as it accounts for over 60% of the production cost (Ademola and Farinu, 2006; Orayaga et al., 2019). This fact is re-echoed by Oladeji et al. (2023) that feed is the major cause of increased poultry production cost in Nigeria and the developing world as a whole.

It is apt to say that insufficient high quality low-cost alternative feed resources that could warrant optimal broiler chicken performance, and man-animal competition for most of the conventional feed stuffs, especially maize, are the root causes of the unbearable and unprofitable cost of poultry (broiler chicken) production in developing countries. The quantity of cereal grains such as maize, produced, which is reported by Worldgrain (2022) to be 12.6 metric tonnes, is not even enough for consumption as food for the human population of 220 117 998 Nigerians (Worldometer, 2023); 25% of the requirement of these grains is still imported (Worldgrain, 2022). Sequel to this, prices of manufactured feeds which usually contain 40 to 75% cereal grains, have risen by 300% in less than two years in the country, proportionately increasing the price of animal products such as meat, milk and eggs beyond the purchasing power of average Nigerians, forcing demand for broiler chicken meat to fall and a less profitable enterprise for meat poultry farmers, becomes the unsolicited consequence.

Sequel to this, Animal Nutritionists are incessantly researching better alternatives that can replace the costly conventional feed ingredients like maize. Oluremi et al. (2006) reported the use of sun-dried sweet orange peel meal in broiler chicken feeding and put the safe level at 10%, Orayaga et al. (2015) reported the use of water-soaked sweet orange peel meal in broiler chickens and recommended 15% inclusion as the safe level that broiler chickens responded comparably to the control – maize based diet. In other reports on alternative feeds in broiler chicken, Oluremi et al. (2022) reported the use of oil mill sludge- biodegraded sweet orange peel meal in starter broiler diets with digestibility results on treatment diets comparable to the control and Upah et al. (2021) reported the use of Euphorbia heterophylla in broiler feeds. Many other alternative feedstuffs have been investigated and reported. However, some of them have low nutritional value for broiler chickens due to high fiber content, low nitrogen-free extract, high anti-nutritional contents or poor palatability. The case is different with most fruit based alternative feedstuffs, particularly rejects as they are usually only unfit for human consumption but retain their nutrients composition, example mango fruit reject (Orayaga, 2016). According to Sruamsiri and Silman (2009), mango fruit by-products include the peel, pulp and kernel and have been investigated in cattle feeding.

Mango fruit rejects could be obtained in large quantities because it is the 5th largest fruit produced in the whole world (FAO, 2018) and accounted for a global production of 56 million tons in 2019 (FruiTrop, 2021). Nigeria occupies the 10th position topmost producers of mango fruits on the world scale, amounting to 850 000MT and Benue state where the research was conducted is the largest producer of mango fruit in Nigeria, so the mango fruit reject pulp is in large quantities, cheap to harvest, and contain low levels of anti-nutritional factors that finding use for it as a feedstuff is apt (Orayaga et al., 2018). More so, the rejected mango fruits and waste arising from the processing of fruit are high; accounting for about 50% of the production figure (FAO, 2019). The rejected mango fruits litter the ground at the peak of the production season, thus constituting an environmental hazard and pollution.

Mango fruit reject meal has the potential to replace maize as an energy feedstuff in poultry nutrition due to its rich nutrient profile. It contains 0.82% (4.96%; 49.6 g/kg on dry matter basis) crude protein, 1.6% (9.67; 96.7 g/kg dry matter basis) crude fiber, 0.38% (2.5%; 25 g/kg dry matter basis) ether extract and up to 14.98% (90%, 900 g/kg on dry matter basis) Nitrogen-free extract and metabolizable energy of 60kcal/100g (362 kcal/100g on dry matter basis) (Maldonado-Celis et al., 2019). Orayaga and Sheidi (2018) reported the proximate composition of mango fruit reject meal (pulp and peel together) as 43.80 g/kg crude protein, 27.00 g/kg crude fiber, 16.00 g/kg ether extract, 39.90 g/kg ash, 810.10 g/kg NFE and 936.80 g/kg dry matter.

Mixing mango fruit reject pulp with maize offal is an ideal on-farm method of processing that could dry the pulp to retain usefulness in livestock feeding. Maize offal is a by-product of maize milling and has physical characteristics of being dry; it quickly absorbs moisture from another material mixed with it and allows for easy drying. It has low energy value. According to Ezieshi et al. (2010), the nutritive value of maize offal is 2225 ME kcal/kg, 12.8% CP, 12.07%, CF, 11.72% EE, 5.42% Ash and 49.91% NFE. Aduku (2004) reported its energy and crude protein values as 2500kcal/kgME and 11.9% respectively.

According to Orayaga et al. (2019), mixing mango fruit reject pulp with maize offal makes the mixture have higher energy than maize offal by lowering the fiber content of maize offal and increasing the nitrogen-free extract.

Mango fruit rejects come in different forms: unripe, half-ripe and over ripe. These require different processing approaches to convert them to feedstuffs – mango fruits reject meal. The on-farm technology of slicing and sun-drying rejected half-ripe mango fruits (pulp +peel) has been successful in the tropics (Orayaga *et al*., 2017), with the meal replacing 100% of maize in rats (Orayaga et al., 2016) and Rabbits (Orayaga et al., 2024) at performances comparable to the control – maize based diet. Soomro et al. (2013) reported inclusion of mango fruit reject pulp up to 4% in broiler chicken diets with performance comparable to control but better at 2%. Growth performance, laying performance and egg characteristics of quail birds were similar to control diet up to 16% inclusion of mango fruit reject (peel + pulp) meal.

However, over ripe mango fruit rejects could not sufficiently dry under the sun to warrant easy milling. Nevertheless, an on-farm technology of using a carrier reported by Orayaga *et al*. (2019) was successful. They effectively dried water over ripe mango fruit reject pulp using maize offal as a carrier and incorporated it in broiler chicken diets. The results of their research were worth confirming with another research. This is because, though costs of feeds steadily decreased as mango fruit reject pulp-maize offal mix increased in diets, growth performance and profit were significantly lower than broiler chickens control diet at 20% replacement of maize, which was the least level of replacement. Also, the effect of mango fruit reject pulp-maize offal mix meal on digestibility was not reported. It therefore became necessary to carry out this work for more comprehensive investigation to pinpoint the level of maize replacement is optimal and will clear dark spots on the previous reports.

Mango fruit rejects are usually left to litter the round and as they rotten, they become breeding grounds for flies whose large population is a nuisance to the health of the society and where hygiene is prioritized, they significantly stress the economy of a state or nation in a bid to appropriately dispose them. Where they are converted to feeds, this will be a double plus, providing feedstuffs, turning waste to wealth and keeping the environment clean.

The aim of this research was, therefore, to investigate the response of broiler chickens fed mango fruit reject pulp-maize offal mix (MFRP-MO)-based diets. Specifically, the research is aimed at: i) converting waste to wealth when rejected mango fruit pulp is processed into a feedstuff using simple technique of mixing it with maize offal and sun drying, ii) determining the proximate composition of MFRP-MO meal, iii) evaluate the growth performance, digestibility, carcass characteristics and economics of production of broiler chickens fed diets containing MFRP-MO, iv) recommend the level of inclusion of MFRP-MO meal with optimal performance and least cost to the feed industrialists, agriculturists, academia and the scientific world.

In the long run, the expected outcomes are conversion of waste (mango fruit reject pulp) to wealth, addition of a feedstuff (MFRP-MO) to the list of alternative feeds, lowered feed cost, affordable broiler chicken meat, higher animal protein intake in developing countries and a hygienic environment.

Having the above aims and objectives in mind, we hypothesize that there is no significant difference (P>0.05) among groups of broiler chickens fed maize based diet (control) and those fed diets having maize partially replaced with MFRP-MO meal, in response.

MATERIALS AND METHODS

Experimental Site

This research was conducted at the poultry pen, Livestock Teaching and Research Farm, Joseph Sarwuan Tarka University, Makurdi. Makurdi town, the headquarters of Benue State, is located at latitude 7° 43' and longitude 80^0 3' E (Google map, 2022). The Benue floodplain is between 0 m and 100m above sea level. The area is warm, characteristic of a tropical climate, with a minimum temperature of 24.20 + 1.40°C and a 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 a mean wind speed of 2.47 knots/second northeast (TAC, 2011).

Preparation of mango fruit rejects pulp-maize offal mix meal

The overripe mango fruit rejects were collected during the peak of mango production season, between March and May, at no monetary cost. The collection was made from tree stands and markets in Makurdi town without recourse to variety for the purpose of extracting the pulp. The composite, which consisted of different varieties such as Alphonso, Hindi, John, Julie, Peter, and local varieties, was cleaned using dry pieces of cloth. The rind was peeled with a sharp, sterilized knife, and the pulp extracted by scrubbing the pulp into a clean plastic container. The extracted pulp was kneaded with the palms of the hand thoroughly and evenly mixed with previously well dried maize offal (dusa) in the ratio of 1:1; weight for weight. Weighing of both maize offal and mango fruit reject pulp was done using a sensitive digital weighing scale – SF – 400, Gujarat, India. The mixture was spread thinly (< 1.00" thick) on polyethylene sheets for three days, and the lumps formed were frequently smashed manually to obtain an even mixture until a moisture content of less than 10% was achieved, when it felt cripsy. The thin spread and constant smashing of lumps formed was to hasten drying; being in the tropics and in a summer season, 12 hours of sun light and heat effectively and sufficiently dried the mango fruit reject pulp-maize offal mix to a low moisture level that inhibited microbial growth. Drying for up to three days was meant to ensure proper drying. The sundried material was stored in polythene sacks to avoid re-absorption of moisture until it was used. Before MFRP-MO was incorporated into the diets of broiler chickens, it was first milled using a corn milling machine (Bajaj, Mumbai, India) to obtain MFRP-MO meal, which was further subjected to proximate analysis according to standard procedures (AOAC, 2015) to determine proximate constituents.

Chemical Analysis

Proximate compositions of MFRP-MO, broiler chicken diets and broiler chicken faecal materials were determined in triplicates and mean calculated with standard deviations. The proximate components determined were: moisture, crude protein, ether extract, crude fibre, ash and nitrogen-free extract. For each of the items above that was analysed, samples were prepared and analyzed according to standard procedures (AOAC, 2015).

Samples from mango fruit reject pulp-maize offal mix or broiler chicken diets or their feacal, portions from the bulk were fetched using a sampling spoon or spatula as appropriate and mixed together. They were then milled to powder, using laboratory micro milling machine (Jurgens & Co). After that 30g weight of samples were made each, using a digital weighing scale (Mettler toledo) and kept in airtight bags for proximate analysis of the materials whose proximate compositions were to be determined. Analytical procedures were carried out at the Department of Animal Nutrition laboratory, Joseph Sarwuan Tarka University (formerly, Federal University of Agriculture) Makurdi, Benue State, Nigeria.

Moisture was determined using an oven (Gallenkamp, London, England). Five grams (5g) of sample were first placed in a previously weighed crucible and then sample and crucible were put in the oven. The oven was switched on and the temperature adjusted to 105 degrees Celsius and oven-dried till a constant weight was achieved.

Crude protein was determined by digesting 1 g of sample using the Kjedhal apparatus, distilling with the Markham's set up having boric acid as the receiving acid and titrating, using hydrochloric acid. The nitrogen content was determined and a conversion factor, 6.25, was multiplied by the value of Nitrogen to obtain crude protein.

Crude fat or ether extract was determined by using the Soxhlet apparatus and the solvent was diethyl ether. Three grams (5g) of sample were transferred to the thimble and the thimble with sample was inserted into the extractor, which was connected to the condenser. Flask containing diethyl ether was heated and extraction run for four hours. Diethyl ether was collected, and ether extract (lipid) and flask were weighed to determine the weight of ether extract by difference.

Crude fiber was determined by digesting 2g of sample in acid, washing in water and acetone, then digesting it in a base (NaOH) and washing in water and acetone under suction. The residues were dried and weighed, then ashed. Weight of dried residue minus weight of ash gave crude fibre.

Ash was determined by first placing 2g sample in a crucible, then placing the crucible together with the sample in a muffle furnace (Wincom, Hunan, China). After that the muffle furnace was switched on and set at a temperature of 600 degree Celsius and the sample was burnt to ash.

Nitrogen-free extract was determined as the difference between 100 and the sum of the percentages of all the other components of proximate: NFE =100 - (%moisture +%CP +%CF+ %EE + %Ash). The proximate compositions were converted to dry matter where it was meant for calculation of digestibility coefficients. All measurements were performed in triplicate.

The preparation of experimental diets

Five diets were prepared in which MFRP-MO partially replaced maize at 0, 5, 10, 15, and 20% respectively to produce diets T1 (0%), T2 (5%), T3 (10%), T4 (15%), T5 (20%), and 0% served as control as shown in table 1 and 2.

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

Ingredients (%)	Experimental Diets				
	T1 (0%)	**T2 (5%)**	**T3 (10%)**	**T4 (15%)**	**T5 (20%)**
Maize	52.50	49.87	47.25	44.62	42.00
MFRP-MO	0.00	2.63	5.25	7.88	10.50
Soybean 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 (MEkcal/kg)	2759.90	2755.25	2754.04	2751.11	2748.18
Crude Protein	23.50	23.50	23.53	23.55	23.56
Crude Fibre	4.36	4.43	4.53	4.59	4.68
Ether Extract	3.64	3.70	3.77	3.84	3.91
Methionine	0.66	0.65	0.65	0.64	0.64
Lysine	1.36	1.35	1.35	1.34	1.34
Calcium	1.30	1.30	1.30	1.30	1.30
Phosphorus	0.75	0.74	0.74	0.74	0.74

MFRP-MO = Mango Fruit Reject Pulp-Maize Offal, BDG = Brewer's Dried Grain, VMP= Vitamin/ Mineral Premix

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

Ingredients (%)	Experimental Diets				
	T1 (0%)	**T2 (5%)**	**T3 (10%)**	**T4 (15%)**	**T5 (20%)**
Maize	60.05	57.05	54.04	51.04	48.04
MFRP-MO	0.00	3.00	6.01	9.01	12.01
Soybean 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 (Mekcal/kg)	2872.76	2853.97	2850.61	2847.26	2843.91
Crude Protein	20.35	20,32	20.34	20.36	20.38
Crude Fibre	4.23	4.31	4.40	4.50	4.59
Ether Extract	3.76	3.81	3.89	3.97	4.05
Methionine	0.50	0.49	0.49	0.48	0.48
Lysine	1.15	1.14	1.14	1.13	1.12
Calcium	1.26	1.26	1.26	1.26	1.25
Phosphorus	0.70	0.70	0.70	0.70	0.69

Experimental procedure, design and management of birds

A total of one hundred and eighty (180) day-old Marshall Broiler Chicks were obtained from Zartech Hatchery Farm, Jos, Plateau State, North Central Nigeria, for the study. Prior to the arrival of the birds, proper sanitation and disinfection were done on the pens and equipment. Upon arrival, the initial body weights of all the chicks were recorded using a digital scale. The chicks were thereafter allotted randomly to five dietary treatments with three replicates of twelve birds each. The experimental design was Completely Randomized Design (CRD). The day-old chicks were brooded for a period of four weeks. The environmental conditions were kept optimal: temperature was set at 37 degrees celciuls at day old and gradually reduced in accordance with the chicks' behaviour towards heat, relative humidity was 55% and light was 22 hours. Brooding and data collection went on concurrently. Routine medications and vaccinations were carried out to ensure the proper health of the birds. The birds were all vaccinated against Newcastle disease with the use of the lasota vaccine in normal saline water intra-ocularly at day one, then against infectious bursal disease (gumboro) with the use of the gumboro vaccine, which was administered orally in drinking water at day 14, and finally lasota was administered orally through drinking water at day 21, as recommended by NVRI VOM (2019). Other drugs given to the birds included: amprolium® as an anti-coccidiostat®, Wormazine® (a dewormer), poultry boost vitaminolyte® (vitality), and neomycin for the treatment of bacteria gastrointestinal infections, Doxy-gen was used against bacterial infections, while oxytetracycline® was injected intramuscularly against chronic respiratory disease (CRD). The birds were raised in a deep litter half-walled house, with its upper half covered with wire mesh. Feed and water were served *ad libitum* throughout the experimental period, which lasted for 49 days.

Data Collection

Growth performance

Data for the initial live weight of the birds were taken by weighing the birds with a sensitive digital scale (Mettler Toledo) before introducing them to the experimental diets – initial weight. Subsequently, weekly live weights were recorded for the seven weeks and the 7th week's wight was the final live weight. Feed intakes were determined by recording the weights (g) of feeds served and feeds left over and calculating the difference between weight (g) of feed served and weight of feed left over. Body weight gain was determined as the difference between final body weight and initial body weight, while daily weight gain and daily feed intake were determined by dividing the totals of feed intake and weight gain against the number of days that the feeding trial lasted (49). Feed conversion ratio was determined by dividing the total feed intake (g) by the weight gain (g), while feed conversion efficiency was calculated by dividing the weight gain by the total feed intake.

Flock uniformity

Flock uniformity was determined using the coefficient of variation generated from standard deviations and means of treatment multiplied by 100.

Digestibility trial

A week to the end of the feeding trial which lasted for 49 days, two birds per replicate, whose mean weights were close to the mean weight of the birds in the entire replicate were selected and placed in clean, disinfected digestibility cages for nutrient digestibility study. The birds were allowed an acclimatization period of two days before data collection commenced. A known quantity of feed was given daily to the birds, while excreta voided per replicate were collected and dried in the oven for 24 hours at a temperature of 80^0C and weighed. Dried excreta per replicate for the period of the trial, four days, were pulled together (four of the collections, each per day) and representative samples were obtained and analyzed of their proximate compositions according to the standard procedures of AOAC (2000) and expressed on dry matter basis. The digestibility coefficient was determined using the following formula:

$$Digestibility\ coefficient = \frac{\text{Nutrient conc. in feed} - \text{Nutrient conc. in faeces}}{\text{Nutrient conc. in feed}} X\ 100$$

Economics of production

The cost of feed ingredients including services such as transportation and processing of feed ingredients was used to arrive at the actual cost of the feedstuffs. The formula for each diet was used to determine the cost per kg of the feeds by multiplying the unit cost (₦) of each ingredient by its proportion in the diet to determine its cost contribution to the diet. The sum of the cost contributions from all the ingredients in the diet gave the unit cost (₦) Kg^{-1} of the diet. The cost of feed consumed per bird during the experimental period was obtained by multiplying the total feed consumed in kg per bird by the cost per kg of the diet. The total cost of production was obtained by the summing up the cost of a day-old chick, the cost of feed consumed per bird, and other costs incurred per bird such as house maintenance, feeders, drinkers, medications, and litter materials. The cost of reusable items was measured using straight line depreciation according to their lifespan, as recorded at the Livestock Teaching and Research Farm, Joseph Sarwuan Tarka University, Makurdi. The cost per kg of diet multiplied by the feed conversion ratio gave the feed cost per kg weight gain. Revenue per bird referred to the value (₦) per kg of live weight. Gross margin (profit) was obtained by subtracting the total cost of production from revenue.

Carcass evaluation

Carcass yield: Prior to the end of the experiment, three birds per treatment, one per replicate, with weight similar to the replicate's average were fasted of feed for 18 hours. After that, the animals were bled immediately post manual cervical dislocation and the carcass evaluated as described by Aduku and Olukosi (2000). The carcass was separated into cuts namely breast, thigh, drumstick, wing, and back; and offals, namely shank, head. and fats, and internal organs, including the heart, liver, spleen, gall, pancreas, gizzard, proventriculus, lungs and kidney. The gastro-intestinal tract (GIT) morphometry components; small intestine, large intestine, and caeca, were also examined. All parts were weighed using a sensitive digital scale.

Data analysis

The data obtained on chemical composition of MFRP-MO mix were analyzed using descriptive statistics and presented as means with their standard deviations. Data generated in percentage (digestibility coefficients or carcass relative weights) were first transformed using arcsine transformations before subjecting them to analysis of variance (ANOVA) along with other data on growth performance and economics of production. Analysis was done using statistical software [SPSS, 2004], which was configured to automatically separate means that were significant. A probability level below 5% was considered significant.

RESULTS AND DISCUSSION

Proximate composition of Mango Fruit Reject Pulp-Maize Offal (MFRP-MO) mix.

The results of the proximate composition of MFRP-MO mix are presented in Table 3. The metabolizable energy (ME), calculated from the proximate components using the formula of Pauzenga (1989) was 3315.16 kcal/kg ME.

The 9.63%CP of MFRP-MO was similar to that of maize whole grain (9 % CP) as reported by NIAS (2019), while the energy of 3315.16kcal/kg ME was lower than the 3420 kcal/kg in maize (Aduku, 2004) but similar to 3300 kcal/kg reported by NIAS (2019). The high crude protein of the MFRP-MO mix is likely as a result of microbes inoculated by chance, which multiplied during the drying period, thus increasing the CP of the mixture. According to Orayaga et al. (2015), chance fermentation has also been reported to increase the crude protein level in feed materials. The fat and crude fibre contents of the mixture (MFRP-MO) were higher than those of maize. This is a direct consequence of the properties of maize offal which has higher fibre and fat than maize grain. Aduku (2004) reported that maize offal has 11.9 % crude protein, 4% ether extract, 12% crude fibre and 2500kcal/kg Metabolisable energy on dry matter basis. He, on the other had reported maize as containing 8.7% crude protein, 2% ether extract, 2 % crude fibre and 3420 kcal/kg metabolizable energy.

Table 3: Proximate composition of MFRP-MO mix

Crude protein	Crude fibre	Ash	Moisture	Ether extract	Nitrogen free extract
9.63±1.34%	5.05±0.44%	4.84±0.82%	5.57±0.17%	6.56±1.67%	68.38±1.71%

Results are presented as mean ± standard deviation.

Growth Performance of Broiler Chickens fed Mango Fruit Reject Pulp-Maize Offal Mix Based Diets

The effects of MFRP-MO mix inclusion on the growth performance of broiler chickens are presented in table 4. There was no significant difference (P >0.05) in daily feed intake across the treatment groups. This means that the palatability of the diets was not affected by MFRP-MO mix inclusion. The final weight and weight gain were not significantly different (P >0.05) across the treatment groups. This result did not corroborate with the findings of Orayaga et al. (2019), who reported declining weight gain at a 20-80% level of MFRP-MO mix inclusion. The final weight range of 1815.75g to1859.06g obtained in the research was superior to the range of 1549.70g to 1715.24g reported by Makinde and Soniaya (2011) when broiler chickens were fed diets containing maize bran-blood meal mixture, and 1663g to 1785g reported by Mir et al. (2017), but inferior to 1746.67g to 22515.88g reported by Orayaga et al. (2019), when broiler chickens were fed a diet containing MFRP-MO mix-based diet. FCR and FCE were also not significantly different (P >0.05) across treatment groups, thus, indicating that the test ingredient (MFRP-MO) had no deleterious effects on weight gain in relation to feed intake. Both protein intake and protein efficiency ratio were not significantly different (P >0.05) across the treatment groups. This simply means, the feeds containing MFRP-MO supported broiler chicken performance as did maize.

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

Parameter (g)	Experimental Diets						
	T1 (0%)	**T2 (5%)**	**T3 (10%)**	**T4 (15%)**	**T5 (20%)**	**SEM**	**P-value**
IW	41.81	41.67	42.08	42.50	42.08	0.56	0.34
FW	1859.06	1815.75	1817.55	1851.26	1855.94	57.06	0.96
ATWG	1817.08	1771.08	1775.47	1808.76	1813.58	56.10	0.96
ADWG	37.08	36.21	36.23	36.91	37.01	1.16	0.96
ADFI	76.20	76.08	76.77	76.58	76.93	1.59	0.69
FCR	2.06	2.10	2.12	2.10	2.13	0.05	0.80
ADPI	16.00	15.98	16.11	16.08	16.59	0.33	0.69
PER	2.32	2.26	2.25	2.30	2.23	0.05	0.76
TPI	784.10	782.86	789.62	787.98	812.96	16.28	0.69
FCE	0.49	0.47	0.47	0.49	0.47	0.00	0.60
TFI	3733.81	3727.90	3761.52	3752.27	3871.23	77.85	0.69

MFRP-MO= Mango Fruit Reject Pulp-Maize Offal, IW= Initial Weight, FW = Final Weight, ATWG= Average, SEM= Standard error of mean, P= probability level, 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; TPI= Total Protein Intake; FCE= Feed Conversion Efficiency; TFI=Total Feed Intake

Flock uniformity of broiler chickens fed diets containing MFRP-MO mix-based diets

The effect of feeding MFRP-MO mix-based diet on the uniformity is shown in Table 5. The results showed no significant variation (P >0.05). None of the performance parameters under consideration in the study had coefficient of variation (CV) up to 10. A CV of less than 10 is an indication of high uniformity. This means that the diet did not affect the growth performance of individual birds differently, hence their uniformity.

Table 5: Effects of MFRP-MO based diets on flock uniformity of finisher broiler chicks using coefficient of variation (CV)

	Experimental Diets				
Parameter	**T1 (0%)**	**T2 (5%)**	**T3 (10%)**	**T4 (15%)**	**T5 (20%)**
IW	0.57	0.00	0.99	0.99	0.56
FW	6.64	7.15	6.09	2.89	2.16
ATWG	6.78	7.32	6.21	2.98	2.22
ADWG	6.77	7.31	6.09	2.98	2.22
ADFI	3.07	4.86	4.48	2.26	2.38
FCR	6.31	3.33	3.30	3.86	0.47
ADPI	3.06	4.88	4.41	2.24	2.35
PER	6.03	3.54	3.11	3.91	0.00
TPI	3.07	4.90	4.43	2.25	2.38
FCE	6.12	4.26	2.13	4.08	0.00
TFI	3.07	4.91	4.49	2.25	2.38

MFRP-MO= Mango Fruit Reject Pulp-Maize Offal; IW= Initial Weight, Fw = Final Weight 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; TPI= Total Protein Intake; FCE= Feed Conversion Efficiency; TFI= Total Feed Intake

Nutrient digestibility of broiler chickens fed diets containing MFRP-MO mix-based diets.

Table 6 shows the results of the nutrient digestibility of broiler chickens fed graded levels of MFRP-MO mix-based diets. The results revealed that the digestibility of crude protein, ether extract, crude fibre, nitrogen free extract, ash and dry matter were not significantly affected (P >0.05) across the treatment groups. The dry matter digestibility of 71.28-73.49% obtained in this study was in the normal range of 56-97% Coefficient of digestibility of balanced feed documented by Ghislaine et al. (2019). The digestibility of crude protein (69.21-71.81%), fats (76.61-78.97%), Crude fibre (65.34-68.63%), nitrogen free extract (74.79-77.41%), ash (57.05-60.34%), obtained in this research were similar to those of Sobayo et al. (2012), when broilers were fed diets containing ethanol-treated castor oil seed meal. Crude fibre digestibility coefficient values of 57.26% to 70.19% reported by Orayaga (2016), when rabbits were fed mango fruit reject meal based diets were similar to 65.34 to 68.63% recorded in this finding; while dry matter, crude protein, ether extract and Nitrogen-free extract digestibility values in ranges of 76.71% to 81.35%, 87.95% to 90.88% and 79.92 to 84.24 reported by Orayaga (2016) when rabbits were fed diets containing mango fruit rejects are higher than values reported in this study.

Broiler chickens may have lower digestibility of nutrients in comparison to rabbits in diets involving mango fruit. In another report, dry matter, crude protein, crude fibre and nitrogen-free extract value ranges of 53.84% to 58.69%, 39.44% to 56.55%, 41.64% to 50.40% and 47.25% to 59.30% reported by Sruamsiri and Silman (2009), when native cattle were fed ensiled mango by-products were lower than values in this finding. These variations indigestibility coefficient values are due to differences in animals involved. They may also be due to the processing method applied on the mango fruit.

The digestibility values obtained in the study indicate that the mixture did not introduce toxic substances that affected the birds' GIT or digestive enzymes negatively. Evidently, the fast growth rate and weight gain were good indices of feed digestibility and utilization by the birds.

Table 6: The effect of MFRP-MO based diets on the digestibility of finisher broiler chicken

Parameter (%)	Experimental Diets						
	T1(0%)	**T2(5%)**	**T3(10%)**	**T4(15%)**	**T5(20%)**	**SEM**	**P-value**
Crude protein	69.37	69.21	71.81	70.37	70.26	0.81	0.18
Ether Extract	76.61	77.37	78.97	78.23	78.71	0.32	0.2
Crude fibre	67.12	65.83	65.34	66.73	68.63	0.15	0.18
NFE	74.79	75.15	77.41	76.9	76.56	0.4	0.34
Ash	57.15	57.03	60.34	58.73	58.06	1.96	0.4
Dry matter	71.28	71.32	73.49	72.49	72.6	0.66	0.17

SEM = standard error of mean; P= probability level; MFRP-MO = mango fruit reject pulp-maize offal; NFE = nitrogen free extract

Carcass characteristics of broiler chickens fed diets containing MFRP-MO based diets

Table 7 shows the result of the effects of feeding diets containing MFRP-MO mix on the carcass characteristics of broiler chicken. Fasted weight, eviscerated weight and drumstick were not statistically significant (P >0.05) across the treatment groups. This means that MFRP-MO inclusion exerted no adverse effect on the carcass traits of the birds. This result stood parallel with the findings of Orayaga et al. (2019), who reported significant difference (P

<0.05) on these carcass traits when MFRP-MO was included up to 60% in broiler chicken diets. This difference may be premised on the variation in both experimental procedures and amount of inclusion of the test ingredient. The bled weight, dressed weight, breast, thigh, drumstick, back, neck, wing, shank and head were not significantly different (P >0.05) across all the treatment groups. This result corroborates the findings of Orayaga et al. (2019) who found out when MFRP-MO was included up to 80% in broiler chicken diets. The mean fasted weights of between 1796.67 and 1841.67g obtained in this study were within the broiler chicken table weight range of 1750.00g to 2200g, as reported by Oluyemi and Robert (2000). The dressing percentage of 54.04-58.61% was within the range reported by Aduku and Olukosi (2000), but inferior to 68.68 to 75.99% (Orayaga et al., 2019) and 66.37% to 70.19% reported by Tuleun et al. (2011), when broiler chickens were fed diets containing mucuna seed meal.

Table 7: The effect of MFRP-MO based diets on the carcass characteristics of finisher broiler chicken

Parameter (g)	Experimental Diets						
	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	T5 (20%)	SEM	P-value
Fasted weight	1796.67	1830.0	1836.67	1816.67	1841.67	70.42	0.99
Bled weight	75.01	77.32	75.79	74.11	74.59	1.18	0.32
Plucked weight	71.22	72.29	71.09	70.52	70.04	0.83	0.52
Eviscerated weight	58.44	62.27	60.76	59.50	60.13	1.11	0.24
Dressed weight	54.36	58.61	56.44	54.64	55.82	0.95	0.06
Breast	28.39	31.60	29.77	28.40	28.77	0.67	0.30
Thigh	19.16	18.92	18.97	18.99	19.28	0.32	0.92
Drum stick	18.28	18.12	18.43	18.52	18.29	0.39	0.97
Back	18.62	18.36	18.43	18.22	18.32	0.32	0.74
Neck	14.18	15.10	13.90	13.57	13.61	0.91	0.75
Wing	16.59	16.50	16.63	16.07	16.39	0.22	0.44
Shank	11.87	11.46	11.72	12.32	12.59	0.37	0.27
Head	8.89	8.33	8.54	8.80	8.74	0.22	0.41

SEM = standard error of mean, P = probability level, MFRP-MO =mango fruit reject pulp-maize Offal

Internal Organs and GIT morphometry of broiler chickens fed diets containing MFRP-MO mix-based diets.

The result of the effects of feeding MFRP-MO mix-based diets on the internal organs and GIT morphometry of broiler chickens is shown in table 8. There was no significant difference (P>0.05) across the treatment groups.

Internal organs such as the liver and gallbladder showed no enlargement and maintained normal morphology and physiology, thus indicating that the diet exerted no adverse effect on these organs. This agrees with the finding of Orayaga et al. (2019) when MFRP-PO mix was included in broiler chicken diets. The effect of mango fruit rejects in whatever form on the internal organs is scarce. A 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 an 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. Gastrointestinal tract morphometry results showed that the GIT length and the large intestine were not significantly different (P >0.05) across the treatment groups. The GIT lengths in this study which ranged from 225.5 to 244.8cm, 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 chickens, but similar to 245cm to 265cm, reported by Orayaga et al. (2016). Non-significant difference indicates that the dietary effects on the GIT and large intestine were the same. No significant differences occurred in the relatively small intestine length and caeca length. This implied that the level of inclusion of MFRP-MO mix had no alteration on the morphology and physiology of these internal organs.

Table 8: The effect of MFRP-MO based diets on internal organs and GIT morphometry of finisher broiler chicken

Parameter (g)	Experimental Diets						
	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	T5 (20%)	SEM	P-value
Gizzard	1.16	1.92	1.89	1.70	1.80	0.35	0.56
Liver	1.93	1.67	1.74	1.77	1.88	0.24	0.17
Lungs	0.53	0.55	0.61	0.60	0.49	0.28	0.61
Spleen	0.28	0.51	0.17	0.16	0.18	0.24	0.84
Pancreas	0.20	0.22	0.24	0.23	0.27	0.19	0.16
Gall	0.16	0.22	0.21	0.21	0.20	0.51	0.13
Kidney	0.44	0.33	0.34	0.29	0.31	0.28	0.41
Proventriculus	0.35	0.38	0.41	0.43	0.38	0.23	0.44
Heart	0.40	0.43	0.41	0.38	0.40	0.13	0.17
Small intestine	64.28	63.53	62.45	64.21	62.63	0.59	0.16
Large intestine	12.67	12.58	12.56	12.10	13.01	0.32	0.43
Caeca	21.98	23.21	24.01	22.35	23.62	0.56	0.12
GIT	239.50	227.50	241.00	225.50	244.80	7.98	0.24

SEM= standard error of mean, P= probability level, GIT= gastrointestinal tract, MFRP-MO=mango fruit reject pulp-maize offal

Economics of production of broiler chickens fed diets containing MFRP-MO mix-based diets

The result of the economics of production is presented in table 9. There was no significant difference (P >0.05) on the cost per kg weight gain, cost of feed, revenue, total cost, profit, cost benefit ratio, percent feed cost, percent cost per kg and percent miscellaneous cost across the treatment groups. This result stands in parallel with the findings of Orayaga et al. (2019), who reported better economic indices when MFRP-MO was included as high as 80% in broiler diets. This implies that the level of inclusion of MFRP-MO in this research (5-20%) was within positive economic limits.

Table 9: The effects of MFRP-MO based diets on the Economics of production of finisher broiler chickens

Parameter (₦)	Experimental Diets						
	T1 (0%)	**T2 (5%)**	**T3 (10%)**	**T4 (15%)**	**T5 (20%)**	**SEM**	**P-value**
Ckgg	306.78	305.15	300.37	285.83	286.40	6.87	0.15
CFC	555.57	541.15	531.89	517.44	519.59	11.13	0.17
Revenue	2230.87	2178.90	2181.06	2221.52	2227.12	68.40	0.96
TC	852.02	837.60	828.34	813.89	816.04	11.13	0.17
Profit	1378.85	1341.30	1352.72	1407.63	1411.09	60.91	0.89
CBR	0.62	0.62	0.61	0.58	0.59	0.03	0.45
%FC	65.20	64.58	64.19	63.57	63.67	0.48	0.17
%DC	14.09	14.33	14.49	14.75	14.71	0.19	0.17
%MSC	20.72	21.08	21.31	21.68	21.62	0.28	0.17
CKgD	148.68	145.08	141.46	137.86	134.26	-	-

SEM = standard error of mean, P = probability level, CFC= cost of feed consumed, Ckgg= cost per kilogram weight gain, TC= total cost of production, DC= day old chick, MSC= Miscellaneous cost

CONCLUSIONS

The research showed that mango fruit reject pulp and maize offal could be mixed together to produce a feed ingredient for chicken nutrition.

The result from the feeding trial demonstrated that the inclusion of 20% mango fruit reject pulp-maize offal mix in the diets of broiler chickens has no deleterious effects on the growth performance, carcass yield, gastrointestinal morphometry, flock uniformity or nutrient digestibility.

It was recommended that 20% MFR-MO be used to replace maize in broiler chicken nutrition.

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