PERFORMANCE OF STARTER BROILER CHICKENS FED DIETS CONTAINING REJECTED MANGO FRUIT PULP and MAIZE OFFAL Mix

Original Research Article

Abstract

The study was conducted to determine the performance of broiler chickens fed diets containing rejected mango fruit pulp - maize offal mix. The extracted mango pulp was evenly mixed with maize offal (Dusa) in a ratio of 2:3 (RMFP: MOM). The mixture was sun dried for 5 days until moisture of less than 12% was achieved. Five diets were prepared in which RMFP-MOM partially replaced maize at 0, 5, 10, 15 and 20% representing treatments T1, T2, T3, T4 and T5 respectively. A total of (200) day-old ROSS chicks averaged 44.24 g were randomly allocated to 5 dietary treatments, balancing for body weight. Each treatment group made up of forty birds, was replicated four times and each replicate had ten (10) birds in a completely randomized design (CRD). Result of the proximate analysis revealed that, RMFP-MOM contains 9.59 % crude protein, 0.99% ether extract, 3.02 %, moisture, 11.51 % crude fibre, ash was 5.47 %, 75.85 % nitrogen free extract and 3127.79 kcal/kg metabolizable energy. Phytochemicals and minerals found included Phytates (0.13%), tannin (2.53%), mycotoxin (3.76%), citric acid (0.1%), calcium (0.98%) and phosphorus (0.17%) while ADF, NDF and hemicellulose were found at levels of 10.10 %, 45.10% and 35.00 % respectively. Result on performance of the starter broiler chickens revealed significant effects ($p<0.05$) of RMFP-MOM on final body weight (FBW), daily weight gain (DWG) and daily feed intake (DFI) which all declined at T5 (20 % RMFP-MOM). Result on digestibility showed that, there was significantly lower ($p<0.05$) digestibility of ether extract in T1 (80.73 %). Cost of feed consumed was significantly lower ($p<0.05$) at T5. Gross revenue was ₦4000 across treatments while gross profit was higher at T5. Given the nutrients profile of RMFP-MOM as revealed by the result of the proximate analysis, it was inferred that these materials are valuable feedstuff in broiler nutrition as the use of RMFP-MOM in the diets of the broiler chicken up to 15% maintained growth rates at levels comparable to the control. The result of this study also revealed that broiler chickens can be reared at cheaper cost with the inclusion of RMFP-MOM at 15%. It was recommended that, 15 % RMFP-MOM be used in broiler diets.

Key words: starter broiler chickens, rejected mango fruit pulp, maize offal, Growth, Digestibility

1. INTRODUCTION

1.1 Description of the Problem

The cost of conventional protein and energy sources like groundnut, fish meal, soya bean, maize, sorghum and wheat for monogastric animal feeding has been on the increase in some developing countries since the last decade, making it uneconomical to use these feedstuffs solely for poultry feed production (Alade, 2018). The increase in population growth in the developing countries like Nigeria has placed a higher demand on animal protein. This population growth in Nigeria was reported to be at 2.38% in 2023 according to the World Bank collection of development indicators (Trading Economics, 2024). However, there is shortage of animal protein due to limitations placed on livestock products by inadequate supply of good quality feeds throughout the year due to seasonal fluctuation in supply and high cost of conventional ingredients is a serious setback preventing optimum production of poultry birds in the developing countries. Feeding cost according to Alade (2018) accounts for 65 to 75 % of all the cost of production of non-ruminant animals.

In many countries however, per capital consumption of animal protein has expanded due to the increase awareness of the need for animal protein consumption. This is so because, consumers around the world including those in the developing countries are increasingly becoming conscious of the type of food they consume, their nutritional benefits and safety of the food they consume (Anongo *et al*., 2024). All stakeholders in the animal production industry are therefore interested on issues of availability and quality of feed. There is, therefore, great interest in the potential of any material to serve as feed ingredients. Since by-products are generally less expensive than the parent material, the use of these by-products will lower the cost animal production and thus the cost of animal products (Carew *et al*., 2020 and Anongo *et al*., 2023).

Mango (*Mangifera indica*) fruit is one of the most popular, nutritionally rich fruits with unique flavour, fragrance, taste and health promoting qualities. These qualities make it a common ingredient in new functional foods Nigeria is said to be one of the leading producers of mango in the global market with an annual production estimated at about 800,000 tones (FAO, 2011). In Nigeria, Benue state is the highest quantitative producer of mango fruit according to Ugese *et al*. (2012). Ajayi and Nyishir (2006) also reported that though there is no clear figure of mango production in Benue state, the state supplies mango fruits to many other states of the country. A large quantity of the fruit wastes away because of non-availability of fruit processing factories.

The by-products of mango fruits and the rejects are not consumed by humans. Its disposal is a major problem among many fruit processing industries because such wastes are easily spoiled, degraded, and is a potential hazard to both people and the environment. These products have been reported by many scholars (Orayaga, 2016; Orayaga and Sheidi, 2018) to contain high nutrients than other fruit by products. The nutritive value of mango fruit reject meal according to Orayaga *et al*. (2015) is 88.50% dry matter, 3.24% crude protein (CP), 3.53% crude fibre (CF), 1.57% ether extract (EE), 0.97% ash, 79.19% nitrogen free extract (NFE), 3059.55 kcal/kg ME, 0.49% calcium and 0.04 % phosphorus. Among the fruits' by-products, mango has gained more attention in the recent time, being successfully incorporated in the diets of farm animals (Orayaga *et al*., 2015) without compromising performance. This study therefore seeks to determine the performance of broiler chickens fed diets containing rejected mango fruit pulp- maize offal mix (RMFP-MOM) as this will reduce the cost of feeding broiler chicken and environmental pollution.

2. MATERIALS AND METHODS

2.1 Experimental Site

The study was conducted at the poultry unit of Livestock Teaching and Research farm, Joseph Sarwuan Tarka University Makurdi, Benue State, Nigeria. Makurdi lies on latitude 07^0 41’ 0” N and longitude 8^0 37’0” E and is within the Southern Guinea Savannah Agro ecological zone of Nigeria. (Anon, 2004).

2.2 Preparation of Rejected Mango Fruit Pulp-Maize Offal Mix and Experimental Diets

The rejected mango fruits were collected at minimal 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 (plate 1) comprising different varieties; exotic and local mango fruits rejects was collected and cleaned using dry piece of cloth. The pulp was manually extracted after the peels had been removed and the pulp brushed into a container using iron spoon (plate 2). The extracted pulp was kneaded with the palms of the hand, thoroughly and evenly mixed with maize offal (*Dusa*) in a ratio of 2:3 w/w. The mixture was sun dried for 5 days by spreading on polyethylene sheets and frequently breaking the lumps by scrubbing in between the palms to obtain an even mixture until moisture of less than 12% was achieved (Plate 3). The sundried material was stored in polyethylene bags and kept safe to the time it was used. Before the rejected mango fruit pulp-maize offal mix (RMFP-MOM) was incorporated into the broiler chicken diets, it was first milled using hammer milling machine to obtain rejected mango fruit pulp-maize offal mix (RMFP-MOM) which was subjected to proximate analysis using standard procedures (AOAC, 2015).

Five diets were prepared in which RMFP-MOM partially replaced 0, 5, 10, 15 and 20% of maize respectively to produce diets T1 (0%), T2 (5%), T3 (10%), T4 (15%) and T5 (20%), while diet T1 (0%) served as control

Plate 1: RMF **Plate 2: RMFP** **Plate 3: RMFP-MOM**

RMF = Rejected mango fruit; RMFP-MO = rejected mango fruit pulp-maize offal mix

RMFP = rejected mango fruit pulp

2.3 Experimental birds, design and duration

A total of (200) day-old ROSS 308 broiler chicks were purchased from Sayed Farm in Oyo state, Nigeria and used for 4 weeks (28 days). The broiler chicks were randomly allocated to 5 dietary treatments, balancing for body weight. Each treatment group contained forty birds and was replicated four times and each replicate had ten (10) birds. The experimental design was a completely randomized design (CRD).

Table 1: Composition of RMFP-MOM based diets for starter broiler chicks

	Replacement levels of RMFP-MOM				
Ingredients	**T_1 (0%)**	**T_2 (5%)**	**T_3 (10%)**	**T_4 (15%)**	**T_5 (20%)**
Maize	52.00	47.00	42.00	37.00	32.00
RMFP-MOM	-	5.00	10.00	15.00	20.00
SBM	35.00	35.00	35.00	35.00	35.00
BDG	5.40	5.40	5.40	5.40	5.40
Blood meal	3.00	3.00	3.00	3.00	3.00
Bone Ash	2.50	2.25	2.25	2.25	2.25
Palm oil	1.00	1.00	1.00	1.00	1.00
Methionine	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20
Common Salt	0.30	0.30	0.30	0.30	0.30
V/M premix	0.25	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**	**100**
Calculated composition					
ME (Kcal/kg)	2882.00	2877.00	2870.00	2863.00	2853.00
Crude Protein (%)	24.00	23.80	23.50	23.20	23.00
EE (%0)	3.73	3.88	3.90	3.92	3.94
Crude fibre (%)	3.83	4.03	4.60	4.90	5.20
Ca (%)	1.29	1.28	1.28	1.29	1.29
P (%)	0.70	0.73	0.73	0.74	0.74
Methionine (%)	0.58	0.54	0.54	0.53	0.53
Lysine (%)	1.25	1.23	1.23	1.22	1.22

RMFP-MOM=rejected mango fruit pulp-maize offal mix, SBB=soybean meal, BDG=brewer's dried grains, V/M=vitamins and mineral premixes, EE=ether extract, Ca=calcium, P=Phosphorus

2.4 Management of Experimental Birds

Prior to the arrival of the birds, the poultry house was thoroughly cleaned, washed, and disinfected using detergents and izal solutions. The feeders and drinkers were likewise washed and disinfected for optimum hygienic environment. The birds were reared in a deep litter half – walled house, having its upper half covered with wire mesh. Feed and clean water were served *ad-libitum* throughout the experimental period of 28 days. 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 intraocular(i/o) at day one, then against infectious bursal disease (Gumboro) with the use of Gomboro vaccine which was administered orally (in drinking water) at day 14 and finally Lasota was given at day 21 orally through drinking water.

2.5 Chemical Analysis

The proximate composition (moisture, Crude protein, crude fibre, ether extract and ash) of the test ingredient (RMFP-MOM) and the experimental diets were determined according to the standard procedures of AOAC (2015).

2.6 Growth Performance

The chicks were weighed initially at the start of the experiment and weekly thereafter to obtain weekly weight changes by difference. The weight at the beginning of the feeding trial was termed initial weight (IW) while the weight measured at the end of the feeding trial was called final weight (FW).

Total weight gain: This was calculated by subtracting initial weight from the final weight of the birds, for starter and finishing phases respectively.

Average Daily Weight Gain: this was computed by subtracting the initial weight from the final weight, then dividing the result by duration of study (28 days for starter and 49 days for finisher).

$$ADWG = \frac{FW - IW}{Duration\ of\ study}$$

Where; ADWG = Average daily weight gain, FW =Final weight, IW =Initial weight.

Feed Intake: Weighed quantities of feed were supplied *alibitum* to the chickens in each replicate and left over were weighed at the end of every week. Records of feed intake (FI) were determined weekly by calculating the difference between the feed supplied (FS) and feed left over (FLO), i.e. FS – FLO. Total feed intake was determined as the sum of the weekly feed intake. This was divided by the number of birds per replicate to obtain average feed intake.

Average daily feed intake was calculated as

$$ADFI = \frac{\Sigma(FI1+FI2+FI3+FI4}{Duration\ of\ Study\ (28days)}$$

Feed Conversion Ratio (FCR): Feed conversion ratio was calculated as ratio of feed consumed(g) to body weight gain(g)

$$FCR = \frac{Feed\ intake(g)}{Body\ weight\ gain(g)}$$

2.7 Digestibility Trial

The digestibility trial was carried out on the 4th week of the experiment, 1 broiler bird per replicate was selected, and kept separately in appropriate digestibility cages equipped with individual feeders, water troughs and facility for separate excreta collection for the experiment. A 3 – day acclimatization period was allowed prior to the commencement of digestibility trial. The weight of feed given to each bird was recorded. The total droppings voided from the birds was collected in a labelled envelop, weighed wet and dry in the oven at 105^{0}C to constant weight daily. The dried droppings from the same replicate was pooled and milled. The dried, pooled and milled samples were analyzed for dry matter (DM) crude protein (CP), crude fibre

(CF), ether extract (EE) and nitrogen free extract according to standard procedures of AOAC (2015). The apparent digestibility was calculated using the formula of Aduku (2004).

$$\text{Apparent digestibility} = \frac{Weight\ of\ Nutrient\ intake\ in\ feed - Weight\ of\ Nutrient\ voided\ in\ feaces}{Weight\ of\ Nutrient\ intake\ in\ feed} \times 100$$

2.8 Cost Analysis

The cost per kilogram of each experimental diet was calculated based on the current prices of feed ingredients in Makurdi. To calculate the cost per kilogram of feed, the unit price, (P, ₦) of each ingredient was multiplied by the quantity (Q, kg) of that ingredient in % for the different experimental diets and divided by 100 (i.e. Cost/kg = $\frac{P\ x\ Q}{100}$). This gave the cost contribution in the diet. The sum of cost contributions from all the ingredients gave the cost per Kg diet. The cost of feeding each bird was calculated as the cost of 1kg of feed multiplied by the amount (Kg) of feed consumed by the bird (i.e. cost of feeding/bird = cost/kg feed x feed intake).

For the calculation of cost per kg weight gain, the cost per kg of each diet was multiplied by feed conversion ratio, (i.e. Cost/kg/WG = Cost x FI/WG). Total cost was determined as the sum of day old, operational cost (cost of feeders, drinkers, transportation, housing, light and vaccines/drugs) and cost of feeding. Birds at the starter phase were sold at a flat rate of ₦4000/ brooded chick.The profit was calculated by difference as, profit = revenue (R) - total cost (TC).

Rate of return on investment was calculated as given in the formula;

$$\text{Rate of return on investment} = \frac{Profit}{Cost\ of\ production} \times 100$$

2.9 Data Analysis

The data collected (with exception of results of chemical analysis of test ingredients and diets) were analyzed by one-way Analysis of Variance (ANOVA) and where significant differences occurred at P<0.05, treatment means were separated using Duncan's Multiple Range Test (DMRT) using computer software known as Statistical Package for Social Science (SPSS) 20th version (2021). Data in percentages were first subjected to arcsin transformation before ANOVA was done on them.

3 RESULTS AND DISCUSSION

3.1 Proximate Constituents of RMFP-MOM

Results of proximate constituents of RMFP-MOM shows that it contained 9.59% CP, 0.99% EE, 11. 51%, moisture, 8.10%CF, ash 5.47% and 75.85 %NFE. Metablizable energy; calculated from the proximate components using the formula of Pauzenga (1985) was 3127.79 kcal/kg ME. The 9.59% CP of RMFP-MOM mix was similar to that of maize grain (9%) as reported by Aduku (1993). The high protein content of the mixture is likely the consequence of mixing maize offal (12.80 % CP) (Ezieshe *et al.*, 2011)and rejected mango fruit pulp (3.8% CP) (Orayaga *et al.*, 2015)and an interplay of microbes inoculated by chance, which over time, multiplied during the drying period thereby increasing the CP content of the test ingredient (RMFP-MOM). The result of this study was consistent with the findings of Orayaga *et al.* (2015) who also reported that an increase crude protein level in feed materials could be as a result of chance fermentation.

The mixture had lower fat (0.90 %) and higher fibre (7.39 %) in comparison to maize (4.00 and 3.00 % respectively) reported by NIAS (2020); but lower than that of maize offal. Since maize offal has higher fat and fibre (2.80 and 12.00 % respectively; NIAS 2024), it is expected as such, when mixed with rejected mango fruit pulp with lower fat and fibre, the mixture had these proximate constituents in-between; being above rejected mango fruit pulp and below maize offal. This mixture by chemical composition has the potential to replace maize in broiler chicken diets.

While the energy was lower than 3420kcal/kg in maize as reported by Aduku (2004), it was similar to 3150.00 kcal/kg reported by NIAS (2020).

Table 2: Proximate Composition and Metabolisable Energy values of RMFP-MOM

Nutrients	Values (%)
Crude protein	9.59
Ether extract	0.99
Moisture	11.51
Crude fibre	8.10
Ash	5.47
NFE	75.85
ME	3127.79 (Kcal/Kg)

NFE=nitrogen-free extract, ME=metabolizable energy (Kcal/kg), RMFP-MOM=rejected mango fruit pulp-maize offal mix, ME=(37 x CP) + (81.1 x EE) + (35.5 x NFE) Pauzenga, 1985.

3.2 Growth Performance of Starter Broiler Chicks

Result of growth performance of the starter broiler chicks is presented in Table 3. Feed conversion ratio, protein efficiency ratio (PER) and mortality were not significantly ($p>0.05$) different among treatment groups. Performance parameters such as final body weight, daily weight gain and DFI were significantly reduced ($p<0.05$) at T5 (20% RMFP-MOM). The final body weight of broiler starter chickens was higher than 436.22g to 563.93g reported by Orayaga *et al.* (2015) when broiler starter chickens were fed diets containing mango fruit reject meal but, close to the range 945. 14- 1143.75g final weight reported by Zendesha *et al*. (2025) when different strains of broiler chickens were fed with common or uniform diets. The significant differences observed in the final weights, daily weight gain and daily feed intake at the starter phase collaborates the report of Orayaga *et al*. (2017) who also reported differences among treatments on these parameters. The values reported for final weights in this study were however, higher than the value (436.22 – 564.93 g/bird) reported by Orayaga *et al*. (2017) when strater broiler chickens were fed diets containing composite mango fruits reject meal. Comparing this growth performance result to pervious reports, the performances of the birds was undoubtedly high across the treatment groups. The test ingredients, strain of birds, management and environmental factors could also result to differences between the present study and previous findings.

Daily weight gain was patterned as the final body weight. The values obtained in this study were also higher than 14.14 – 18.46 g/bird/day reported by Orayaga *et al*. (2017). Though the experimental diets were formulated to meet the requirements of the chicks as can be seen in the calculated nutritional composition, an increase in the level of RMFP-MOM resulted to an increase in fibre levels with a corresponding decrease in the energy content of the diets. This reason could account for the poor performance of birds in T5 (20 % RMFP-MOM) in their growth parameters of final body weight and daily weight gain. It is also likely that nutrient utilization was reduced by increase in fiber occasioned by increase in RMFP-MOM. High fiber is implicated for reduced utilization of nutrients by monogastric animals (Carew *et al*., 2020).

Table 3: Effect of RMFP-MOM based diets on growth performance of starter broiler chickens (28 days)

Parameters	Treatments T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	T5 (20%)	SEM	P-value
Initial body weight (g/bird)	44.48	43.80	43.88	44.15	44.90	0.59	0.18
Final body weight (g/bird)	1080.00^{a}	1076.97^{a}	1078.28^{a}	1027.14^{a}	926.81^{b}	16.52	0.00
Daily weight gain (g/bird)	36.98^{a}	36.89^{a}	36.94^{a}	35.10^{a}	31.51^{b}	0.59	0.00
Daily feed intake (g/bird)	54.98^{b}	58.82^{ab}	61.31^{a}	57.54^{ab}	46.39^{c}	1.38	0.00
Feed conversion ratio	1.48	1.60	1.66	1.64	1.47	0.03	0.15
Protein efficiency ratio	2.80	2.64	2.51	2.54	2.83	0.05	0.14
Mortality (%)	0.25	0.75	1.00	0.50	0.25	0.15	0.50

* abc=means on the same row with different superscripts are significantly ($p<0.05$) different from each other, SEM = standard error of mean, RMFP-MOM = Rejected mango fruit pulp-maize offal mix.

It can also be seen that the inclusion of RMFP-MOM up to 20% resulted to a decline in daily feed intake. Implying the inability of the birds to consume much of the feed probably due to high anti-nutritional factor and high fibre levels. This observation is in line with an earlier report of Orayaga *et al.* (2018) who reported that in as much as mango fruit is known to convert its acids to sugar at ripening, this biochemical process is more efficient during normal ripening. For rejected mango fruit, 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 poor feed intake and depressed overall general performance of the chicks as some of these acids are anti-nutritional. The authors further states that, sour taste alone may not be an impediment to feed intake of broiler chickens but somehow, these acids, being anti- nutritional, may have affected feed intake and utilization. This observation also agreed to the report of Oloruntola (2018) who observed a significant decline in the performance of broiler chickens when fed Gloricidia leaf meal at 10 % thus, attributing it to the high concentration of anti-nutritional factors. The significant difference ($p<0.05$) reported for daily feed intake by Orayaga *et al*. (2017) was consistent to this study, the values obtained in this study were higher than those (32.74-36.94 g/bird/day) reported by these authors.

Feed conversion ratio (FCR) even though, not significantly affected, tended to increase in no particular pattern across the treatment, implying poor utilization. This FCR (1.4 to l.66) was however better than 1.96 to 2.41 and 1.80 to 1.88 reported by Orayaga *et al*. (2017) and

Adedokun *et al*. (2022) respectively. The non- significant difference (p<0.05) recorded for FCR in this study contradicts the findings of Orayaga *et al*. (2017) but in line with the report of Adedokun *et al*. (2022) when different strains of broiler chickens were fed with straight diet. The non-significant effect (p>0.05) FCR and PER of starter broiler chickens fed RMFP-MOM compared favourably with the control. This is an indication of comparable utilization of the nutrients in the experimental diets. similarly, mortality was not affected by dietary treatment but probably may be due to other management factors during brooding.

3.3 Digestibility of Nutrients by Broiler Starter Chicks

The digestibility of nutrients by broiler starter chicks fed diets containing graded levels of RMFP-MOM is presented in Table 4 The result showed no significant difference (p>0.05) among the treatment groups for crude protein, dry matter and nitrogen-free extract digestibilities except in ether extract and crude fibre. There is significantly higher (p<0.05) digestibility of ether extract in T5 (89.20%), T2 (85.95%) and T4 (87.86%) compared to T1 (80.73%) and T3 (81.22%) which are similar and significantly lower in ether extract digestibility. The crude fibre digestibility was significantly higher (p<0.05) in T2 (66.4%), T3(56.71%) and T4 (61.05%) while treatments T5 (36.51%) and T1(47.20%) had lower digestibility values.

Table 4: Effect of RMFP-MOM Based Diets on Nutrients Digestibility of Starter Broiler Chickens

Parameters	Treatments						
	T1 (0%)	**T2 (5%)**	**T3 (10%)**	**T4 (15%)**	**T5 (20%)**	**SEM**	**P-value**
Crude protein (%)	74.73	78.02	72.78	83.52	79.06	1.42	0.14
Ether extract (%)	80.73^{b}	85.95^{ab}	81.22^{b}	87.86^{a}	89.20^{a}	1.08	0.02
Dry matter (%)	80.18	83.08	80.20	86.51	82.85	1.19	0.25
Crude fibre (%)	47.20^{bc}	66.41^{a}	56.71^{ab}	61.05^{ab}	36.51^{c}	3.17	0.01
NFE (%)	89.20	90.50	89.13	92.10	90.87	0.54	0.41

* a,b,c means on the same row with different superscripts are significantly (p<0.05) different from each other, SEM = standard error of mean, RMFP-MOM = Rejected mango fruit pulp- maize offal mix, NFE= Nitrogen-free extract

The digestibility of dry matter (DM), crude protein (CP) and Nitrogen -free extract (NFE) were not significantly affected (p>0.05) among the treatment groups implying that, the digestive physiology of the starter broiler chicks was not altered in any direction by the inclusion of RMFP-MOM in their diets. This result shows that the digestibility of these nutrients was at levels equivalent to the control. The inclusion of RMFP-MOM did not exact any effect on them and the values obtained of thee nutrients did not imply a decline in the digestibility of them since they were comparable to normal literature values. The digestibility values obtained were in the ranges of 56.00-97.00 %, 52.00-92.00 %, 46.00-93.00 %, 50.00-76.00% for DM, CP, EE and CF respectively reported by Atchade *et al*. (2019) to be the digestibility values reported in most experimental studies carried in Africa using balanced diets comprising of both agricultural by products and conventional feed ingredients. The higher digestibility of fats in this study by the birds on diets containing RMFP-MOM might be due to higher concentration of polyunsaturated fats (PUFA) which enhance lipase activity and bile secretion. This was in affirmation with the report of Upah *et al*. (2021) who reported that fats containing higher saturated or unsaturated fatty acids or a mixture enhances bile secretion and lipase activity, which promote digestibility in young chickens by increasing the ability to form micelles, which facilitates digestion and absorption of fats. Values of digestibility of fat in this study were similar to the range of 87. 81 to 89.19 % reported by Upah *et al*. (2021) when starter broiler was fed diets containing spurge weed. The digestibility values for crude fibre in this study was lower than 61.06 to 69.21 % reported by Upah *et al*. (2021). Fibre digestion was declined at 20% RMFP-MOM inclusion implying the starter broiler chicks' inability to handle RMFP-MOM above 15%. The animal's ability to cope with them as well as fibre will be determined by the age of the animals as can been seen in this study when RMFP-MOM went above 15%.

3.4 Economics of production of starter broiler chicks fed diets containing graded level of RMFP-MOM

Results of the economics of finisher broiler production is presented in Table 11. Similar to the starter broiler diet, the unit cost of feed reduced from 554. 30- 512.25 Naira/kg with increasing level of RMFP-MOM in the diet. The cost of feed consumed was higher in the birds on T3 (2416.74 Naira/bird) with the least recorded in the birds on T5 (1850.38 Naira/bird). The consumption of birds in T1, T2 and T4 however, worth similar amount.

The cost of production was observed to be high in birds on T3 (4621.37 Naira/bird) followed by those in T2, T4 and T1 with the lowest observed in T5 (4055.01). Higher revenue was realized from the sales of birds on T1, T2, T3, and T4, than those on T5. Save for T4, these values were observed to decline with increasing level of RMFP-MOM. the gross profit/bird was seen to decline as the level of RMFP-MOM in the diets increased with the exception of the birds in T4. The rate of return on investment followed a similar trend as that of gross profit.

Table 5: Effect of RMFP-MOM Based Diets on Economics of Production of Starter Broiler Chicks

Parameters (₦)	**T1 (0%)**	**T2 (5%)**	**T3 (10%)**	**T4 (15%)**	**T5 (20%)**	**SEM**	**P**
Cost/day old chick (₦/bird)	950	950	950	950	950	-	-
Operational costs (₦/bird)	1254.63	1254.63	1254.63	1254.63	1254.63	-	-
Cost/kg diet (₦/kg)	548.59	538.08	527.57	517.06	506.55	-	-
Cost of feed consumed (₦/bird)	844.65[a]	886.29[a]	905.76[a]	833.01[a]	658.02[b]	22.91	0.00
Cost per kg gain (₦/kgwg)	811.92	860.93	873.38	846.69	794.63	16.96	0.50
Cost of production (₦/bird)	3044.28[a]	3090.92[a]	3110.39[a]	3037.64[a]	2862.65[b]	22.91	0.00
Gross revenue (₦/bird)	4000.00	4000.00	4000.00	4000.00	4000.00	-	-
Gross profit (₦/bird)	955.72	909.08	889.60	962.36	1137.33	41.30	0.10
Rate of Return on investment	16.90	15.12	14.35	11.57	6.85	1.34	0.13

RMFP-MOM = Reject mango fruit pulp- maize offal mix. ₦=Naira, KgWG=kilogram-weight gain

The economic analysis of the feed cost shows steady reduction in cost per kg diet as RMFP-MOM increase in diet. A similar result was report of Shaahu *et al.* (2020) who also found that Cost per kg diet steadily decreased as the level of replacement of maize for shea butter nut meal (SNM) increased in the diets of rabbits. The difference in the cost per kg diet is because, maize which is the major energy source in the diets is priced higher than RMFP-MOM at the time of purchase. This is true when the prices of most agro and agro-industrial by-product are compared with agricultural products.

Cost of feeding and total cost of production were significantly ($p<0.05$) reduced when RMFP-MOM was added up to 20%. The cost of kg feed, the quantity of feed consumed and the weight gain by the birds influence cost of feeding and to a large extent the cost of production of birds. The cost to gain per kg of weight was similar among across the treatment groups. The variables determining the cost per kg gain are feed conversion ratio and the unit cost of the diet. Since these variables were similar across treatments, the non-significant difference observed on the cost per kg gain can be hinged on the similarities obtained in the determining variables (unit cost of the diet and FCR). This is a manifestation of the feed to gain ratio (FCR) of the experimental birds as can be seen in the performance table. Since birds are sold based on their live weight, the similar revenue derived from the sales of the birds could be a reflection of a similar final weight of the birds across the treatment.

4 Conclusion and Recommendation

Given the nutrients profile of RMFP-MOM as revealed by the result of the proximate analysis, it can be inferred that this material is a valuable feedstuff in broiler nutrition. The combination with other feed materials at levels up to 15 % provided nutritionally adequate diet for the broiler chickens that supported growth, digestibility and profitability of broiler chicks. It is therefore recommended that, RMFP-MOM at ratio of 2:3 is a good alternative feedstuff with crude protein value close to maize and should be used at levels not more than 15% for good performance.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Competing Interest

Authors have declared that they have no known conflicting interests that could have appeared to influence the work reported in this paper.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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