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National Animal Production Research Institute
Ahmadu Bello University
P.M.B 1096, Shika-Zaria,
Kaduna State, Nigeria.
Email:japr@napri.gov.ng Url:journals.napri.gov.ng

PERFORMANCE AND BLOOD PROFILE OF RED SOKOTO BUCKS FED DIFFERENT REPLACEMENT LEVELS OF MAIZE OFFAL WITH SUN DRIED MANGO (*Mangifera indica*) FRUIT WASTE MEALS

[*1]Ibrahim, T. A., [1]Turang, S., [1]Jamilu, M., [1]Abdu, S. B., [1]Hassan, M. R., [1]Musa, A. and [2]Alhabib, I. K.

[1]Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria
[1]College of Agriculture and Animal Science, Ahmadu Bello University, Mando Road, Kaduna, Nigeria
[*]Corresponding Author: taibrahim@abu.edu.ng

ABSTRACT

This study evaluated the effects of dietary replacement levels of maize offal with sun dried mango fruit waste meal (SMFWM) on performance and blood profile of Red Sokoto bucks. Four growing Red Sokoto bucks with average body weight of 11kg, aged between 8-10 months were randomly allotted to four dietary treatments with each animal serving as replicate in a 4x4 Latin Square Design with 0, 10, 20 and 30% replacement levels of SMFWM for maize offal. The parameter measured included feed intake, weight gain, nutrient digestibility, haematology and serum biochemical indices. Weight gain (0.75kg/head) and average weight gain (53.57g/head/day) were numerically higher in bucks fed 20% SMFWM compared to bucks on 0 and 10%, with 30% replacement having least ($P<0.05$) value. Dietary replacement of 0 and 20% SMFWM both recorded higher ($P<0.05$) feed intake. The 20% replacement of SMFWM had lower FCR and cost/kg gain of 6.28 and ₦368.80 respectively. The dry matter digestibility of 10% SMFWM (89.45%) was higher ($P<0.05$) than 0 and 30% replacement levels. The 0% had the least (70.56%) coefficient of digestibility for ether extract while NFE for the 10% level of SMFWM was ($P<0.05$) low than other treatments. However, the digestibility of crude protein and crude fibre was not altered by replacement levels. The lymphocyte, total protein, globulin and serum glucose were affected by inclusion of SMFWM. It was therefore concluded that SMFWM can replace maize offal up to 20% in the diet of growing Red Sokoto bucks for improved weight gain, better FCR and also cost effective without any compromise on the health of Red Sokoto bucks.

Key words: *Blood profile, Digestibility, Feed intake, Mango fruits, Red Sokoto bucks*

INTRODUCTION

The population of goats and sheep in Nigeria has been estimated to be about 72.5 and 41.3 million respectively (National Agricultural Sample Survey, 2011). From this estimate, goats represent about 54.4% of total ruminant livestock. The goats are predominantly made up of the Red Sokoto/Maradi (50%), West African Dwarf (45%) and the Sahelian (5%) breeds (Ajala *et al.*, 2008). In combination with sheep, small ruminants contribute 17% and 12% meat and milk respectively consumed in sub-Saharan Africa (Lebbie, 2004).

The requirements for meat and milk by 2050 will increase by 70%, as the world will have an expected population of more than nine billion people (Wadhwa and Bakshi, 2013). However, producing the amount of animal protein that will be needed to feed the growing population and reduce the environmental impact are the main challenges to be faced (Silva *et al.*, 2015).

Many more non-conventional feed resources are yet to be incorporated into the feed bank for low-cost animal production. This is because most of them could be gotten free or at very low costs (Orayaga and Anugwa, 2014). Agro-industrial by-products such as mango fruit waste (Rao *et al.*, 2003), mango fruit peel and mango seed kernel (Diarra and Usman, 2008), mango fruit pulp (Soomro *et al.,* 2013), integral mango meal (Silva *et al*., 2015) have been identified as feed resources.

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. The tree is believed to have originated from the Sub-Himalayan plains of Indian sub-continent. Botanically, mango belongs within the family of Anacardiaceae (Berardini *et al*., 2005). It is produced on a large scale around many countries of the world, with total world figure put at 38 million metric tonnes (USDA, 2010).

The fruit could however, be considered unfit for human consumption due to bruises, infections, improper handling, and activities of animals (especially birds) on the fruit, and as such rejected. These rejected fruits, also known as cull fruits (Sruamsiri and Silman, 2009) litter the ground during its season, constituting environmental hazard.

According to Rao *et al*. (2003), dried mango waste included in finishing pig diets at 10% had no deleterious effect on feed conversion ratio, animal performance and was cost effective. Although the seed and peel of mango fruits have been utilized in animal feeding, a large quantity of the pulp and peel of rejected fruits wastes are thrown away in Nigeria. However, considering the high nutrients (energy, vitamin A, vitamin C and polyphenols) value of mango fruits (Sanon *et al*., 2013), these rejected fruits could serve as a feed resource in animal feeding, mainly as a source of energy because of its high energy - 100 kcal/oz (3527.34 kcal/kg) DM (Sruamsiri *et al.,* 2009), and at the same time check its negative impact on the environment. Mango can be found in several locations in Nigeria in its improved and native forms but little is known about its potential for feeding livestock. Also, it is important to recognize its impact on the performance and metabolism of growing ruminants. This indicates the need for an investigation, and in the context of evaluation, the metabolic profile becomes an adequate tool. The metabolic profile allows us to establish the nutritional status of the animals based on the blood analysis of representative groups using biochemical indices of energy and protein. This study therefore evaluated the performance and blood profile of Red Sokoto bucks fed diets containing different replacement levels of maize offal with SMFWM.

MATERIALS AND METHODS

Study Site

The study was conducted at the Small Ruminant Unit of the Department of Animal Science Teaching and Research Farm, Ahmadu Bello University, Zaria. Zaria is within the northern guinea savannah zone of Nigeria, latitude 11^{0} 14' 44" N and longitude 7^{0} 38' 65" E, at an altitude of 610m above sea level. The climate is relatively dry with mean annual rainfall of 700mm – 1400mm, occurring between the month of April and September (Ovimaps, 2014).

Sourcing of mango fruits wastes and diet formulation

The mango fruits wastes were collected without preference to varieties from mango tree stand within Kaduna town during its season, between March and May. The composite comprising improved and local mango varieties were cleaned, cut open, sun dried for seven days and milled using 5mm sieve mesh after which they were stored in polythene sacks pending diet formulation. Other feedstuffs were purchased from a reputable feed miller. Four iso-nitrogenous and iso-caloric diets were formulated with SMFWM at 0, 10, 20 and 30% replacement levels (Table 1).

Table 1: Ingredients and calculated nutritional values of the experimental diets

Parameter (% of DM)	0%	10%	20%	30%
Roselle Seeds	20.00	20.00	20.00	20.00
Maize offal	40.00	30.00	20.00	10.00
Groundnut Cake	10.00	10.00	10.00	10.00
Rice bran	27.00	27.00	27.00	27.00
SMFWM	0.00	10.00	20.00	30.00
Bone meal	2.00	2.00	2.00	2.00
Salt	1.00	1.00	1.00	1.00
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated composition (% of DM)				
Crude protein	12.19	12.17	12.16	12.15
ME (kcal/kg)	2051	2073	2091	2119
Ether Extract	6.71	6.98	7.25	7.52
Crude fibre	20.33	20.11	19.89	19.67
Cost (Naira/kg DM)	73.65	67.65	61.65	55.65

DM= Dry Matter, SMFWM=Sun Dried Mango Fruit Wastes Meal, ME=Metabolizable Energy

Experimental design

Four healthy growing Red Sokoto bucks of about 8 to 10 months old (9–14kg) purchased from a livestock market in Giwa Local Government Kaduna State were used for the experiment. The animals were randomly allotted into four dietary treatments with every animal serving as replicate of the dietary treatment in a 4x4 Latin square design with four treatments, four periods and four animals per square.

The experiment lasted for a total period of 112 days. The experimental animals were housed in individual metabolic crates of 6.25m^2 with feeders and drinkers and treated against endo and ecto parasites using Ivomec according to the manufacturer's recommendation, after which the animals were placed on experimental diet and each round allowed for 14 days adjustment period during which they were fed with the dietary treatments before commencement which lasted for another 14 days in four successions. At every phase of the experiment, the animal's body weights were taken using a spring balance for three consecutive times and the average value recorded. The animals were fed the concentrate diet at 2% and cowpea husks at 1% of live weight daily at 8:00 am while the offer and leftover of feeds were weighed daily to calculate the voluntary intake. Daily faecal outputs collected during each period were weighed, sub sampled and sun dried for 48hrs for dry matter determination which were later bulked for laboratory analysis. According to MAFF (1983), the digestibility coefficients of nutrients were calculated as:

Digestibility coefficient of nutrient

$$= \frac{\text{Nutrient intake (g/d)} - \text{Faecal nutrients (g/d)}}{\text{Nutrient intake (g/d)}}$$

Sample analysis

Feeds and faeces

The proximate analysis of SMFWM, cowpea husks, experimental diets and faeces was conducted according to standard methods (AOAC, 2005). The residual dry matter of the samples was determined by oven-drying at 60^{o}C for 48h. Nitrogen was determined by the micro Kjeldahl method with Tecator Product apparatus (Kjeltec^{TM}2100), while crude protein was calculated by multiplying N×6.25. The Soxhlet extraction procedure was used for determination of crude fat (ether extract) using electromantle ME. The ash was measured by combustion of the dried material in a muffle furnace at 600^{o}C for 8h. Crude fibre, sequential neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined using Tecator Line (FT 122 Fibertec^{TM}) according to the method described by Van Soest (1991). The concentration of phytic acid was determined according to Wheeler and Ferrel (1971). A standard curve of ferric nitrate was plotted. Phytate phosphorus was calculated from the standard curve assuming a 4:6 Fe to P molar ratio. The concentration of total tannins present was determined colorimetrically as described in AOAC (2005), whereby tannic acid was used as a reference standard. The content of metabolisable energy (ME) in each diet was determined using the equation of Pauzenga (1985).

ME (Kcal/kg DM) = 37 × %CP + 81.8 × %EE +35 × %NFE

Blood analysis

Blood samples of 10 ml volume were taken from the jugular vein of each animal using a hypodermic needle at end of every 14 day of each phase of the trial into two types of test tubes; 5 ml into sterile plain test tubes for serum preparation and the remnant 5 ml into Ethylene Diamine Tetra Acetic acid (EDTA) anticoagulant bottles containing 0.5ml EDTA for determination of haemoglobin (Hb), packed cell volume (PCV), red blood cells (RBCs), white blood cells (WBCs), lymphocytes and neutrophils according to standard methods (Coles, 1986). The blood in EDTA anticoagulant bottles was immediately inserted in ice containers. RBCs count was done in a haemocytometer chamber with Natt and Herdrics diluents to obtain a 1:200 blood dilution. The number of leucocytes was estimated as total WBC×200. PCV was determined as micro haematocrit with 75×16mm capillary tubes filled with blood and centrifuged at 3000 rpm for 5 minutes. The differential count of leucocytes was obtained from blood stained with Wrights dye and the neutrophil and lymphocyte cells were counted with a laboratory counter while the Hb concentration was also calculated. The serum biochemical parameters determined were blood urea nitrogen, glucose, total serum protein, globulin, albumin, creatinine and cholesterol. The blood in the plain test tubes was immediately centrifuged for serum preparation so as to ensure optimum glucose determination. Blood glucose was measured by the glucose oxidase method. It involved the production of a coloured compound from the activities of glucose oxidase enzyme on Beta-D-glucose and the colorimetric measurement of the coloured compound (Miller, 1959). Total serum protein and serum globulin were determined using the burette method as described by Doumas (1975); urea nitrogen was analyzed by the di-methyl monoxide method as described by Varley *et al.* (1980). Creatinine was determined by the Jaffe reaction method (Jaffe, 1886). Albumin was measured using dye–binding technique with bromocresol green as described by Doumas and Bigger (1972), while serum cholesterol was assessed according to the reaction described by Adolph (1918).

Statistical analysis

All data collected during the experiment were subjected to statistical analysis using the general linear models (GLM) procedure of SAS version

9.13 (SAS 2002) according to a completely randomized model. Significance was declared at P<0.05. Significantly different means were compared using Duncan multiple range test (Duncan 1955).

RESULTS AND DISCUSSIONS

Chemical composition of mango fruits wastes and experimental diets

The proximate composition of the experimental diets and mango fruits wastes are presented in Table 2. The analyzed total tannin and phytate for SMFWM are 2.40% and 0.09% respectively. The crude protein content of mango fruits wastes in this study was 6.56% which is within the range of values of crude protein (4.6 to 9.1%) of mango fruit peel reported by Règo *et al*. (2010). It was slightly higher than the crude protein of 5.6% reported by Silva *et al*. (2015) for integral mango meal and<5.0% reported by Kansci *et al.* (2008). Nunes *et al.* (2007) reported the proximate composition of mango fruit pulp alone as 4.2% CP, 6.9% crude fibre, 2.4% EE, and 83.3% NFE. The crude fiber, EE and NFE obtained in this study were slightly lower than that reported by Nunes *et al*. (2007). Though, the EE (2.04%) observed in this study was lower than the 4.12% reported by Silva *et al*. (2015) for integral mango meal, the NFE (72.76%), lignin (11.72%), ADF (29.88%), NDF (58.49%) and tannin (3.40%) levels were higher. Kansci *et al.* (2008) reported that mango fruit composition varies greatly. It may therefore be normal to have differences among different reports. It is also likely that the factors making the mango fruits to be rejected by humans such as bruises, infections, premature ripping and/or premature fallen from the tree etc. contribute to variation in the chemical compositions. It could also be due to varietal differences as well as part of the fruits of interest.

Table 2: Chemical compositions of dietary treatments, SMFWM and Cowpea husk

Component (% of DM)	0%	10%	20%	30%	SMFWM	CH
Dry matter	87.33	86.77	86.47	86.45	92.65	89.92
Crde protein	11.01	10.68	10.56	10.08	6.56	12.97
Crude fibre	21.64	24.12	25.67	25.35	4.89	33.40
Ether extract	4.15	4.20	4.51	4.09	2.04	5.65
Ash	10.74	10.79	8.26	10.68	7.37	7.14
Nitrogen free extract	52.46	50.21	51.00	49.80	72.76	53.09
Acid detergent fibre	39.10	37.98	39.50	38.88	29.88	39.44
Neutral detergent fibre	48.76	46.99	49.80	50.08	43.40	56.58
Lignins	12.14	15.03	10.70	17.04	11.72	21.67
Hemicellulose	9.66	9.01	10.30	11.20	13.52	17.14

DM= Dry Matter, SMFWM=Sun Dried Mango Fruit Wastes Meal, CH=Cowpea Husk

Table 3: Feed Intake and Growth Performance of Red Sokoto bucks fed diet containing SMFWM as a replacement for maize offal

	Replacement levels of SMFWM				
Variables	**0%**	**10%**	**20%**	**30%**	**SEM**
Initial weight (kg/head)	11.38	11.38	10.88	10.38	0.38
Final weight (kg/head)	12.00[a]	11.93[a]	11.63[a]	10.60[b]	0.40
Weight gain (kg/head)	0.63[a]	0.55[ab]	0.75[a]	0.38[b]	0.10
Average weight gain (g/head/day)	44.64[ab]	39.29[bc]	53.57[a]	27.15[c]	6.18
G/Haulms Intake (g/head/day)	106.43	88.31	98.84	88.57	11.67
Concentrate Intake (g/head/day)	220.54[a]	163.31[b]	207.14[a]	172.86[b]	12.65
Total feed intake (g/head)	4577.50[a]	3522.50[c]	4091.30[ab]	3660.00[bc]	255.60
Average feed Intake (g/head/day)	326.97[a]	251.61[c]	291.99[b]	261.43[c]	18.28
Feed conversion ratio	7.28	6.44	6.28	6.76	1.87
Feed cost (₦/kg gain)	535.13	434.27	386.80	535.99	-

[a-c]Means with different superscript within rows are significantly different ($P<0.05$), SMFWM= Sun Dried Mango Fruit Wastes Meal. SEM= Standard Error Mean. G= Groundnut

Feed Intake and Growth Performance of Red Sokoto Bucks Fed Diets containing SMFWM as a Replacement for Maize offal

Table 3 shows the effects of SMFWM as a replacement for maize offal on feed intake and growth performance of Red Sokoto bucks in diets. The weight gain and feed intake obtained in this study were higher (P<0.05) for 0, and 20% and numerically higher for 10% inclusions of SMFWM than for the dietary inclusion level of 30%. The 20% SMFWM inclusion level had statistically (P<0.05) lower feed cost per kg gain and FCR while treatment with 30% inclusion level had the highest feed cost per kg gain. Feed cost per kg diet reduced as the inclusion level of mango fruit waste increased implying there was reduction in the cost of the diets. Sanon *et al*. (2013) reported an improvement in chemical composition and higher feed intake for mango peels and kernels by sheep while Silva *et al.* (2015) observed no effect on nutrient intake of lactating goats fed diets containing integral mango meal as replacement for corn. Maize offal has low nutritive values compared to corn also the difference in sex and physiological status of the animals may justify the variation. The weight gain obtained for 20% replacement level (53.57g/head/day) as reported in this study is slightly higher than the 50g/head/day observed for sheep by Sanon *et al*. (2013). The improved weight gain up to 20% replacement of SMFWM may be attributed to the better digestion of the diet. The drop in voluntary intake and weight gain of bucks fed 30% SMFWM was due to reduction in the dietary quality which may be linked to antinutrients and in the SMFWM as earlier observed by Ravindran and Sivakanesan (1996) who stated that mango kernels were fairly rich in tannin, oxalates, cyanogenic glycosides and trypsin inhibitors which could progressively lead to reduced growth rates and less efficient feed digestion and utilization as a major component in the diets if fed unprocessed.

Nutrient digestibility of Red Sokoto bucks fed diets containing SMFWM as a replacement for maize offal

Table 4 evaluated the effect of SMFWM as a replacement for maize offal on nutrient digestibility of Red Sokoto bucks. The highest dry matter (DM) digestibility of 89.45% was observed in 10% which was similar (P>0.05) to 20% (86.15%) replacement level, but higher (P<0.05) compared to diet containing 0 and 30% SMFWM. These coefficients of digestibility of DM were above the range of 63.25-74.15% reported by (Sruamsiri *et al.*, 2009). The coefficients of digestibility for Ash and NFE as observed in this study were not altered for 0, 20 and 30% dietary replacement levels of SMFWM while 10% recorded the least value. There was no effect (P>0.05) observed in crude protein and crude fibre digestion.

Table 4: Nutrient digestibility of Red Sokoto bucks fed diet containing SMFWM as a replacement for maize offal

Replacement levels of SMFWM					
Digestibility (%)	**0%**	**10%**	**20%**	**30%**	**SEM**
Dry Matter	82.25^{b}	89.45^{a}	86.15^{ab}	81.15^{b}	2.98
Crude Protein	72.02	73.76	73.22	71.55	3.11
Crude Fibre	82.12	81.34	81.28	81.92	0.62
Ether Extract	70.56^{c}	80.11^{ab}	84.61^{a}	77.25^{b}	3.04
Ash	73.25^{a}	67.58^{b}	72.09^{a}	70.05^{ab}	1.99
Nitrogen Free Extract	69.52^{a}	68.56^{b}	69.65^{a}	66.68^{c}	0.41

$^{a-c}$Means with different superscript within rows are significantly different (P<0.05), SMFWM= Sun Dried Mango Fruit Wastes Meal. SEM= Standard Error Mean

Haematology and serum metabolite of Red Sokoto bucks fed diets containing SMFWM as a replacement for maize offal

Table 5 revealed the haematology and serum metabolites of Red Sokoto bucks fed SMFWM diets as a replacement for maize offal. There was no effect (P>0.05) observed in packed cell volume, haemoglobin, albumin and cholesterol across the treatment groups. White blood cell obtained in this study ranged from 6.40 to 10.90 with the 10% SMFWM replacement level, being higher (P<0.05) than all other treatments. The highest neutrophil 40.25% as observed for 0% SMFWM replacement level was similar (P>0.05) to 37.75% and 37.25% on 20 and 30% SMFWM but higher (P<0.05) than the diet with 10% replacement level. The lymphocyte, total protein, globulin and glucose values for dietary replacement of 0% SMFWM were lower (P<0.05) than all other treatments. The values of creatinine obtained in this study ranged from 94.00mmol/l to 111.76mmol/l with 10% dietary replacement level of SMFWM being lower (P<0.05) than 20 and 30% SMFWM. Blood urea for the dietary replacement of 0, 10 and 30% SMFWM were statistically (P<0.5) higher with 20% dietary replacement level having the lowest value.

Silva *et al*. (2015) reported that there was no effect observed on serum protein, globulin, albumin, glucose, total cholesterol, creatinne and blood urea of lactating goats fed diets containing integral mango meals as a replacement for corn from 33-100%. The effects noted in this study for serum glucose, proteins, creatinine and blood urea may be attributed to the differences in the sex and physiological status of the animals, as well as diet compositions. Maize offal was replaced with SMFWM in this study as compared to the corn (whole grain) replacement in the previous findings. This may be responsible for the variation. Despite the effects noted in some haemato-biochemical indices in this study, the values are all within the reference for normal range.

Table 5. Haematology and Serum metabolite of Red Sokoto buck fed diets containing SMFWM as a replacement for maize offal

Parameter	0%	10%	20%	30%	RVR for goat	SEM
Packed Cell Volume (%)	33.25	32.75	31.75	33.75	24-45	1.44
Haemoglobin (g/10ml)	11.30	10.62	10.55	11.23	8.0-16	0.50
Red Blood Cell (g/100m)	5.75^{a}	5.57^{ab}	5.15^{b}	5.70^{a}	5.0-8.0	0.26
White Blood Cell ($x10^3/mm^3$)	9.05^{b}	10.90^{a}	6.40^{c}	9.30^{b}	4.0-12	0.44
Neutrophil (%)	40.25^{a}	35.50^{b}	37.75^{ab}	37.25^{ab}	30-48	1.79
Lymphocyte (%)	56.00^{b}	60.75^{a}	62.25^{a}	60.25^{a}	40-70	1.51
Total Proteins g/100mI	7.40^{b}	7.80^{a}	7.70^{a}	7.90^{a}	6.4-7.9	0.25
Globulin(% of TP)	53.75^{b}	72.50^{a}	66.00^{a}	69.00^{a}	29-70	3.25
Albumin (% of TP)	24.25	26.50	25.70	26.25	20-64	1.58
Glucose (mmol/l)	2.80^{b}	3.90^{a}	3.75^{a}	4.50^{a}	2.78-4.16	0.40
Cholesesterol (mmol/l)	4.10	4.40	4.45	4.23	3.37-5.12	0.19
Creatinine (mmol/l)	102.50^{ab}	94.00^{b}	109.00^{a}	111.76^{a}	68.4-159	6.70
Blood Urea (mmol/l)	5.08^{a}	5.20^{a}	4.83^{b}	5.15^{ab}	3.6-7.1	0.11

$^{a-b}$Means with different superscript within rows are significantly different (P<0.05), SEM=Standard Error of Mean, RVR=Reference Value Range. Adopted from Tambuwa, *et al*., (2002); Daramola, *et al*., (2005); & Duncan & Pressey's Veterinary Laboratory Medicine: Clinical Pathology. 5th Eds (Larimer, K.S.)

CONCLUSION

It could be concluded that processed SMFWM holds potential for feeding Red Sokoto bucks as an energy source. Therefore, SMFWM can be included up to 20% in the diets of growing Red Sokoto bucks for improved weight gain at low production costs, without any compromise on health. The use of this non-conventional feed ingredient of no human value had led to lower production cost and more revenue will be accrued to the farmers thus encouraging them to produce more and ultimately making more animal proteins to the populace.

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