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The Effect of Cassava Chips, Pellets, Pulp and Maize Based Diets on Performance, Digestion and Metabolism of Nutrients for Broilers

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Abstract: A 21 days feeding trial was carried out with 160 Cobb male broilers to compare the effect of diets containing maize, Cassava Chips (CC), Cassava Pellets (CP) and Cassava Residue pulp (CR) on growth performance and digestive parameters of broilers. Four experimental diets with isocaloric and isonitrogenous were formulated to make the same nutrition level of them. The results revealed that feed intake to 14 or 21 days was higher ($p<0.05$) on the diets containing CP than on the other cassava products but similar to maize diet. Body weight, viscosity of the ileal digesta, digestibility of non starch polysaccharides, crude protein and dry matter as well as energy utilization, concentrations of lactic, succinic and total short chain fat acid in ileal were generally lower on diets containing the CC, CP and CR than on the diet containing maize with weight of birds on the CP being the lowest ($p<0.05$) over the 21 days growth period. However, the relative weight of the gizzard and small intestine at both 7 and 21 days of age was increased ($p<0.05$) on diets containing the cassava products while the weight of the bursa was reduced. Feed/Gain ratio over day 1-14 or 21 days was better ($p<0.01$) on the maize based diets than on the CC and CR based diets The concentrations of valeric, lactic and succinic acids in the caeca were lower ($p<0.05$) in chickens on the cassava containing diets than on the maize containing diet but the reverse was the case for formic, acetic and butyric acids.

Key words: Cassava products, broilers, performance, digestion and metabolite profiles, acids, diets

INTRODUCTION

Energy and protein feedstuffs have been the major hindrances to efficient poultry production in most of countries. Inadequate supply, exorbitant prices and diversion of cereal grains, particularly maize, toward biofuel production has led to a constant scout for alternative energy sources for poultry and other non-ruminant species (Chauynarong *et al*., 2009). In addition, the case is further accentuated by the rising competition between human and animal for these feed ingredients (Ojewola *et al*., 2006; Iheukwumere *et al*., 2008). A large quantity of cassava products are produced in South-East Asia and are used predominantly to replace more expensive cereal grains for animal feeding. Cassava products are rich in carbohydrate, total starch contents ranged from 65-70% which are basically an energy source for animal (Garcia, 1999; Uchegbu *et al*., 2011; Okoli *et al*., 2012). It has a number of advantages as feedstuff including beneficial for animal health and a high content of soft starch which rapidly absorbs water and is highly digestible in the upper digestive tract of animals (Jupamatta *et al*., 2011).

Although, cassava products have been promoted as animal feed for >2 decades, the amount used is very limited due to the unsuitable quality of cassava products available and most is being used in ruminant such as cattle than for poultry. Previous results which focused on the substitution of Cassava Meal (CM) for maize in broilers diets have shown that CM substituted for 50% of the maize or at a inclusion levels up to 25% in broiler starter have no adverse effects on the performance of the animals (Garcia, 1999; Ojewola *et al*., 2006) and the inclusion levels of 8-40% have been recommended for poultry provided the rations are balanced with respect to other essential nutrients (Ochetim, 1991; Esonu *et al*., 1999). However, the content of nutrients and anti-nutrition varies with the cassava products variety and may have different feeding value for broilers. The objective of this study was to compare the effect of higher level

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replacement of maize with three cassava products on growth, profiles of digestion and metabolite for broilers and also to provide reference information for broiler industry.

MATERIALS AND METHODS

Birds and cassava products: The experimental protocol was in agreement with the standards procedures for animal experiments and was approved by the Ethical Committee of University of New England. About 160 days old Cobb male broiler chickens (Baiada Country Road Hatchery, Tamworth, NSW, Australia) were used for this study. The birds were randomly allocated to 20 battery cages with 8 birds per cage and each experimental treatment consisted of five replicates. The treatments were: Control-Maize based diets (M), Cassava Pellets based diets (CP), Cassava Chips based diets (CC) and Cassava Residue pulp based diets (CR). All three cassava products (chips, pellets and residue pulp) were sourced from Thailand. Cassava chips used in this trail was prime quality clean roots with no stems or woody parts. Roots were chipped into small pieces and sun-dried on concrete floors for 3-6 days, depending on weather conditions and sunlight and the content of Hydrocyanide (HCN) reduced by the methods outlined by Agbor-Egbe and Mbome (2006) Pellets were obtained from dried cassava chips by grinding, steaming and hardening them into a cylindrical shape which were more compact, less dusty and very convenient for transportation and bulk shipment. Residual pulp which contained a substantial amount of starch was a by product of the cassava starch industry.

Birds husbandry: Day old chicks were kept in a warm environment. The temperature of the room was maintained at 34-35°C during days 1-7 and decreased by 3°C each week to 23-24°C by the 3rd week. Lighting was for 16 h day^{-1}. At day old, chicks were assigned to dietary treatments, considering treatments equally distributed across floors, on the basis of live weight and then were transferred to battery cages equipped with a separate feeder and a manual drinker. Both feed and water were available *ad libitum* and birds were raised and handled manually. Feed intake and body weight of birds were recorded on a weekly basis during the experiment and mortality recorded as it occurred to allow for corrected feed conversion to be calculated. Hygiene and sanitary measures were also observed during the experimental periods.

Experimental diets: Experimental diets with isocaloric and isonitrogenous were formulated according to the commercial nutrient specifications used in China (NY/T33-2004) as shown in Table 1. Before mixing the diets, all three cassava products and maize were ground to pass through a 3.0 mm screen and samples of them were determined for the content of dry matter, ether extract, nitrogen, amino acid, total starch, sugar and minerals. The Metabolizable Energy (ME) of cassava products used in formulating diets was calculated according to the equation developed by Carpenter and Clegg (1956):

Table 1: Ingredient and nutrient composition of experimental diets (as fed basis)

Ingredients (%)	M	CP	CC	CR
Maize	66.00	0.00	0.00	38.66
Cassava pellets	0.00	60.80	0.00	0.00
Cassava chips	0.00	0.00	63.49	0.00
Cassava pulp	0.00	0.00	0.00	25.00
Sunflower oil	0.00	3.50	1.00	4.80
Soycomil P (CP, 65%)	25.00	31.50	31.30	27.50
Dicalcium phosphate	2.15	2.10	2.15	2.00
Limestone	1.70	1.25	1.20	1.20
DL-methionine	0.20	0.24	0.25	0.23
Common salt	0.35	0.35	0.35	0.35
Premix[1]	0.20	0.20	0.20	0.20
Choline Cl-70%	0.06	0.06	0.06	0.06
Sand[2]	4.34	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00
Nutrition level of diets (g kg^{-1})				
ME (MJ kg^{-1})	11.92	11.92	11.92	11.92
CP	220.00	220.00	220.00	220.00
Calcium	12.00	12.00	12.00	12.00
Avail. phosphorus	5.00	5.00	5.00	5.00
Methionine	5.40	5.40	5.40	5.40
Lysine	12.50	12.50	12.50	12.50
Total starch	38.50	39.00	38.70	32.30
Total NSP	78.90	82.30	89.20	82.40

[1]Provided per kilogram of diet: Vitamin A (as all-trans retinol), 12,000 IU; cholecalciferol, 3,500 IU; Vitamin E (as d-α-tocopherol), 44.7 IU; Vitamin B12, 0.2 mg; biotin, 0.1 mg; niacin, 50 mg; Vitamin K3, 2 mg; pantothenic acid, 12 mg; folic acid, 2 mg; thiamine, 2 mg; riboflavin, 6 mg; pyridoxine hydrochloride, 5 mg; D calciumpantothenate, 12 mg; Mn, 80 mg; Fe, 60 mg; Cu, 8 mg; I, 1 mg; Co, 0.3 mg and Mo, 1 mg. [2]Particles range in diameter from 0.06-0.5 mm, red color

$$ME\ (kcal\ kg^{-1}) = 53+38\times(CP_t\%+2.25\%\times EE+1.1\times Starch\%+Sugar\%)$$

Where:

Cp_t = Crude Protein
EE = Ether Extract

The values were converted to MJ kg^{-1} using a conversion factor of 1 MJ = 239 kcal. The nutrient content of maize and other ingredients were adopted in formulating diets based on the NY/T33-2004 recommended value. Experimental diets were provided as mash and titanium dioxide (TiO_2, 0.5%) was added as an indigestible marker.

Sample collection: Swabs of excreta were collected daily between day 18 and 21 for the determination of total tract digestibility on nutrients. After collection, excreta were dried at 80°C. On day 22, four birds per cage were killed by cervical dislocation and the small intestine was removed. The mesentery was also removed and contents of the ileum and caeca were collected. The pH value of the contents was measured and approximately 5 g of digesta were used for viscosity and Short Chain Fatty Acid (SCFA) analyses. The remaining digesta were stored at −20°C and subsequently freeze-dried. After freeze-drying, the samples were preground with a pestle and mortar and subsequently further milled through a Retsch mill to pass through a 1 mm screen. On day 7 and 21, one bird per cage was randomly selected, slaughtered by cervical dislocation and dissected to obtain the weights of liver, spleen, pancreas, bursa, gizzard, proventriculus and small intestine. The digestive tract regions were weighed with empty condition.

Chemical analysis: All samples were analyzed in duplicate. Diets, digesta and excreta samples were analyzed for dry matter, TiO_2, nitrogen, total starch, Gross Energy (GE) and Non-Starch Polysaccharides (NSP) to determine nutrient digestibility. GE of the samples was determined using an IKA®-WERKE bomb calorimeter at University of New England, Australia. Total starch was determined colorimetrically using Megazyme Glucose (HK) 20 assay kit and the procedure described by Mccleary *et al.* (1997). NSP contents were measured by gas chromatography (VARIAN, CP-3800, USA) as outlined by Englyst and Hudson (1993).

Statistical analysis: Data were subjected to one-way ANOVA using the General Linear Model procedure of SAS to assess the main effects of treatment. Differences of variables were separated using Duncan's multiple-range test at p<0.05 level of significance.

RESULTS AND DISCUSSION

Feed intake from day 1-14 or 21 days was higher (p<0.05) on the diets containing cassava pulp than on the other cassava products but similar to maize diet. Body weight was generally lower on diets containing the cassava products than on the diet containing maize with weight on the pellets being the lowest (p<0.05) between day 1 and 7, 14 or 21 days. Feed/Gain ration from day 1-14 or 21 days was lower (p<0.05) on the maize based diets than on the cassava chips and pellets based diets (Table 2).

The viscosity of the ileal digesta was lower (p<0.05) in chicks on the cassava containing diets than in those on the maize containing diet (Table 3). However, the cassava products caused a reduction (p<0.05) in the digestibility of NSP, Crude Protein (CP) and Day Matter (DM) as well

Table 2: Biological response (feed intake, g; body weight, g; FCR) of birds on diets

Biological response	Treatments M	CP	CC	CR	SEM	p-value
Day 1-7						
Body weight	131.50^{a}	109.60^{b}	113.50^{b}	126.30^{ab}	4.30	*
Feed intake	102.40	103.20	104.20	108.70	2.10	NS
Feed/Gain	1.19	1.26	1.25	1.20	0.08	NS
Day 1-14						
Body weight	298.20^{a}	218.80^{c}	229.20^{c}	253.90^{b}	3.90	*
Feed intake	331.40^{a}	314.90^{c}	309.30^{c}	320.80^{b}	5.80	*
Feed/Gain	1.25^{b}	1.57^{a}	1.51^{a}	1.35^{ab}	0.11	*
Day 1-21						
Body weight	527.10^{a}	398.60^{c}	401.20^{c}	470.50^{b}	7.90	*
Feed intake	690.10^{a}	619.50^{b}	614.30^{b}	683.90^{a}	10.20	*
Feed/Gain	1.52^{b}	1.78^{a}	1.76^{a}	1.62^{ab}	0.10	*

Mean values without common superscript letters (a-c) within columns differ significantly (*p<0.05). NS: Not Significant, p≥0.05

Table 3: Ileal digestibility (%) of diets and digesta viscosity at 21 days of age

Treatments	Viscosity	DM	CP	DE (MJ kg^{-1})	Starch	NSP
M	3.2^{a}	74.4^{a}	85.4^{a}	12.50^{a}	93.4	21.80^{a}
CP	2.4^{b}	66.6^{b}	80.9^{b}	11.70^{b}	95.2	18.60^{b}
CC	2.5^{b}	64.1^{b}	79.9^{b}	11.30^{b}	97.5	18.40^{b}
CR	2.1^{b}	69.5^{b}	83.1^{ab}	11.80^{ab}	96.5	19.10^{b}
SEM	0.1	2.2	1.3	0.04	0.7	1.29
p value	*	*	*	*	NS	*

Table 4: Total tract digestibility (%) of diets assessed between 18 and 21 days of age

Treatments	DM	CP	AME (MJ kg^{-1})	Starch
M	76.1^{a}	85.0^{a}	12.20^{a}	98.4
CP	69.7^{b}	81.8^{b}	11.50^{b}	97.6
CC	67.8^{b}	82.3^{b}	11.40^{b}	98.6
CR	72.1^{ab}	84.6^{ab}	12.00^{ab}	98.0
SEM	1.8	2.0	0.02	1.3
p value	*	*	*	NS

Table 5: Relative weight of visceral organs (g kg^{-1} live-weight) of chicks at 7 days of age

Treatments	Liver	Spleen	Pancreas	Bursa	Gizzard	Proventriculus	Small intestine
M	41.6	0.99	4.6	1.58^{a}	55.8^{c}	9.01^{b}	79.2^{b}
CP	42.8	0.91	4.9	1.15^{b}	82.4^{a}	9.14^{b}	102.5^{a}
CC	43.2	1.01	4.4	1.25^{ab}	62.8^{b}	9.32^{b}	94.6^{a}
CR	40.5	0.95	5.4	1.45^{ab}	66.7^{b}	10.75^{a}	95.1^{a}
SEM	2.69	0.16	0.6	0.18	3.9	0.76	4.7
p-value	NS	NS	NS	*	*	*	*

Mean values without common superscript letters (a and b) within columns differ significantly (*p<0.05). NS: Not Significant, p≥0.05

as lower digestible energy at this age. The results of total tract apparent digestibility at 18-21 days showed that the cassava pellets and chips based diets led to a pronounced reduction (p<0.05) in the total tract apparent digestibility of DM and CP and poorer (p<0.05) energy utilization compared to that of maize (Table 4).

The relative weight of the proventriculus, gizzard and small intestine at 7 days of age was increased (p<0.05) on diets containing the cassava products while the weight of the bursa was reduced (Table 5). At 21 days of age, the weight of the pancreas, gizzard and small intestine was generally higher ($p<0.05$) in chickens on diets containing cassava products than on the diets containing maize (Table 6).

Table 7 shows the concentrations of SCFA in the ileal contents of chicks on different diets at 21 days of age. Feeding diets containing cassava products generally led to a reduction ($p<0.05$) in concentrations of lactic, succinic and total SCFA. Formic acid was also lower in chickens on diets containing cassava pulp. The concentrations of valeric, lactic and succinic acids in the caeca were lower ($p<0.05$) in chickens on the cassava containing diets than on the maize containing diet but the reverse was the case for formic, acetic and butyric acids (Table 8).

Available reports in the literature have showed the Metabolisable Energy (ME) of cassava meal in poultry rations ranging from 12.1-18.0 MJ kg^{-1} dry matter which is close to the ME value of maize (15.2 MJ kg^{-1} dry matter) (Olson *et al*., 1969; Maust *et al*., 1972; Stevenson and Jackson, 1981) so, in this study the primary aim of incorporating the three kinds of cassava products (chips, pellets and pulp) with high levels in the diets is to serve as a replacement for maize however, the nutrients in the cassava products based diets are less efficiently used for growth of birds than the nutrients in maize based diet, especially in energy utilization (11.5 vs. 12.2 MJ kg^{-1}). It indicated that the ME value of cassava chips, pellets and pulp which was calculated according to equation developed by Carpenter and Clegg (1956) and adopted in formulating diets was higher than its real ME value. Although, the body weight of CR was significant higher than that of CC and CP and was close to that of M, only 25% cassava pulp and >39% maize were include in the diets, thus the total contribution of CR to dietary AME is much less, resulting in less effect on performance. In the earlier years many studies have been undertaken to evaluate replacement of cereals with higher levels cassava meal in poultry feeds resulting in generally depressed performance and the reasons of that generally attributed to Hydrocyanic acid (HCN) levels in cassava meal and the composition and make-up of diets and unbalancing of nutrients to meet requirements (Vogt, 1966; Machin and Nyvold, 1991; Panigrahi *et al*., 1992). In the present study, the significant depression in performance characteristics of birds fed CC and CP could not result from HCN of cassava chips and pellets but principally due to drop in feed intake and lower digestibility of nutrients. This is because the sun-drying cassava products used in study which have been known to reduce to the level of these compound to the point where they have no negative effect on the animal.

The pronounced lower in feed intake among birds fed CC and CP compared to M was in agreed with findings reported by Ochetim (1991) that there was 5% reduction in feed intake by feeding diets containing 48% cassava root meal. This phenomenon could probably be attributed to diets dusty and bulky which caused crop impaction and irritation of the respiratory tract of chickens as >60% cassava chips and pellets was included and mash feed was provided. Additionally, poor texture of cassava products affected the palatability and therefore the intake of broiler was also limited.

The reasons for higher retention and NSP digestibility of M diets than others diets observed in this trial are not known. However, one study by Stevenson and Jackson (1983) showed the inclusion of cassava root meal in chick diets can result in watery excreta. Therefore, perhaps we can speculate from this angle that the passage rate of digesta increased and

Table 6: Relative weight of visceral organs (g kg^{-1} live-weight) of chickens at 21 days of age

Treatments	Liver	Spleen	Pancreas	Bursa	Gizzard	Proventriculus	Small intestine
M	81.3	1.16	3.64^{b}	2.37	18.3^{b}	4.74	33.7^{c}
CP	81.6	1.02	4.39^{a}	2.03	24.7^{a}	5.01	41.1^{ab}
CC	82.8	1.01	4.08^{a}	2.24	21.5^{a}	4.77	36.7^{bc}
CR	85.7	1.09	4.63^{a}	2.17	26.3^{a}	5.05	45.2^{a}
SEM	4.1	0.13	0.25	0.14	1.1	0.32	2.5
p-value	NS	NS	*	NS	*	NS	*

Mean values without common superscript letters (a-c) within columns differ significantly (*$p<0.05$). NS: Not Significant, $p\geq 0.05$

Table 7: Concentrations of SCFA (mmol L^{-1}), lactic acid (mmol L^{-1}) and pH of the ileal contents of chickens at 21 days of age

Treatments	pH	Formic	Acetic	Lactic	Succinic	Total
M	7.6	0.70^{a}	3.78	28.64^{a}	0.51^{a}	33.65^{a}
CP	7.9	1.07^{a}	3.92	15.46^{b}	0.03^{b}	20.48^{b}
CC	8.0	0.91^{a}	3.39	9.49^{b}	0.03^{b}	13.32^{b}
CR	7.8	0.16^{b}	3.75	12.17^{b}	0.06^{b}	16.22^{b}
SEM	0.2	0.29	0.63	6.71	0.16	7.20
p-value	NS	*	NS	*	*	*

Mean values without common superscript letters (a and b) within columns differ significantly (*$p<0.05$). NS: Not Significant, $p\geq 0.05$

Table 8: Concentrations of SCFA (mmol L^{-1}), lactic acid (mmol L^{-1}) and pH of the caecal contents of chicks at 21 days of age

Treatments	pH	Formic	Acetic	Propionic	Butyric	Valeric	Lactic	Succinic	Total
M	7.3	0.01^{c}	96.00^{b}	10.3	12.5^{b}	1.69^{a}	1.10^{ab}	23.1^{a}	144.8
CP	7.1	0.70^{a}	94.60^{b}	8.5	16.8^{a}	1.27^{b}	2.46^{a}	16.0^{b}	140.4
CC	7.2	0.75^{a}	111.10^{a}	9.6	14.5^{ab}	1.33^{b}	0.30^{b}	16.8^{b}	154.4
CR	7.1	0.28^{b}	116.10^{a}	9.3	14.8^{ab}	1.38^{b}	0.51^{b}	16.5^{b}	152.7
SEM	0.1	0.12	7.09	0.5	1.40	0.11	0.85	5.3	9.0
p-value	NS	*	*	NS	*	*	*	*	NS

Mean values without common superscript letters (a-c) within columns differ significantly (*$p<0.05$), NS: Not Significant, $p\geq 0.05$

digest time decreased when birds fed cassava products which caused poorer nutrients utilization. Cassava pulp contains >14% crude fiber which can reduce the availability of minerals and depress nutrient digestibility (Uchegbu *et al*., 2011).

The finding for the increase in the relative weight of the proventriculus, gizzard and small intestine of broilers fed diets containing cassava products was similar with the report by Erubvetine *et al*. (2003) and Khempaka *et al*. (2009) who suggested that the increased size of the gizzard in broilers fed a high concentration of cassava could be a result of the bulkiness of the feed. With regard to the weight of the bursa of birds reduced as fed CC, CP and CR, the reason is not known.

The result that the concentration of total SCFA was lower in the ileal than that in the caecal and acetic acid was the primary SCFA detected in the digesta of both ileal and caecal was agreed with literatures (Jozefiak, 2004; Wu *et al*., 2010). The decreases in the amounts of SCFA in both ileal and caecal contents maybe partially reflect the amount of digesta contents decreased in the birds given cassava products.

Stevenson and Jackson (1981) reported the mean wet weight of the caecal contents of the birds on the diet with no added cassava meal was decreased from 5.3-3.2 g in the birds given the highest level of cassava meal but this reduction was not statistically significant. High concentrations of SCFA and lactic acid are indicative that fermentations by obligate anaerobic bacteria took place (Van der Wielen *et al*., 2000). Negative correlations between SCFA and Enterobacteriaceae had been reported by Van Immerseel *et al*. (2004). As we didn't determine the number of Enterobacteriaceae, it is difficult to deduce the relationship between SCFA and broiler health when lower mortality present in this study. The results for the SCFA would suggest that there is a change in the pattern of fermentation in the ileal and caeca associated with changes in the diet and this may contribute to the appearance of the flow rate of ileal digesta and semifluid caecal contents in the excreta.

CONCLUSION

It can be concluded from this study that completely substituted for maize with cassava chips and pellets induced a generally depression in growth, NSP and CP digestibility and ME utilization of broilers. Birds fed diets containing 25% cassava pulp exhibited poor performance and nutrients retention compared to that of maize based diets but not significant in statistics. Feed intake of broilers fed cassava chips and pellets based diets was limited as the mash feed was provided. Therefore, further evaluate for the potential value of cassava products should be focused on factors not only balance of nutrients in diets but also feed form, processing techniques and enzyme supplementation.

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