Nutrient utilization by broiler chickens fed differently processed cassava-soya blends

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Abstract

Due to insufficiency in maize supplies for use as poultry feed and its high price, there is the need for alternative energy sources for poultry. The availability of cassava in the tropical part of the world and the need to fashion a way of incorporating cheaper alternative ingredients into poultry feed makes cassava a good alternative to maize in poultry feeding. However, compared with cereal grains, cassava is low in protein and the protein it has is of poor quality with very low essential amino acid contents, hence the need to make a blend of it with oil seeds such as soyabean which are rich in protein. This study was thereby conducted to determine the nutrient utilization by broiler chickens fed diets of differently processed Cassava-Soya Blends (CSB). Cassava pulp and full fat soyabean (dry and wet heated) mixed at ratios 50:50, 60:40, and 80:20 was subjected to two types of dehydration methods (frying and sun drying) to obtain 12 types of CSB. The blends were included at 15% level in the ration of broiler chickens in a 2x2x3 factorial arrangement. 360 one-day-old Cobb-500 broiler chicks used for this study were randomly allotted to the 12 dietary treatment groups in three replicates with 10 birds each. Eight weeks of feeding trials (starter and finisher phases) were observed. Nutrient digestibility trials were carried out on the birds at 4th and 8th week of the experiment. Cassava blended with wet heated full fat soya at 50:50 had the highest crude protein (CP) of 37.72% and metabolizable energy (3,314kcal/kg) with low HCN residue of 1.70 mg/kg. The interaction of heat treatments, mixing ratio and dehydration methods resulted in higher CP digestibility from 75.82% to 77.27% and metabolizable energy from 10.65MJ/kg to 12.92 MJ/kg at the starter phase. It is concluded that the interactions of soyabean heat treatment, dehydration methods and mixing ratio of CSB positively influenced crude protein digestibility and metabolizable energy at the starter phase.

Keywords: broiler chickens, cassava-soya blends, nutrient digestibility, hydrocyanide, soyabeans

Utilisation des nutriments par les poulets à griller nourris de mélanges manioc-soja transformés différemment

Résumé

En raison de l'insuffisance des approvisionnements en maïs destiné à l'alimentation des volailles et de son prix élevé, il existe un besoin de sources d'énergie alternatives pour la volaille. La disponibilité du manioc dans la partie tropicale du monde et la nécessité de trouver un moyen d'incorporer des ingrédients alternatifs moins chers dans l'alimentation des volailles font du manioc une bonne alternative au maïs dans l'alimentation des volailles. Cependant, comparé aux céréales, le manioc est pauvre en protéines et les protéines qu'il contient sont de mauvaise qualité avec des teneurs en acides aminés essentiels très faibles,

d'où la nécessité d'en faire un mélange avec des graines oléagineuses comme le soja qui sont riches en protéines. Cette étude a ainsi été menée pour déterminer l'utilisation des nutriments par des poulets à griller nourris avec des régimes de mélanges manioc-soja (MMS) transformés différemment. La pulpe de manioc et le soja entier (chauffé à sec et humide) mélangés à des ratios 50:50, 60:40 et 80:20 ont été soumis à deux types de méthodes de déshydratation (friture et séchage au soleil) pour obtenir 12 types de MMS. Les mélanges ont été inclus à un niveau de 15 % dans la ration de poulets à griller dans un arrangement factoriel 2x2x3. 360 poussins de chair Cobb-500 d'un jour utilisés pour cette étude ont été répartis au hasard dans les 12 groupes de traitement alimentaire en trois répétitions avec 10 oiseaux chacun. Huit semaines d'essais d'alimentation (phases de démarrage et de finition) ont été observées. Des essais de digestibilité des nutriments ont été effectués sur les oiseaux à la 4^e et à la 8^e semaine de l'expérience. Le manioc mélangé avec du soja entier chauffé humide à 50:50 avait la protéine brute (PB) la plus élevée de 37,72 % et l'énergie métabolisable (3 314 kcal/kg) avec un faible résidu de HCN de 1,70 mg/kg. L'interaction des traitements thermiques, du rapport de mélange et des méthodes de déshydratation a entraîné une digestibilité de PB plus élevée de 75,82 % à 77,27 % et une énergie métabolisable de 10,65 MJ/kg à 12,92 MJ/kg à la phase de démarrage. Il est conclu que les interactions du traitement thermique du soja, les méthodes de déshydratation et le rapport de mélange du MMS ont influencé positivement la digestibilité des protéines brutes et l'énergie métabolisable à la phase de démarrage.

Mots-clés : poulets à griller, mélanges manioc-soja, digestibilité des nutriments, cyanure d'hydrogène, graines de soja

Introduction

The prices of energy source for livestock feed have been on the increase in Nigeria. The chief source of energy is maize. But maize is also required by humans and processing industries. Maize proportion in monogastric diets ranges from 50 - 70% which implies that increasing cost of maize is being currently experienced due to low level of production which invariably leads to increase cost of conventional animal feeds (Salami and Odunsi 2003). The survival of the livestock industry is dependent on the availability of feedstuffs which sometimes is unavailable due to the high competition between man and animal (Esonu *et al.*, 2006). Shortage of cereals has become a serious issue in Nigeria; using cereal products as animal feeds is economically unjustifiable. Non ruminants like poultry are markedly affected by such a trend. Maize, which is the predominantly used ingredient for energy supply in poultry feeds in Nigeria, is very costly, because of higher demand for it by humans as food and

industrial purposes (Bot *et al.*, 2013; Etuk *et al.*, 2013). Therefore, there is a need to exploit cheaper energy sources to replace expensive cereals for livestock production to relieve the food-feed competition (Oduguwa *et al.*, 2004). One of such alternatives for replacement of maize in animal diets are Cassava pulp (Abu and Onifade, 1996; Eruvbetine *et al.*, 1995, Agiang *et al.*, 2004). Cassava (*Manihot esculenta* Crantz) according to Phillips *et al.* (2004), is one of the most important food crops grown in the tropics, and a significant source of calories for more than 500 million people world-wide. Cassava products have been widely used during the last decade in animal feed as a potential source of energy in poultry diets and for other non-ruminants (Adejumo *et al.*, 2011). However, despite the good potentials of cassava, it has high percentage of antinutritional factor known as cyanide. It is also low in protein with unbalanced amino acid profile and very dusty in nature (Chauynarong *et al.*, 2009). Hence, improving the nutritional value of

cassava food products through processing becomes a necessary intervention. A solution to this problem could be grinding of the cassava alongside oil seeds such as soyabean as it has been reported by several researchers (Eruvbetine and Adejobi, 1999; Oil World, 2010; Yasothai, 2016) to be a rich source of protein which requires processing before consumption. Nigerian scientists have therefore investigated several ways of enriching cassava products by fortifying it with protein rich legume, chief of such as soyabeans. Soyabean (*Glycine max*) is an excellent source of protein (40-45%); hence the seeds are one of the richest in plant foods consumed in the world (Kure *et al.*, 1998). It is the principal protein source for monogastric animals such as poultry and represents two-thirds of the total world output of protein feedstuffs, including all other major oil meals and fish meal (Oil World, 2010). As reported by Yasothai (2016), soyabeans represent 55% of the total global production of oilseeds followed by rapeseed (14%), cottonseed (10%), peanut (8%), sunflower (9%), palm kernel (3%), and copra (1%), whereby about 98 percent of soybean meal is used as animal feed globally. This current study thereby aimed to investigate the effect of differently processed cassava-soya blends on nutrient utilization of broiler chickens.

Materials and methods

Study area

The experiment was carried out at the Poultry Unit of the Directorate of University Farms (DUFARMS), Federal University of Agriculture, Abeokuta (FUNAAB), Ogun state, Nigeria. The area falls within the rainforest vegetation zone of south western Nigeria on latitude 7°13' 49.46''N, longitude 3°26' 11.98''E with an altitude of 76 meters above sea level (Google Earth, 2020). The climate is humid within a mean annual rainfall of 1037mm. The annual mean temperature and humidity is 34.7% and 82% respectively (Federal

University of Agriculture, Abeokuta, Meteorological Station).

Ethical permit

The practices adopted in the conduct of the study was according to the guidelines approved by the project review committee of the College of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta, Ogun State.

Experimental birds and management

The feeding trial was conducted with a total number of 360-day-old Cobb 500 broiler chicks. The birds were intensively managed on a deep litter system in two phases (the starter and the finisher phases). The starter phase lasted for four weeks (0-4weeks), while the finisher phase also lasted for four weeks (4-8 weeks). The deep littered pen and equipment were washed and disinfected prior to arrival of the birds. All the routine management practices including medications (vaccines and drugs) specified for Cobb 500 breed of chickens were strictly adhered to. Feed and water were supplied to the birds *ad libitum*. The experimental birds were managed under standard management conditions of broiler chicken rearing in the tropics.

Test ingredients and processing

Test ingredients for the experiments were cassava (*Manihot esculenta Crantz*) of the variety TMS 30572 and Soyabeans (*Glycine max*) of the variety TGX 923E. The cassava tubers were obtained from local farmers within Abeokuta metropolis, Ogun state, while the soyabeans were obtained from International Institute of Tropical Agriculture (IITA), Ibadan. The cassava tubers were processed according to the protocols described by Adeyemi and Balogh (1985). They were peeled, washed and grated in a commercial grating machine. The grated cassava pulps were packed in hessian bags and allowed to ferment while dewatering gradually under pressure for 48 hours. Thereafter, the dewatered pulps were pulverized with hands and sifted on a local raffia made sieve

to remove the fibers. The soyabean seeds of the variety TGX 923E were sorted to ensure homogeneity of samples, washed, sun dried and divided into two, then subjected to two heat treatments (dry and wet heat treatments);

Dry heat treatment: Part of the cleaned raw soyabeans was poured into a hot metal dry pan (common driers). The soyabeans were dry heated by continuous stirring until the beans were slightly roasted to a golden-brown color, following the method of Cheva-Isarakul and Tangtaweewipat (1995). The dry heated soyabeans were spread to cool before milling into full fat soya meal.

Wet heat treatment: The other part of the cleaned raw soyabeans was poured into a

vat containing as much liters (unmeasured) of boiling water per each batch of kg of soyabeans. The soyabeans were allowed to soak at 100°C for 30minutes according to the methods described by Kaankukaet *al.* (1996). Thereafter, the water was decanted and the boiled soyabeans oven-dried before milling into full fat meal. Cassava-soya blends were then prepared from mixtures of sieved cassava pulps and full fat soyabeans (dry heated and wet heated) in the following ratios: 50:50, 60:40 and 80:20 (Table 1). The resulting mixtures were then further subjected to two types of dehydration methods (sun drying or frying) to make twelve different Cassava-soya blend sample treatments as shown in Table1.

Table 1: Processing techniques and mixing ratios of cassava-soya blends (CSB).

Treatments	Components	Mixing ratio	Processing techniques
CDF ₁	CP +DHTS	50:50	Frying
CDF ₂	CP +DHTS	60:40	Frying
CDF ₃	CP +DHTS	80:20	Frying
CDS ₁	CP +DHTS	50:50	Sun drying
CDS ₂	CP +DHTS	60:40	Sun drying
CDS ₃	CP +DHTS	80:20	Sun drying
CWF ₁	CP +WHTS	50:50	Frying
CWF ₂	CP +WHTS	60:40	Frying
CWF ₃	CP +WHTS	80:20	Frying
CWS ₁	CP +WHTS	50:50	Sun drying
CWS ₂	CP +WHTS	60:40	Sun drying
CWS ₃	CP +WHTS	80:20	Sun drying

CP – cassava pulp, DHTS – dry heat-treated soya, WHTS – wet heat-treated soya

Proximate composition of test ingredients

Proximate composition (moisture, crude protein [CP], crude fiber [CF], ether extract [EE], Nitrogen Free Extract [NFE] and ash content) of the cassava-soya blends were determined by method described by AOAC (2005) while the metabolizable energy was calculated using Ponzenga equation as follows: $ME = 35 \times \% CP + 81.1 \times \% EE + 35.5 \times \% NFE$. NB: ME- Metabolizable energy, CP- Crude protein, EE- Ether extract, NFE- Nitrogen free extract. Hydrogen cyanide (HCN) content was determined according to the procedure of Anhwange et al. (2004) while the trypsin

inhibition unit (TIU) was also determined.

Experimental diets and layout

The twelve dietary treatments were arranged in a 2x2x3 factorial experimental design to have 2 heat treatments of soyabean (wet and dry heat treatments), 2 dehydration methods of cassava-soya blends (sun drying and frying) and 3 mixing ratios of cassava-soya blends (50:50, 60:40, and 80:20). The cassava-soya blends (CSB) were included in the broiler chickens' diet at 15% inclusion. At the onset of the experiment, the 360 Cobb-500 one-day-old broiler chicks were randomly allotted to the 12 experimental groups (30 birds per

treatment). Each treatment was replicated three times to have 10 chicks per replicate group on weight equalization bases. At the end of the starter phase, the experimental birds were mixed together and re-assigned on weight equalization bases to the same number of dietary treatment groups with the same number of replicates. This was done to remove any carryover effect of the starter phase to finisher phase. All diets were formulated following recommended procedures (NRC, 1994) as presented in Tables 2 and 3.

Data collection

Metabolic Trial

Two birds per replicate were randomly selected and used for metabolic trials which were conducted at 28th and 56th days of the study to determine the apparent nutrient digestibility, apparent metabolizable energy (AME), true metabolizable energy (TME) and nitrogen corrected apparent and true metabolizable energy (AMEn and TMEn) of the diets. The randomly selected birds were housed separately in appropriate metabolic cages fitted with individual feed troughs and facility for separate excreta collection. The birds were acclimatized for 3 days prior to the commencement of four days metabolic trial. Known weight of feed (slightly above the respective daily requirements) was fed to the birds housed in individual metabolic cages. Excreta collected per bird per day (for four days) were dried (at 60°C), cooled, weighed and stored in well labeled, sealed sample bottles for subsequent analysis for apparent nutrient digestibility determination. At the expiration of the determination of apparent nutrient digestibility, birds were starved of diets but were given unrestricted access to clean water for 24 hours during which the excreta voided within the period (of first 24 hours starvation) was discarded. After the expiration of 24 hours starvation, each bird was dosed with 50ml of warm glucose solution to reduce stress and deprived of

feed for another 24 hours making a total of 48 hours starvation period. Total excreta collection per bird was done during the last (24 hours) phase of feed starvation for the estimation of endogenous losses which was used in the determination of True metabolizable energy (TME). Dried samples of the excreta voided were analyzed to determine their respective proximate composition (AOAC, 1990). Gross energy of the excreta samples collected and feed samples were measured using the adiabatic bomb calorimeter. The coefficient of apparent digestibility (CAD) and true digestibility (CTD) of nutrients were calculated. The following equations were used to calculate apparent nutrient digestibility, apparent metabolizable energy (AME), nitrogen corrected apparent metabolizable energy (AMEn), true metabolizable energy (TME), and nitrogen corrected true metabolizable energy (TMEn) of dietary treatments (Sibbald, 1989):

$$\text{Apparent nutrient digestibility (\%)} = \frac{\text{Nutrient in feed (DM)} - \text{Nutrient in faeces (DM)}}{\text{Nutrient in feed}} \times 100$$

$$\text{AME of feed (MJ/Kg)} = \frac{(\text{FI} \times \text{GEf}) - (\text{E} \times \text{GEe})}{\text{FI}}$$

$$\text{AMEn of feed (MJ/Kg)} = \frac{(\text{FI} \times \text{GEf}) - (\text{E} \times \text{GEe}) - (\text{NR} \times \text{K})}{\text{FI}}$$

$$\text{NR (g)} = (\text{FI} \times \text{Nf}) - (\text{E} \times \text{Ne})$$

Where;

AME = Apparent Metabolizable Energy, AMEn = Nitrogen corrected apparent metabolizable energy, FI = Feed intake (g), E = Excreta output (g), GEf = Gross energy (MJ/kg) of feed, GEe = Gross energy (MJ/kg) of excreta, NR = Nitrogen retention (g) for fed birds and K = Constant (measured as the enthalpy of oxidation of uric acid; 36.53 KJ/g), Nf = nitrogen content (g/kg) of feed, Ne = nitrogen content (g/kg) of excreta

$$\text{TME of feed (MJ/Kg)} = \frac{[(\text{FI} \times \text{GEf}) - (\text{E} \times \text{GEe})] + (\text{FEm} + \text{UEe})}{\text{FI}}$$

$$\text{TMEn of feed (MJ/Kg)} = \frac{[(\text{FI} \times \text{GEf}) - (\text{Ef} \times \text{GEe})] + (\text{FEm} + \text{UEe}) + (\text{NRo} \times \text{K})}{\text{FI}}$$

$$\text{NRo (g)} = (\text{FI} \times \text{Nf}) - (\text{Ef} \times \text{Nef})$$

Table 2: Percentage (%) composition of experimental starter diets (0-4 weeks)

Ingredients	Fried CSB blend						Sun dried CSB blend					
	Dry heated soyabean			Wet heated soyabean			Dry heated soyabean			Wet heated soyabean		
	50:50	60:40	80:20	50:50	60:40	80:20	50:50	60:40	80:20	50:50	60:40	80:20
CSB	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Maize	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
FFS	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
Soyabean meal	15.05	15.05	15.05	15.05	15.05	15.05	15.05	15.05	15.05	15.05	15.05	15.05
Palm Oil	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Fish meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Bone meal	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Oyster Shell	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
*Premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100	100	100	100	100	100
Calculated analysis												
ME(Kcal/Kg)	3187.03	3164.47	3170.18	3164.43	3168.12	3162.78	3168.83	3169.87	3163.32	3169.42	3170.31	3163.07
Crude Protein(%)	23.72	23.46	21.52	23.06	22.68	20.72	23.16	23.16	21.65	22.16	22.17	20.71
Crude Fibre(%)	3.67	3.68	3.73	3.67	3.68	3.73	3.68	3.73	3.6	3.67	3.68	3.73
Calcium(%)	1.20	1.20	1.21	1.20	1.20	1.21	1.20	1.20	1.21	1.20	1.20	1.21
Phosphorus(%)	0.68	0.67	0.67	0.68	0.67	0.67	0.68	0.67	0.67	0.68	0.67	0.67
Lysine(%)	1.20	1.21	1.21	1.20	1.21	1.21	1.20	1.21	1.21	1.20	1.21	1.21
Methionine(%)	0.47	0.47	0.46	0.47	0.47	0.46	0.47	0.47	0.46	0.47	0.47	0.46

CSB- Cassava-soya blend, FFS- Full fat soya, ME- Metabolizable energy

*Vitamin A: 4000000IU, Vit CW3: 250000IU, Vit E: 40000mg; Vit K : 800mg, Vit CDS3: 3000mg, Vit CDS2: 6000mg, Vit B : 5000mg, Vit CDS1 : 25mg, Niacin: 6000mg, Pantothenic Acid: 20000mg, Folic Acid: 800mg, Biotin: 8mg, Manganese: 300000mg, Iron: 80000mg, Zinc: 20 000mg, Copper:

25mg, Cobalt: 80mg, Iodine: 400mg, Selenium: 40mg, Chlorine: 800000mg.

Table 3: Percentage (%) composition of experimental finisher diets (4-8 weeks)

Ingredients	Fried CSB blend						Sun dried CSB blend					
	Dry heated soyabean			Wet heated soyabean			Dry heated soyabean			Wet heated soyabean		
	50:50	60:40	80:20	50:50	60:40	80:20	50:50	60:40	80:20	50:50	60:40	80:20
CSB	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Maize	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
Full fat soyabean meal	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Soyabean meal	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Palm Kernel Meal	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Fish Meal	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Wheat Offal	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05
Palm Oil	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Bone meal	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Oyster Shell	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
*Premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100	100	100	100	100	100
Calculated analysis												
ME(Kcal/Kg)	2902.28	2902.54	2902.16	2902.28	2902.54	2902.16	2902.28	2902.54	2902.16	2902.28	2902.54	2902.16
Crude Protein(%)	20.52	20.22	19.72	20.52	20.22	19.72	20.52	20.22	19.72	20.52	20.22	19.72
Crude Fibre(%)	4.24	4.26	4.29	4.24	4.26	4.29	4.24	4.26	4.29	4.24	4.26	4.29
Calcium(%)	1.20	1.21	1.20	1.20	1.21	1.20	1.20	1.21	1.20	1.20	1.21	1.20
Phosphorus(%)	0.66	0.66	0.65	0.66	0.66	0.65	0.66	0.66	0.65	0.66	0.66	0.65
Lysine(%)	1.13	1.12	1.08	1.13	1.12	1.08	1.13	1.12	1.08	1.13	1.12	1.08
Methionine(%)	0.45	0.44	0.43	0.45	0.45	0.44	0.45	0.44	0.43	0.45	0.44	0.43

CSB- Cassava-soya blend, ME- Metabolizable energy

*Vitamin A: 4000000IU, Vit CWS3: 2500000IU, Vit E: 40000mg; Vit K₃: 800mg, Vit CDS3: 3000mg, Vit CDS2: 6000mg, Vit B₆: 5000mg, Vit CDS1₂: 25mg, Niacin: 6000mg, Pantothenic Acid: 20000mg, FolicAcid: 800mg, Biotin: 8mg, Manganese: 300000mg, Iron: 80000mg, Zinc: 20000mg, Copper: 25mg, Cobalt: 80mg, Iodine: 400mg, Selenium: 40mg, Chlorine: 800000mg.

Where;

TME = True Metabolizable Energy, TMEn = Nitrogen corrected true metabolizable energy, FI = Feed intake (g), E = Excreta output (g) of fasted birds, GEf = Gross energy (MJ/kg) of feed, GEe = Gross energy (MJ/kg) of excreta, FE_m = metabolic faecal energy (KJ), UE_e = endogenous urinary energy (KJ), NRo = Nitrogen retention for fasted birds (g) and K = Constant (measured as the enthalpy of oxidation of uric acid; 36.53 KJ/g), Nf = nitrogen content (g/kg) of feed, Nef = nitrogen content (g/kg) of excreta voided by fasted birds

Statistical analysis

Data obtained were subjected to analysis of variance in a 2x2x3 factorial arrangement, and were analyzed using the general linear model procedure of SAS 9.1.3 computer software statistical package (SAS, 2002). Significant (p<0.05) means were separated using Duncan's Multiple Range Test as contained in the procedure of the statistical package.

Statistical model

$$Y_{ijkl} = \mu + T_i + L_j + M_k + (TL)_{ij} + (TM)_{ik} + (LM)_{jk} + (TLM)_{ijk} + \sum_{ijkl}$$

Where,

Y_{ijkl} = Observed values of the dependent variable

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μ = Population mean

T_i = Main effects of soyabean heat treatments (Wet and dry heat treatments)

L_j = Main effects of dehydration methods of cassava-soya blends (Sun-drying and frying)

M_k = Main effects of mixing ratio of cassava-soya blends (50:50, 60:40, 80:20)

$(TL)_{ij}$ = Interaction effects of heat treatments of soyabean and dehydration methods of cassava-soya blends

$(TM)_{ik}$ = Interaction effects of heat treatments of soyabean and mixing ratio of cassava-soya blends

$(LM)_{jk}$ = Interaction effects of dehydration methods of cassava-soya blends and mixing ratio of cassava-soya blends

$(TLM)_{ijk}$ = Interaction effects of heat treatments of soyabean, dehydration methods of cassava-soya blends and mixing ratio of cassava-soya blends

Σ_{ijkl} = Random/residual error

Results and discussion

Proximate composition of cassava-soya blends

The proximate composition of cassava-soya blends (CSB) is presented in Table 4.. The proximate values (Crude protein, Ether extract, Crude fiber, Ash digestibility, Nitrogen free extract), hydrogen cyanide and Trypsin inhibition unit) values of the CSB ranged from 18.81-37.72%, 0.47-1.40%, 4.43-5.37%, 1-2%, 55.47-75.57%, 1.60-1.77mg/kg and 2.1-7.8 mg/g, respectively. The CSB containing dry heated soyabeans and dehydrated by frying at 50:50. Sample (CDF₁) recorded the least values for crude fiber (4.43 %) and hydrogen cyanide (1.60 mg/kg) but recorded the highest value for ether extract (1.40 %). The CSB containing dry heated soyabeans and dehydrated by sun drying at 80:20 (CDS₃) had the least value for metabolizable energy (3270 kcal/kg) while CSB containing wet heated soyabeans and

dehydrated by sun drying at 60:40 (CWS₂) had the highest (3320 kcal/kg). The CSB containing dry heated soyabeans and dehydrated by sun drying at 80:20 (CDS₃) had the least dry matter (66.59 %) content and ether extract (0.47 %). The CSB containing dry heated soyabeans and dehydrated by frying at 80:20 (CDF₃) recorded the least value for crude protein (18.81 %) while CSB containing wet heated soyabeans and dehydrated by sun drying at 50:50 (CWS₁) had the highest crude protein (37.72 %) value. The hydrogen cyanide had the highest (1.77 mg/kg) and least (1.60 mg/kg) values in CSB dehydrated by sun drying and containing wet heated soyabeans (CWS₃) and CSB containing dry heated soyabeans and dehydrated by frying 50:50 (CDF₁) respectively. CSB containing dry heated soyabeans and dehydrated by sun drying at 50:50 (CDS₁) recorded the highest value for trypsin inhibition unit (7.80 mg/g) while CSB containing wet heated soyabeans and dehydrated by frying at 50:50 (CWF₁) recorded the least (2.10 mg/g) value.

Main effects of soyabean heat treatments, dehydration methods and mixing ratio of CSB on nutrient digestibility and metabolizable energy of broiler chickens (0-8 weeks)

Table 5 shows the main effects of soyabean heat treatments, dehydration methods and mixing ratio of CSB on nutrient digestibility and metabolizable energy of broiler chickens (0-8 weeks). At 0 – 4 weeks, the table showed that all the parameters measured were not significantly ($p>0.05$) affected by soyabean heat treatment. Nevertheless, higher values of crude protein digestibility, nitrogen free extract ether extract digestibility, apparent metabolizable energy, as well as true metabolizable energy and nitrogen corrected true metabolizable energy were obtained from birds fed diets containing wet heated soyabeans. At 4 – 8 weeks, nitrogen

Table 4: Proximate composition of cassava-soya blends

Samples	Dry matter (%)	ME (Kcal/kg)	Crude Protein (%)	Ether Extract (%)	Crude Fibre (%)	Ash (%)	NFE (%)	Hydrogen Cyanide (mg/kg)	TIU (mg/g)
CDF ₁	70.23	3281.62	33.47	1.40	4.43	2.00	58.70	1.60	7.50
CDF ₂	70.00	3319.98	31.75	1.11	4.51	1.00	61.63	1.61	7.40
CDF ₃	68.64	3281.54	18.81	0.58	5.03	2.00	73.58	1.65	7.30
CDS ₁	66.82	3279.56	35.72	1.35	4.48	2.00	56.45	1.68	7.80
CDS ₂	68.64	3305.90	33.19	1.06	4.91	1.00	59.84	1.72	7.70
CDS ₃	66.59	3270.30	20.10	0.48	5.37	2.00	72.05	1.76	7.60
CWF ₁	70.00	3310.66	36.37	1.34	4.59	1.00	56.68	1.61	2.10
CWF ₂	71.59	3317.61	34.65	1.08	4.55	1.00	58.72	1.61	2.00
CWF ₃	69.36	3273.96	19.63	0.52	5.28	2.00	75.57	1.66	2.20
CWS ₁	67.73	3314.58	37.72	1.34	4.47	2.00	55.47	1.70	2.60
CWS ₂	67.95	3320.51	35.12	1.02	4.49	1.00	58.37	1.73	2.50
CWS ₃	66.59	3272.56	20.07	0.47	5.32	2.00	72.14	1.77	2.30

TIU-Trypsin inhibition unit; ME-Metabolizable Energy; (CDF₁-CDF₃)- Fried (cassava pulp+ dry heated soyabeans) at 50:50, 60:40 and 80:20; (CDS₁-CDS₃)- Sun dried (cassava pulp+ dry heated soyabeans) at 50:50, 60:40 and 80:20; (CWF₁-CWF₃)- Fried (cassava pulp+ wet heated soyabeans) at 50:50, 60:40 and 80:20; (CWS₁-CWS₃)- Sun dried (cassava pulp + wet heated soyabeans) at 50:50, 60:40 and 80:20.

free extract digestibility was significantly ($P < 0.05$) affected by soyabean heat treatment.

Although, birds fed diets containing wet heated soyabeans had higher values of crude protein digestibility, ether extract digestibility, crude fiber and true metabolizable energy corrected. The dehydration methods of CSB had no significant ($p > 0.05$) effect on all the measured nutrient digestibility and metabolizable energy values at 0 – 4 weeks. However, higher ($p > 0.05$) values of ether extract digestibility and ash digestibility were obtained from birds fed diet containing fried CSB, while higher value of nitrogen free extract digestibility was found in birds sundried CSB. At 4 – 8 weeks, nitrogen free extract digestibility was significantly ($p < 0.05$) affected by the dehydration methods of CSB. Although, higher ($p > 0.05$) values of crude fiber digestibility, ash digestibility, apparent metabolizable energy as well as true metabolizable energy corrected were obtained from birds fed diets containing sundried CSB. At 0 – 4 weeks, all the parameters measured were not significantly ($p > 0.05$) affected by mixing ratio of CSB.

However, crude protein digestibility, crude fiber digestibility, ash digestibility and true metabolizable energy recorded the highest ($p > 0.05$) value from birds fed diets containing 80:20 mixing ratio of CSB. At 4 – 8 weeks, the table showed that nitrogen free extract digestibility was significantly ($p < 0.05$) affected by CSB mixing ratio. Other parameters measured were not significantly ($p > 0.05$) affected by the mixing ratio of CSB fed to the finishing broiler chickens. Although, crude fiber digestibility, nitrogen corrected true metabolizable energy, ether extract digestibility as well as digestibility had the highest ($p > 0.05$) values from birds fed diets containing 80:20 mixing ratio of CSB.

Interaction effects of soyabean heat treatments and dehydration methods of CSB on nutrient digestibility and metabolizable energy of broiler chickens (0-8 weeks)

Table 6 shows the interaction effects of soyabean heat treatments and dehydration methods of CSB on nutrient digestibility and metabolizable energy of broiler chickens. At 0 – 4 weeks, the crude protein digestibility, nitrogen free extract digestibility, ether extract digestibility,

Table 5: Main effects of soyabean heat treatments, dehydration methods and mixing ratio of CSB on nutrient digestibility and metabolizable energy of broiler chickens (0-8 weeks)

Parameters	Soyabean heat treatments			Dehydration methods of CSB			Mixing ratios of CSB			p-value		
	Dry heated	Wet heated	SEM	p-value	Fried	Sun dried	SEM	p-value	60:40		80:20	SEM
0-4 Weeks												
CPD (%)	75.97	79.03	2.374	0.172	77.10	77.90	2.445	0.154	77.07	77.39	2.660	0.167
NFED (%)	74.8	77.56	3.302	0.197	75.77	76.07	3.225	0.162	75.25	76.13	1.986	0.179
EED (%)	79.54	82.47	3.266	0.636	82.06	79.95	3.564	0.432	80.62	80.44	3.554	0.613
CFD (%)	61.06	61.55	2.987	0.416	61.18	61.44	2.683	0.316	60.91	60.74	2.867	0.519
AD (%)	77.23	76.68	2.665	0.093	77.42	76.49	2.995	0.081	75.08	77.49	3.224	0.066
AME (MJ/Kg)	10.64	11.75	0.365	0.624	11.10	11.29	0.243	0.464	11.09	11.25	1.003	0.724
AME _N (MJ/Kg)	10.28	11.49	0.867	0.354	10.78	10.99	0.334	0.351	10.84	10.96	0.789	0.357
TME (MJ/Kg)	11.33	12.58	0.678	0.329	11.98	11.93	0.220	0.322	11.77	11.97	0.978	0.289
TME _N (MJ/Kg)	11.22	12.40	1.113	0.312	11.86	11.76	1.210	0.302	11.63	11.83	0.567	0.301
4-8 Weeks												
CPD (%)	75.78	78.09	0.898	0.451	77.52	77.61	1.005	0.456	75.32	78.07	1.867	0.462
NFED (%)	78.42 ^a	76.91 ^b	1.097	0.017	76.73 ^b	78.91 ^a	1.231	0.015	77.36 ^b	77.43 ^b	1.679	0.019
EED (%)	78.64	80.79	1.999	0.821	80.58	79.24	1.116	0.832	79.47	79.39	2.124	0.789
CFD (%)	59.88	62.06	1.001	0.090	61.84	62.19	0.789	0.090	60.08	60.67	0.997	0.091
AD (%)	79.29	78.13	0.898	0.138	77.89	80.15	0.998	0.135	78.24	78.66	0.431	0.129
AME (MJ/Kg)	11.40	11.65	0.220	0.659	11.07	12.01	0.231	0.641	11.42	11.48	0.113	0.633
AME _N (MJ/Kg)	11.10	11.65	0.243	0.558	11.57	11.64	0.231	0.528	10.96	11.18	0.235	0.544
TME (MJ/Kg)	12.09	12.74	0.120	0.781	12.39	12.52	0.124	0.781	12.19	12.32	0.456	0.778
TME _N (MJ/Kg)	11.71	12.02	0.243	0.532	11.82	12.05	0.798	0.530	11.56	11.89	0.456	0.532

^{abc} Means on the same rows having different superscript were significantly ($p < 0.05$) differentCPD - Crude protein digestibility; NFED - Nitrogen free extract digestibility; EED - Ether extract digestibility; CFD - Crude fibre digestibility; AD - Ash digestibility; AME - Apparent Metabolizable Energy; AME_N - Nitrogen corrected Apparent Metabolizable Energy; TME - True Metabolizable Energy; TME_N - Nitrogen corrected True Metabolizable Energy corrected

Table 6: Interaction effects of soyabean heat treatments and dehydration methods of CSB on nutrient digestibility and metabolizable energy values of starter broiler chickens (0-8weeks)

Parameters	Fried CSB		Sundried CSB		SEM	p-value
	Dry heated Soyabean	Wet heated Soyabean	Dry heated Soyabean	Wet heated Soyabean		
0-4 Weeks						
CPD (%)	75.82 ^b	76.31 ^{ab}	76.95 ^{ab}	77.27 ^a	2.476	0.005
NFED (%)	71.43 ^b	71.83 ^b	72.23 ^a	72.95 ^a	3.006	0.007
EED (%)	81.64 ^b	82.19 ^{ab}	82.76 ^{ab}	83.24 ^a	3.984	0.001
CFD (%)	59.73	60.92	61.75	62.14	2.693	0.885
AD (%)	76.59	77.13	77.65	78.09	2.431	0.378
AME (MJ/Kg)	10.92	11.46	11.84	11.95	1.003	0.054
AME _N (MJ/Kg)	10.65 ^b	11.13 ^{ab}	11.63 ^a	11.75 ^a	0.997	0.024
TME (MJ/Kg)	11.85 ^b	12.24 ^{ab}	12.65 ^a	12.92 ^a	1.432	0.042
TME _N (MJ/Kg)	11.56 ^b	12.02 ^{ab}	12.38 ^a	12.74 ^a	1.004	0.049
4-8 Weeks						
CPD (%)	75.43	77.67	76.55	78.49	2.234	0.061
NFED (%)	78.69 ^a	78.51 ^a	78.15 ^a	75.30 ^a	1.998	0.016
EED (%)	78.86 ^b	78.85 ^b	78.42 ^b	82.74 ^a	1.998	0.000
CFD (%)	59.56 ^b	60.63 ^{ab}	60.20 ^{ab}	63.47 ^a	1.245	0.021
AD (%)	79.93 ^a	79.11 ^a	78.65 ^{ab}	77.14 ^b	1.987	0.008
AME (MJ/Kg)	10.98	11.99	11.82	11.31	0.420	0.239
AME _N (MJ/Kg)	10.77	11.83	11.44	10.71	0.345	0.156
TME (MJ/Kg)	11.78	12.75	12.39	12.38	0.124	0.163
TME _N (MJ/Kg)	11.33	12.49	12.08	11.55	0.345	0.216

^{abc} Means on the same rows having different superscript were significantly ($p < 0.05$) different

CPD - Crude protein digestibility; **NFED** - Nitrogen free extract digestibility; **EED** - Ether extract digestibility; **CFD** - Crude fibre digestibility; **AD** - Ash digestibility; **AME** - Apparent Metabolizable Energy; **AME_N** - Nitrogen corrected Apparent Metabolizable Energy; **TME** - True Metabolizable Energy; **TME_N** - Nitrogen corrected True Metabolizable Energy corrected

nitrogen corrected apparent metabolizable energy, true metabolizable energy and nitrogen corrected true metabolizable energy were significantly ($p < 0.05$) affected by the interactions of heat treatments of soyabean and dehydration methods of CSB. Birds fed sun dried experimental diets containing wet heated soyabeans recorded higher values for all significant ($p < 0.05$) parameters. Birds fed fried CSB containing wet heated soyabeans and those fed sun dried CSB containing dry heated soyabeans had similar values for crude protein digestibility and ether extract digestibility. Also, birds fed sun dried experimental diets

containing wet heated and dry heated soyabeans had similar values for AME_N, TME and TME_N. At 4 – 8 weeks, the table showed that nitrogen free extract digestibility, ether extract digestibility, crude fiber digestibility and Ash digestibility were significantly ($p < 0.05$) affected by the interactions of soyabean heat treatments and dehydration methods of CSB. Birds fed fried CSB containing dry heated and wet heated soyabeans as well as those fed sun dried CSB containing dry heated soyabeans had similar values for nitrogen free extract digestibility and ether extract digestibility.

Table 7: Interaction effects of soyabean heat treatments and mixing ratios of CSB on nutrient digestibility and metabolizable energy of broiler chickens (0-8 weeks)

Parameters	Dry heated soyabean			Wet heated soyabean			SEM	p-value
	50:50	60:40	80:20	50:50	60:40	80:20		
0-4 Weeks								
CPD (%)	78.75 ^a	77.29 ^{ab}	75.23 ^b	76.25 ^b	78.29 ^a	78.55 ^a	1.446	0.016
NFED (%)	75.34 ^{ab}	74.73 ^{ab}	74.59 ^{ab}	73.29 ^b	79.20 ^a	78.96 ^a	2.134	0.005
EED (%)	82.14 ^{ab}	81.43 ^{ab}	74.46 ^b	80.42 ^{ab}	85.22 ^a	84.52 ^a	2.324	0.002
CFD (%)	63.58	61.72	61.17	60.58	65.27	65.73	1.896	0.715
AD (%)	77.14	76.04	75.28	77.20	78.52	79.04	1.764	0.362
AME (MJ/Kg)	11.29 ^{ab}	11.18 ^b	11.74 ^a	10.46 ^b	11.26 ^{ab}	11.74 ^a	0.678	0.048
AME _N (MJ/Kg)	10.72 ^b	10.46 ^b	11.49 ^a	10.23 ^b	11.07 ^{ab}	11.59 ^a	0.452	0.034
TME (MJ/Kg)	12.42 ^a	12.11 ^{ab}	12.55 ^a	11.40 ^{ab}	12.65 ^a	12.89 ^a	0.342	0.038
TME _N (MJ/Kg)	11.63 ^b	11.24 ^b	12.42 ^a	11.30 ^b	12.49 ^a	12.63 ^a	0.334	0.041
4-8 Weeks								
CPD (%)	73.34	78.32	76.30	77.29	77.83	79.16	2.045	0.062
NFED (%)	78.12 ^{ab}	77.92 ^{ab}	79.23 ^a	76.61 ^b	76.94 ^b	77.16 ^b	1.948	0.016
EED (%)	78.09 ^c	78.42 ^c	80.04 ^b	80.55 ^b	80.37 ^b	81.15 ^a	1.998	0.001
CFD (%)	60.02 ^b	59.91 ^b	59.70 ^b	60.14 ^b	61.43 ^{ab}	64.58 ^a	1.002	0.019
AD (%)	78.88 ^{ab}	79.33 ^a	79.56 ^a	77.51 ^b	78.00 ^b	78.87 ^{ab}	1.120	0.007
AME (MJ/Kg)	11.60	10.94	11.66	11.23	12.02	11.70	0.968	0.240
AME _N (MJ/Kg)	11.16	10.73	11.42	10.76	11.64	11.40	0.789	0.153
TME (MJ/Kg)	12.00	12.04	12.21	12.38	12.63	12.73	0.895	0.155
TME _N (MJ/Kg)	11.25	11.40	12.07	11.87	11.98	12.21	0.023	0.212

^{abc} Means on the same rows having different superscript were significantly ($p < 0.05$) different

CPD - Crude protein digestibility; **NFED** - Nitrogen free extract digestibility; **EED** - Ether extract digestibility; **CFD** - Crude fibre digestibility; **AD** - Ash digestibility; **AME** - Apparent Metabolizable Energy; **AME_N** - Nitrogen corrected Apparent Metabolizable Energy; **TME** - True Metabolizable Energy; **TME_N** - Nitrogen corrected True Metabolizable Energy corrected

Interaction effects of soyabean heat treatments and mixing ratios of CSB on nutrient digestibility and metabolizable energy of broiler chickens (0-8 weeks)

The interaction effects of soyabean heat treatments and mixing ratios of CSB on nutrient digestibility and metabolizable energy of broiler chickens is shown in Table 7. At 0 – 4 weeks, it was recorded that crude protein digestibility, nitrogen free extract digestibility, ether extract digestibility as well as AME, AME_N, TME and TME_N were significantly ($p < 0.05$) affected by the interaction of heat treatments and mixing ratio of CSB on starting broiler chickens. Birds fed diets containing wet heated soyabeans at 80:20 mixing ratio had higher values for all parameters observed. Birds fed diets containing dry heated soyabeans at 50:50, 60:40, 80:20 mixing ratio of CSB had similar values for nitrogen free extract, while those fed diets containing wet heated soyabeans also had similar values at 60:40, 80:20 ratios for the same parameter. Birds fed diets containing dry heated soyabeans at 80:20 of CSB had higher values for AME, AME_N, TME and TME_N. At 4 – 8 weeks, it was observed that ether extract digestibility, crude fiber digestibility, Ash digestibility and AME were significantly ($p < 0.05$) affected by interactions of heat treatment and mixing ratio of CSB fed to finishing broilers. For nitrogen free extract digestibility, birds fed dry heated soyabeans at 80:20 mixing ratio of experimental diet had the highest value while those fed dry heated soyabeans at 50:50, 60:40 and 80:20 mixing ratios had similar values respectively. Birds fed wet heated soyabeans at 60:40 and 80:20 mixing ratio had the highest value for ether extract digestibility while those fed dry and wet heated soyabeans at 50:50 and 60:40 mixing

ratios also had similar values respectively

Interaction effects of dehydration methods and mixing ratios of CSB on nutrient digestibility and metabolizable energy of broiler chickens (0-8 weeks)

Table 8 shows the interaction effects of dehydration methods and mixing ratios of CSB on nutrient digestibility and metabolizable energy of broiler chickens. At 0 – 4 weeks, crude protein digestibility, nitrogen free extract digestibility and ether extract digestibility and AME_N were significantly ($p < 0.05$) affected by the interactions of dehydration method and mixing ratio of CSB fed to starting broiler chickens. For crude protein digestibility, birds fed diets containing fried CSB at 50:50, 60:40 and those fed sun dried CSB at 60:40, 80:20 mixing ratio had similar value respectively. Also, birds fed diets containing fried CSB at 50:50 together with those diets fed sundried CSB at 50:50, 60:40 and 80:20 had similar values for AME_N. Birds fed fried CSB together with those fed sundried CSB 50:50 mixing ratio also had similar values. At 4 – 8 weeks, the table shows that ether extract digestibility, crude fiber digestibility, Ash digestibility and AME were significantly ($p < 0.05$) affected by the interactions of dehydration methods and mixing ratios of CSB fed to finishing broilers. Birds fed sundried CSB at 60:40 and 80:20 had similar values for ether extract digestibility. Birds fed sundried CSB at 80:20 had the highest crude fiber digestibility value while those fed 50:50 and 60:40 had similar values. Ash digestibility values for birds fed fried CSB at 50:50, 60:40 and 80:20 was similar. Those fed sundried CSB at 60:40 and 80:20 was also similar for Ash digestibility values. ***Interaction effects of soyabean heat treatments, dehydration methods and mixing ratios of CSB on nutrient digestibility and metabolizable energy of broiler chickens at starter and finishing***

Nutrient utilization by broiler chickens fed differently processed cassava-soya blends

Table 8: Interaction effects of dehydration methods and mixing ratios of CSB on nutrient digestibility and metabolizable energy of broiler chickens (0-8 weeks)

	Fried CSB			Sundried CSB				
Parameters	50:50	60:40	80:20	50:50	60:40	80:20	SEM	p-value
0-4 Weeks								
CPD (%)	78.24 ^a	77.86 ^a	76.49 ^{ab}	76.75 ^{ab}	75.43 ^b	75.95 ^b	2.154	0.017
NFED (%)	77.29 ^a	76.24 ^a	75.73 ^a	75.46 ^a	74.79 ^b	73.26 ^b	1.998	0.021
EED (%)	78.32 ^a	77.92 ^a	76.42 ^b	76.13 ^b	75.72 ^c	74.19 ^c	2.569	0.015
CFD (%)	61.75	61.48	60.83	60.74	60.34	59.76	1.567	0.925
AD (%)	77.15	76.84	75.93	73.95	73.54	73.17	1.986	0.526
AME (MJ/Kg)	11.46	12.43	11.84	11.54	11.65	11.46	1.086	0.084
AME _N (MJ/Kg)	11.28 ^b	12.06 ^a	11.53 ^{ab}	11.37 ^b	11.42 ^b	11.19 ^b	0.998	0.036
TME (MJ/Kg)	11.92	12.54	12.15	11.98	11.73	11.62	1.230	0.052
TME _N (MJ/Kg)	11.65	12.39	11.83	11.76	11.38	11.27	1.204	0.069
4-8 Weeks								
CPD (%)	76.07	76.53	77.07	74.55	79.62	78.39	2.101	0.063
NFED (%)	78.16	78.50	78.99	78.44	76.36	77.25	2.017	0.017
EED (%)	79.21 ^{ab}	78.61 ^b	78.74 ^b	79.73 ^{ab}	80.18 ^a	81.82 ^a	1.998	0.002
CFD (%)	58.74 ^b	59.68 ^b	61.86 ^{ab}	61.43 ^{ab}	61.65 ^{ab}	62.43 ^a	1.201	0.022
AD (%)	79.45 ^a	79.29 ^a	79.82 ^a	77.03 ^b	78.04 ^{ab}	78.62 ^{ab}	1.467	0.008
AME (MJ/Kg)	11.32	11.61	11.54	11.51	11.35	11.83	0.888	0.240
AME _N (MJ/Kg)	11.03	11.45	11.42	10.89	10.91	11.41	0.987	0.150
TME (MJ/Kg)	12.34	12.18	11.89	12.04	12.46	12.64	0.896	0.152
TME _N (MJ/Kg)	11.78	11.86	12.09	11.33	11.94	12.18	0.754	0.210

^{abc} Means on the same rows having different superscript were significantly ($p < 0.05$) different

CPD - Crude protein digestibility; NFED - Nitrogen free extract digestibility; EED - Ether extract digestibility; CFD - Crude fibre digestibility; AD - Ash digestibility; AME - Apparent Metabolizable Energy; AME_N - Nitrogen corrected Apparent Metabolizable Energy; TME - True Metabolizable Energy; TME_N - Nitrogen corrected True Metabolizable Energy corrected

phases (0-8 weeks)

Table 9 shows the interaction effects of soyabean heat treatments, dehydration methods and mixing ratios of CSB on nutrient digestibility and metabolizable energy of broiler chickens at starter and finisher phases. At starter phase, the table revealed that crude protein digestibility, nitrogen free extract digestibility, ether extract digestibility, AME and AME_N were significantly ($p < 0.05$) affected by the interaction of heat treatments, dehydration methods and mixing ratio of CSB fed to starting broilers. Crude protein digestibility values for birds fed fried CSB containing dry heated soyabeans at 50:50 and 80:20 was similar while those fed sun dried CSB containing wet heated soyabeans at 60:40 and 80:20 also had similar values. Birds fed sun dried CSB containing dry heated

soyabeans at 80:20 had the highest value for Nitrogen free extract digestibility while those fed fried CSB containing dry heated soyabeans at 50:50, 60:40 and 80:20 had the least values. Birds fed sun dried CSB containing wet heated soyabeans at 50:50 and 60:40 together with those fed sun dried CSB containing dry heated soyabeans at 60:40 and 80:20 had similar values for nitrogen corrected Apparentmetabolizable energy. It was recorded that during the finishing phase, that the interaction of heat treatments, dehydration methods and mixing ratio of CSB significantly ($p < 0.05$) influenced the nitrogen free extract digestibility, ether extract digestibility, crude fiber digestibility as well as ash digestibility of finishing broiler chickens. Nitrogen free extract digestibility values of birds fed, sun dried CSB containing wet

Table 9: Interaction effects of soyabeans heat treatments, dehydration methods and mixing ratio of CSB on nutrient digestibility and metabolizable energy of broiler chickens (0-8 weeks)

Energy of broiler chickens (0-8 weeks)														
Parameters	Fried CSB						Sun dried CSB						SEM	p-value
	Dry heated Soyabeans			Wet heated Soyabeans			Dry heated Soyabeans			Wet heated Soyabeans				
	50:50	60:40	80:20	50:00	60:40	80:20	50:50	60:40	80:20	50:50	60:40	80:20		
0-4 Weeks														
CPD (%)	76.09 ^{bc}	72.99 ^c	75.35 ^{bc}	73.80 ^c	78.56 ^b	79.05 ^{ab}	79.13 ^{ab}	79.11 ^{ab}	79.95 ^a	79.24 ^a	78.53 ^b	78.23 ^b	1.111	0.015
NFED (%)	73.97 ^c	73.66 ^c	73.21 ^c	73.32 ^c	76.27 ^b	76.22 ^b	77.22 ^{ab}	77.46 ^{ab}	79.08 ^a	77.63 ^{ab}	77.14 ^{ab}	76.85 ^b	1.111	0.019
EED (%)	81.43 ^a	80.18 ^{ab}	80.19 ^{ab}	79.17 ^b	78.06 ^b	78.19 ^b	81.43 ^a	81.88 ^a	81.23 ^{ab}	80.46	81.64 ^a	82.19 ^a	2.124	0.012
CFD (%)	59.64	60.43	62.51	62.07	60.53	61.20	61.01	60.26	63.23	60.92	61.75	62.14	1.008	0.875
AD (%)	75.62	78.14	77.24	77.06	77.06	78.28	74.70	78.85	80.27	72.96	75.93	77.65	1.235	0.510
AME (MJ/Kg)	10.29	10.31	10.77	10.73	10.64	11.11	11.52	12.09	11.62	11.84	11.95	11.46	0.543	0.072
AME _N (MJ/Kg)	10.09 ^b	10.05 ^b	10.06 ^b	10.38 ^b	10.12 ^b	10.95 ^{ab}	11.27 ^{ab}	11.94 ^a	11.45 ^a	11.63 ^a	11.75 ^a	11.13 ^{ab}	0.456	0.030
TME (MJ/Kg)	11.00 ^{bc}	11.04 ^{bc}	12.16 ^{ab}	10.91 ^c	11.18 ^{bc}	11.67 ^b	12.53 ^a	12.77 ^a	12.35 ^{ab}	12.65 ^a	12.92 ^a	12.24 ^{ab}	0.784	0.049
TME _N (MJ/Kg)	10.91	10.94	12.05	10.82	11.04	11.57	12.42	12.60	12.25	12.38	12.74	12.02	0.896	0.060
4-8 Weeks														
CPD (%)	74.87	76.15	75.26	71.82	80.49	77.34	77.28	76.91	78.89	77.29	78.75	79.44	1.898	0.053
NFED (%)	77.83 ^b	78.45 ^{ab}	79.79 ^a	78.40 ^{ab}	77.39 ^b	78.67 ^a	78.49 ^{ab}	78.55 ^a	78.50 ^a	74.73 ^c	75.34 ^c	75.83 ^c	2.127	0.013
EED (%)	78.16 ^{bc}	78.61 ^b	79.82 ^b	78.03 ^{bc}	78.23 ^{bc}	78.99 ^b	80.27 ^b	78.61 ^b	77.66 ^c	81.43 ^{ab}	82.14 ^{ab}	84.65 ^a	2.114	0.000
CFD (%)	58.91 ^c	60.08 ^b	59.68 ^{bc}	61.14 ^b	59.73 ^{bc}	59.73 ^{bc}	58.67 ^c	59.29 ^{bc}	64.04 ^a	61.72 ^b	63.58 ^{ab}	65.13 ^a	1.220	0.020
AD (%)	79.73 ^a	79.73 ^a	80.15 ^a	78.03 ^b	78.94 ^{ab}	78.98 ^{ab}	78.98 ^{ab}	78.86 ^{ab}	79.49 ^a	76.04 ^c	77.14 ^{bc}	78.26 ^b	1.985	0.005
AME (MJ/Kg)	11.35	10.47	11.13	11.85	11.41	12.20	11.28	12.76	11.95	11.18	11.29	1.46	0.221	0.220
AME _N (MJ/Kg)	10.99	10.35	10.97	11.33	11.10	11.88	11.07	12.56	11.87	10.46	10.72	10.94	1.123	0.143
TME (MJ/Kg)	12.03	11.59	11.73	11.97	12.50	12.69	12.65	12.77	12.84	12.11	12.42	12.63	0.896	0.147
TME _N (MJ/Kg)	11.07	11.37	11.56	11.43	12.25	12.58	12.50	12.34	12.63	11.24	11.63	11.79	0.234	0.206

^{abc} Means on the same rows having different superscript were significantly ($p < 0.05$) differentCPD - Crude protein digestibility; NFED - Nitrogen free extract digestibility; EED - Ether extract digestibility; CFD - Crude fibre digestibility; AD - Ash digestibility; AME - Apparent Metabolizable Energy; AME_N - Nitrogen corrected Apparent Metabolizable Energy; TME - True Metabolizable Energy; TME_N - Nitrogen corrected True Metabolizable Energy corrected

heated soyabeans at 50:50, 60:40 and 80:20 was similar while those fed fried CSB containing wet heated soyabeans at 50:50 and 80:20 were also similar. Birds fed sun dried CSB containing wet heated soyabeans at 80:20 had the highest ether extract digestibility value, while those fed sun dried CSB containing dry heated soyabeans at 80:20 had the least value. Also, birds fed fried CSB containing dry heated soyabeans at 50:50, 60:40 and 80:20 had similar values for Ash digestibility.

Discussion

Morgan and Choct (2016) reported the feed intake of cassava products is limited in poultry by the palatability of cassava-based rations, due to its dustiness and bulkiness and this could affect its digestibility in poultry. The digestibility of nutrients by the broiler chickens in the present study was not significantly affected by soyabean heat treatment at starter phase. Although, higher values of crude protein digestibility, nitrogen free extract digestibility, ether extract digestibility, apparent metabolizable energy, as well as true metabolizable energy and nitrogen corrected true metabolizable energy were recorded with birds fed diets containing wet heated soyabeans. This is in line with the study of Ari *et al.* (2017) who reported significant effect of soyabean processing methods on crude fiber digestibility only, when the effect of several processing methods of soyabeans on digestibility of broiler chickens were studied. At week 8, only nitrogen free extract digestibility was significantly affected by soyabean heat treatments, and was equally recorded that birds fed diets containing wet heated soyabeans had higher values of crude protein digestibility, ether extract digestibility, crude fiber digestibility and true metabolizable energy corrected. This could suggest that wet heat treatment of soyabean has slight advantage in aiding

digestibility in broiler chickens. The dehydration methods of CSB had no significant effect on all the measured nutrient digestibility and metabolizable energy values during the starter phase. This indicates that, at starter level, both dehydration methods of cassava have similar effects on nutrient digestibility of broiler chickens. Although at the finisher phase, nitrogen free extract digestibility was significantly affected by the dehydration methods of CSB with the sun dried CSB recording higher value, while the other digestibility parameters are similar across the two dehydration methods. The mixing ratio of CSB has no significant effect on the nutrient digestibility of broiler chickens at starter phase, while only the nitrogen free extract was significantly affected during the finisher phase. The interaction of heat treatments of soyabean and dehydration methods of CSB brought about significant effects on the crude protein digestibility, nitrogen free extract digestibility, ether extract digestibility, nitrogen corrected apparent metabolizable energy, true metabolizable energy and nitrogen corrected true metabolizable energy of the broiler chickens at 0 – 4 weeks. Birds fed sun dried CSB containing wet heated soyabeans recorded higher values for the affected parameters. During the finisher phase however, nitrogen free extract digestibility, ether extract digestibility, crude fiber digestibility and Ash digestibility were the parameters which were significantly affected by the interactions of soyabean heat treatments and dehydration methods of CSB. Better values reported for birds fed Sun dried CSB with wet heated soyabean could be due to the fermentation effect the soaking of soyabean had on digestibility of the nutrients.

Birds fed diets containing wet heated soyabeans at 80:20 mixing ratio during the starting period had higher values for all

parameters observed. This is an indication that heat treatments of CSB helped improve nutrient digestibility in broiler chickens at starter phase, with wet heating having the better result. Finishing birds fed wet heated soyabeans at 60:40 and 80:20 mixing ratio had the highest value for ether extract digestibility while those fed dry and wet heated soyabeans at 50:50 and 60:40 mixing ratios also had similar values respectively. Boiling cassava chips according to Morgan and Choct (2016) removes some of the cyanide, with approximately 90% of free cyanide removed within 15 min of boiling and 55% of the bound cyanide removed after 25 min of boiling (Cooke and Maduagwu, 1978). Osei (1992), Tewe and Egbunike (1992), Onyimonyi and Ugwu (2007), and some other researchers stated that cassava peel and peel meal can be successfully used in broiler diets up to a maximum inclusion level of 15%, although feed intake was reported to increase as the level of cassava increases (Morgan and Choct, 2016), which does not necessarily lead to higher weight gain, since the high levels of cyanide and fiber and low energy in cassava made it so that its success as a substitute for maize is limited. But the incorporation of soyabean into the blend with processing could ameliorate this. Birds fed sun dried CSB containing dry heated soyabeans at 80:20 at starter phase had the highest value for Nitrogen free extract digestibility while those fed fried CSB containing dry heated soyabeans at 50:50, 60:40 and 80:20 had the least values. This possibly shows that sun drying CSB is the better heat treatment for the blend (Ngiki *et al* 2014; Ravindran, 1991) since sun drying provided a gradual drying unlike frying where a very high temperature is applied from onset. Birds fed sun dried CSB containing wet heated soyabeans at 50:50 and 60:40 together with those fed sun dried CSB containing dry heated soyabeans at 60:40 and 80:20 had

similar values for nitrogen corrected apparent metabolizable energy. At starter phase, the drying and processing method neither increase nor diminish the apparent metabolizable energy of the blends. Birds fed sun dried CSB containing wet heated soyabeans at 80:20 had the highest ether extract digestibility value, while those fed sun dried CSB containing dry heated soyabeans at 80:20 had the least value. Also, birds fed fried CSB containing dry heated soyabeans at 50:50, 60:40 and 80:20 had similar values for Ash digestibility. Tang *et al.* (2012) found that substituting maize completely with cassava pellets or chips resulted in significantly reduced growth, non-starch polysaccharide and CP digestibility and ME utilization in broilers. The 15% inclusion of cassava-soya blends in this experiment could be the reason for the better result obtained in this current research, when compared to that of Tang *et al.* (2012).

Conclusion and recommendation

Replacing maize with 15% fried CSB blend with dry heated soyabean mixed at ratio 50:50 yielded increased crude protein digestibility. It can thus be concluded that the mixing ratio 50:50 and dry heat treatment turned out best in this current research.

Conflict of interest

None of the authors has any financial or personal relationships that could inappropriately influence or bias the content of the paper.

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