ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF
POULTRY SCIENCE

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International Journal of Poultry Science 10 (5): 350-357, 2011
ISSN 1682-8356

Determination of Chemical Composition and Ant-nutritive Components for Tanzanian Locally Available Poultry Feed Ingredients

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Abstract: Information on nutritive value of locally available feed ingredients is scarce, therefore chemical composition, TAA, ANF and OSI for eleven feed ingredients commonly used in Tanzania were determined. Standard AOAC Official Methods were performed at the US headquarters of Novus International, Inc. The ingredients were cereals/byproducts (BR, RS, WS1, WS2 and MB), leaf meals (MOLM, GLM and LLM) and oil seed meals/by products (SBM, SCM and CSM). Significant differences for CP, NDF, ADF, minerals, TAA and ANF were observed between nutrient groups. Apart from energy most of the chemical components were lower in cereals; CP and TAA were highest in SBM. CSM contained the highest fat content (35.82%) with high oleic (22.63%) and linoleic (50.59%). The observed chemical differences between (BR and MB) were probably due to their differences in physical composition. Low levels (Ca, Na and P) and EAA were noted in all groups emphasizing the need of using synthetic sources during feed formulation. Total phenols and tannins were (7.71-7.26%) and (2.55-1.02%) for GLM and RS, respectively, but negligible in other feed ingredients. Both HCN and OSI were highest in leaf meals but negligible in other feed ingredients. The chemical composition of ingredients obtained in this study was comparable to values reported elsewhere. This means that optimum diets for livestock can be formulated using ingredient values from established tables and other sources. The present results show that feed ingredients of plant origin vary in their chemical composition therefore they complement each other when used in mixtures of animal diets.

Key words: Feed ingredients, chemical composition, nutrient variation

INTRODUCTION

Poultry are monogastric animals which rely on high digestible feeds such as corn for energy and soybean for protein but in most parts of the world particularly Africa corn/maize is a staple food for many people and soybean is not readily available. As such these ingredients are expensive and their inclusion in poultry diets increases the cost of production. Under normal conditions feed costs account for up to 70% of the total cost of production and the proportion has been increasing because of the volatility of the feed market and stiff competition for feed resources between human food sector and animal feed industries (Yegani, 2009). This competition consequently leads to increases in prices of established feed ingredients such as corn and soybean (Tangedjaja, 2011). This situation is more distinct in places where feed availability is a problem due to unreliable rainfall and other agronomic conditions (Olugbemi *et al*., 2010). Inadequacy of feed ingredients and high cost is a setback to the emerging small to medium commercial poultry sector commonly found in urban and peri-urban areas in Africa. In the long run this might affect the expansion of the poultry industry which is badly needed for the provision of income and high nutritional products i.e. meat and eggs. However the current situation can be abridged by using alternative feed ingredients (Dale, 2008).

The search for alternative feed ingredients is driven directly by the economics of the industry with the aim of finding nutrient sources which are at lower costs than those currently in use (Romo and Nava, 2007). The term *alternative ingredient* is wide and depends on location where it is used (Dale, 2008). In the US and other developed countries an alternative ingredient might mean any energy or protein source other than corn, soybean meal and fat. A broad definition of an alternative ingredient can include the following facts i) an ingredient that has not previously been used on a regular basis; ii) an ingredient whose nutrient composition has yet to be fully defined and iii) an ingredient which the maximum level of inclusion is unclear (Dale, 2009). Therefore it is apparent that the key aspects which need to be known about an alternative feed ingredient are nutrient composition, nutrient availability/utilization and inclusion levels. This concept was recently addressed by (Bernard, 2010; Nyachoti, 2011) who stated that in order to use alternative feed ingredients in animal diets one needs to know more about nutrient composition and nutrient utilization so that diets can be properly formulated. This is important because byproducts or co-products vary significantly in their nutrient composition (Bernard, 2010). Feed formulation for poultry feeds in Africa involves the use of many ingredients such as grain by products (maize bran, wheat bran, rice by

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products) for energy; seed oil extraction by products (cotton seed cake, sunflower seed cake) and leaf meals for protein. Thus the term alternative feed ingredients fits well into this situation. The nutrient content especially the micronutrients of most alternative ingredients used in Africa is not known due to lack of advanced analytical facilities. Most of the formulations are based on major nutrient composition such as crude protein, crude fiber, ash and fat, which in most cases do not clearly indicate the availability and utilization of nutrients by animals. Therefore the objective of the present study was to determine the detailed chemical composition of feed ingredients locally used in Tanzania.

MATERIALS AND METHODS

The chemical composition of eleven feed ingredients from Tanzania including energy and plant protein was studied at Novus International Inc, USA. The ingredients were grouped as follows Cereals and cereal by products: - Red sorghum (high tannin) (RS), White sorghum 1 (low tannin) (WS1), White sorghum 2 (low tannin) (WS2), Broken rice (BR) and Maize bran (MB). Leaf meals: *Moringa oleifera* (MOLM), Soyabean meal (SBM), *Leucaena leucocephala* (LLM) and Oil seeds and oil seed by product meal: Sunflower seed cake meal (SSCM), *Gliricidia sepium* (GLM) and *Curcubita maxima* seed meal (CSM).

The leaf meals were harvested and dried under shade for 5-7 days; this was followed by partial drying using forced air oven as described by Goering and Van-Soest (1970). After cooling, the samples were ground through a 1 mm screen, packed and labeled and were then shipped to the USA at Novus International, Inc.

Chemical composition: Dry Matter (DM), Crude Protein (CP), Soluble Protein (SP), Acid Detergent fiber (ADF), Neutral Detergent Fiber (NDF), Lignin, Non Fiber Carbohydrate (NFC) fat, ash and total minerals were determine using the AOAC (1990; 2006) standard methods.

DM of the samples was determined using (930.15) AOAC (1990) whereas CP was determined using Kjeldahl-method (984.13) of AOAC (1990). NDF, ADF and lignin were measured using the AOAC method (973.18). Total ash content of the feed ingredients was measured using AOAC (942.05) and AOAC (920.29) was used to measure total fat as ether extracts.

Minerals: The minerals P, K, Ca, Mg, Mn, Fe, Cu, Zn, Na, Mo were determined using atomic absorption spectrophotometric method described by AOAC Official Method 968.08 D (a). The AOAC Official method 982.30E (a,b,c) chapter 45.3.05, 2006 was used to measure complete Amino Acid Profile (AAP) of the feed ingredient samples.

Urease test: The assay described in AACC Official Method 22-90 was used to determine the presence of trypsin inhibitor using urease activity as a marker. Tannins were analyzed according to AOAC Official Surplus Method 955.35.

Statistical analysis: The differences between feed ingredients were determined using t-test.

RESULTS

Proximate composition and ant-nutritional factors: The results for proximate composition are presented in Table 1 and 2. The DM content was fairly constant across the cereals and cereal by products ranging between 88.1% for BR and 89.5% for MB. A wide variation was noted for CP (9.84% -15.36%); fat (1.48-12.29%); NDF (2.04-22.23%) and NFC (47.71-85.70%). With the exception of NFC most of studied chemical components were higher in MB and lower in BR. Insignificant differences were observed between the red and the white sorghums for CP, fat and ash. Crude protein and fat were higher in WS whereas ADF, ash, total phenols and tannins were higher in RS. Energy content was higher in MB (4.53 ME Mcal/kg) and lower in BR (4.14 Mcal/kg). The Oil stability index (OSI) was highest in WS2 (2.95hrs) and lowest in RS (1.65 hrs).

The DM content of the plant protein sources ranged from 87.2% in MOLM - 99.1% in CSM. SBM had the highest protein (46.26%) while it was lowest in GLM. The protein content in leaf meals was slightly lower than that of oil seed meals whereas no definite trend was observed for soluble protein. Fat content was significantly higher in the oil seed meals (21.54%) compared to the leaf meals with 4.74%. A similar trend was observed for energy and the mean was 4.83±0.4 for oil seed meals and 3.77±0.11 for leaf meals. The major fatty acids in CSM were palmitic (16.38%), Stearic (9.21%), Oleic (22.63%), Linoleic (50.59%). The Oil Stability Index (OSI) was highest for GLM (21.25 h) and lowest for LLM (3.35 h). Non significant differences between oil seed and leaf meals were observed for both ADF and NDF. The ash content was significantly higher (12.09±0.79) in leaf meals compared to 6.10±3.6 in oil seed meals. A clear distinction on the type and amount of ant-nutritional factors was noted between the feed ingredients. Total phenols and tannins were significantly higher in leaf meals but were very low or absent in oilseed meals. GLM had highest levels of both total phenols (7.71%) and tannins (7.26%). Hydrogen cyanide was only found in GLM and LLM whereas trypsin inhibitor activities were highest in SBM (12000 TIU/g) and relatively low in SCM and CSM (<2000 TIU/g). The level of chemical components varied between and within the leaf and oil seed meals.

Table 1: Chemical composition, anti-nutritional factors and oil stability index of sorghum varieties and cereal by products

Component	BR	RS	WS (1)	WS (2)	MB	Mean	Std dev
DM (%)	88.10	89.10	88.80	88.60	89.50	88.8	4.00
CP (%)	9.84	11.19	13.70	13.62	15.36	12.7	7.12
SP (%)	49.94	35.91	18.02	31.60	32.40	33.6	16.58
Fat (%)	1.48	2.92	3.72	3.16	12.29	4.7	12.12
ADF (%)	1.36	7.97	3.49	3.84	6.03	4.5	7.80
NDF (%)	2.04	10.77	10.59	8.24	22.23	10.8	9.41
NFC (%)	85.70	74.41	73.31	76.07	47.71	71.4	13.34
Ash (%)	1.57	3.64	2.42	2.16	4.99	3.0	3.54
Total phenols (%)	-	2.55	0.17	0.17		1.0	3.04
Tannins	-	1.02	0.07	0.10		0.4	2.91
Oil stability index (hrs)		1.65	1.75	2.95			0.60
ME (Mcal/kg)	4.36	4.14	4.30	4.39	4.53	4.3	
NE of gain (Mcal/kg)	1.67	1.56	1.66	1.69	1.79	1.7	

BR: Broken Rice; RS: Red Sorghum; WS1: White Sorghum 1; WS2: White Sorghum 2; MB: Maize Bran; DM: Dry Matter; CP: Crude Protein; SP: Soluble Protein; ADF: Acid Detergent Fiber; NDF: Neutral Detergent Fiber

Table 2: Chemical composition, anti-nutritional factors and oil stability index of leaf and oil seed meals

Component	MOLM	GLM	LLM	SBM	SCM	CSM	Mean	Std dev
DM (%)	87.20	91.00	89.90	92.80	91.10	99.10	91.9	4.00
CP (%)	30.65	25.55	29.38	46.26	31.40	34.10	32.9	7.12
SP (%)	56.19	53.39	35.16	25.86	58.18	20.18	41.5	16.58
Fat (%)	4.13	6.45	3.63	14.98	13.83	35.82	13.1	12.12
ADF (%)	12.50	13.90	20.33	7.44	30.08	16.04	16.7	7.80
NDF (%)	16.28	21.02	28.13	13.04	39.41	24.02	23.7	9.41
NFC (%)	36.24	34.48	34.62	22.63	14.82	3.23	24.3	13.34
Ash (%)	14.28	10.96	11.02	5.92	7.06	5.31	9.1	3.54
Total phenols	3.04	7.71	2.79	0.42	-	0.15	2.8	3.04
Tannins	2.83	7.26	2.35	0.26	-	0.04	2.5	2.91
HCN	-	3.00	3.85	-	-	-	3.4	0.60
Trypsin inhibitor (TIU/g)	-	-	-	12000.00	<2000.00	<2000.00	-	
OSI (h)	7.60	21.25	3.35	-	-	-		
ME (Mcal/kg)	4.04	3.89	3.38	5.13	4.11	5.26	4.3	0.74
NE of gain (Mcal/kg)	1.48	1.42	1.12	2.12	1.56	2.21		

MOLM: *Moringa oleifera* Leaf Meal; GLM: *Gliricidia sepium* Leaf Meal; LLM: *Leucaena leucocephala* Leaf Meal; SBM: Soyabean Meal; SCM: Sunflower Seed Cake Meal; CSM: *Curcubita maxima* Seed Meal; DM: Dry Matter; CP: Crude Protein; SP: Soluble Protein; ADF: Acid Detergent Fiber; NDF: Neutral Detergent Fiber; HCN: Hydrogen Cyanide; OSI: Oil Stability Index; ME: Metabolizable Energy (Mcal/kg); NE: Net Energy (Mcal/kg)

Table 3: Mineral composition for the different sorghum varieties and cereal by products

	BR	RS	WS (1)	WS (2)	MB	Mean	Std dev
Ash (%)	1.57	3.64	2.42	2.16	4.99	2.96	1.36
Ca (%)	0.01	0.03	0.01	0.01	0.02	0.02	0.01
P (%)	0.19	0.26	0.39	0.37	0.79	0.40	0.23
Mg (%)	0.08	0.16	0.20	0.19	0.31	0.19	0.08
K (%)	0.17	0.34	0.34	0.34	0.84	0.41	0.25
Na (%)	0.02	0.03	0.02	0.02	0.02	0.02	0.00
S (%)	152.10	427.61	153.15	64.33	197.77	198.99	136.66
Fe (ppm)	15.89	23.57	28.15	22.57	60.34	30.10	17.46
Zn (ppm)	3.41	5.61	5.63	4.51	4.47	4.73	0.93
Cu (ppm)	21.57	26.94	15.77	14.67	16.76	19.14	5.09
Mn (ppm)	0.11	0.11	0.11	0.11	0.16	0.12	0.02
Mo (ppm)	1.48	1.35	1.01	1.47	0.67	1.20	0.35

BR: Broken Rice; RS: Red Sorghum; WS1: White Sorghum 1; WS2: White Sorghum 2; MB: Maize Bran; Ca: Calcium; P: Phosphorus; Mg: Magnesium; K: Potassium; Na: Sodium; S: Sulphur; Fe: Iron; Zn: Zinc; Mn: Manganese; Mo: Molybdenum

Minerals: The mineral content for the feed ingredients are shown in Table 3 and 4. For cereal by products most of the minerals (Ash, P, Mg, K, S and Fe) were higher in MB and lower in RB. Significant differences between RS and WS; minerals were generally higher in RS and lower in WS. Across the energy sources most of the minerals were higher in MB and lower in BR. Potassium was the highest (0.40±0.23%) major mineral in all the energy sources while Ca (0.02±0.01%) was lowest. Significant differences in the content of trace minerals were observed. The distribution of the trace mineral was almost similar to that of major minerals whereby Fe, Mn

Table 4: Mineral composition for the leaf and oil seed meals

	MOLM	GLM	LLM	SBM	SCM	CSM	Mean	Std dev
Ash (%)	14.28	10.96	11.02	5.92	7.06	5.31	9.09	3.54
Ca (%)	2.47	2.12	1.76	0.28	0.33	0.07	1.17	1.06
P (%)	0.44	0.19	0.22	0.60	0.86	0.92	0.54	0.31
Mg (%)	1.03	0.30	0.37	0.26	0.49	0.46	0.49	0.28
K (%)	1.63	1.42	2.19	1.54	1.14	0.79	1.45	0.47
Na (%)	0.05	0.02	0.03	0.01	0.02	0.01	0.02	0.02
Fe (ppm)	318.81	985.54	304.40	245.69	461.03	228.05	423.92	287.14
Zn (ppm)	21.79	24.47	18.68	34.48	65.86	44.40	34.95	17.85
Cu (ppm)	5.73	7.79	2.20	12.93	25.25	11.10	10.83	8.03
Mn (ppm)	57.34	63.40	162.64	32.33	31.83	30.27	62.97	50.88
S%	1.22	0.31	0.26	0.26	0.33	0.27	0.44	10.38
Mo (ppm)	0.80	0.22	0.44	6.14	1.32	3.23	2.03	2.29

MOLM: *Moringa oleifera* Leaf Meal; GLM: *Gliricidia sepium* Leaf Meal; LLM: *Leucaena leucocephala* Leaf Meal; SBM: Soyabean Meal; SCM: Sunflower Seed Cake Meal; CSM: *Curcubita maxima* Seed Meal; Ca: Calcium; P: Phosphorus; Mg: Magnesium; K: Potassium; Na: Sodium; S: Sulphur; Fe: Iron; Zn: Zinc; Mn: Manganese; Mo: Molybdenum

Table 5: Total amino acid composition for the feed ingredients (in %DM)

Amino acid/ feed ingredient	BR	RS	WS1	WS2	MB	MOLM	GLM	LLM	SBM	SCM	CSM
Methionine	0.23	0.18	0.20	0.21	0.26	0.42	0.35	0.39	0.53	0.63	0.63
Cysteine	0.20	0.18	0.23	0.21	0.27	0.33	0.31	0.30	0.51	0.49	0.40
Lysine	0.34	0.22	0.27	0.26	0.53	1.40	1.29	1.47	2.60	1.02	1.56
Arginine	0.72	0.38	0.46	0.45	0.86	1.62	1.15	1.30	3.47	2.36	4.16
Tryptophan	0.09		0.08	0.08	0.09	0.44	0.30		0.52	0.34	0.47
Tyrosine	0.32	0.36	0.42	0.42	0.40	0.88	0.86	0.93	1.61	0.67	1.63
Threonine	0.30	0.34	0.41	0.38	0.50	1.02	0.92	1.01	1.63	1.02	0.75
Serine	0.40	0.45	0.54	0.53	0.55	1.17	0.98	0.90	1.90	1.12	1.25
Phenyalalanine	0.49	0.53	0.71	0.67	0.57	1.62	1.18	1.26	2.33	1.28	1.34
Aspartic acid	0.79	0.71	0.90	0.79	0.95	2.98	2.57	2.21	4.94	2.60	3.16
Glutamic acid	1.61	2.11	2.67	2.61	1.94	3.49	2.15	2.37	7.52	5.27	4.96
Proline	0.40	0.84	1.09	1.04	0.86	1.19	1.15	1.35	2.17	1.21	0.97
Glycine	0.40	0.31	0.38	0.36	0.67	1.19	1.05	1.20	1.88	1.65	2.50
Alanine	0.51	0.97	1.23	1.20	0.88	1.48	1.20	1.30	1.90	1.21	1.19
Valine	0.56	0.51	0.63	0.61	0.63	1.40	1.21	1.39	2.21	1.10	1.37
Isoleucine	0.40	0.40	0.53	0.51	0.42	1.09	0.97	1.07	2.09	1.01	1.07
Leucine	0.76	1.40	1.84	1.76	1.21	2.01	1.75	2.02	3.47	1.79	1.95
Histidine	0.22	0.21	0.27	0.27	0.38	0.60	0.48	0.51	1.13	0.68	0.86

BR: Broken Rice; RS: Red Sorghum; WS1: White Sorghum 1; WS2: White Sorghum 2; MB: Maize Bran; MOLM: *Moringa oleifera* Leaf Meal; GLM: *Gliricidia sepium* Leaf Meal; LLM: *Leucaena leucocephala* Leaf Meal; SBM: Soyabean Meal; SCM: Sunflower Seed Cake Meal; CSM: *Curcubita maxima* Seed Meal

and Cu were highest in RS while zinc was high in MB. Generally both major and trace minerals were higher in RS and MB and were lowest in BR.

Differences between the plant protein sources were observed for both major and trace minerals. Calcium was significantly higher in leaf meals 2.12±0.36 compared to 0.23±0.14 in oil seed meals whereas phosphorus was higher in oil seed meals 0.79±0.17 compared to 0.28±0.14% in leaf meals. Differences for other minerals were insignificant, although slightly higher levels were noted in leaf meals.

Total Amino Acids (TAA): The distribution for TAA in feed ingredients is shown in Table 5.

The results show that the TAA were lowest in cereals/cereal by products, intermediate in leaf meals and highest in oil seed meals. The lowest and highest AA in all feed ingredients were tryptophan (0.09±0.01%) and glutamic acid (2.19±0.45%) respectively. The content for methionine, cysteine; tryptophan; tyrosine and histidine were less than 0.35% whilst the level of the remaining AA ranged between 0.5-2.19% in cereals/cereal by products. Between cereals/cereal by products MB contained higher levels of Methionine, Cysteine, Threonine, lysine, aspartic and histidine. The content of glutamic, proline, alanine, valine, Isoleucine and leucine were highest in the white sorghums whereas lower levels were noted for RS.

The results showed that methionine, cysteine and tryptophan were less than 0.5% in all leaf meals whereas glutamic acid and aspartic acid were more than 2.5%. Most of the amino acids were consistently higher in MOLM, lower but similar for LLM and GLM. The distribution pattern for AA in oil seed meals was similar to that of leaf meals with methionine, cysteine and tryptophan being the lowest (0.05%) although the content for most AA was higher in oil seed meals. The levels for all AA were highest in SBM and almost similar for SCM and CSM.

DISCUSSION

The results of the present study are discussed in relation to findings reported elsewhere. Feed ingredients are classified as energy or protein sources depending on the major nutrient they contain. The feed ingredients in the present study were grouped as energy source (BR, RS, WS1, WS2 and MB) and as plant protein sources (MOLM, GLM, LLM, SBM, SCM and CSM) composed of leaf meals and oil seed meals.

The dry matter content for the sorghums and cereal by products of 88.1-89.5% observed in the present study was within the range of 85-95% (NRC, 1994; Leeson and Summers, 2005; Donkoh and Attoh-Kotoku, 2009). A number of factors affect the moisture content of feeds and they include timing and method of harvest, weather and environmental conditions, such as humidity and rain. The DM content of feeds that are co-products of manufacturing industries are also affected by the manufacturing processes to which the grains are subjected (Bernard, 2010). Determining DM content of feeds provide a measure for the quantity of a particular feed which is required to supply nutrients to the animal. Increases or decreases in feed DM content result in over or under feeding of nutrients. The average DM content of 88% for sorghum grains was within the expected range for dry stored cereals. The recommended moisture content in stored grains is <15%. Dry matter content below 85% normally leads to spoilage of feed ingredients due to mold growth especially in tropical countries where temperature and relative humidity are relatively high throughout the year (Hamito, 2010). High dry matter content is also beneficial for livestock farmers because it increases the unit value of the feed components.

The CP content was lowest for BR and highest for MB. The variation in CP content between cereal by products was probably due to the type of components found in the by product. Broken rice is obtained after the dehulled rice has been polished, therefore it only contains the endosperm parts whereas maize bran/hominy feed contains the bran, embryo/germ and endosperm. However the nutrient content of maize bran/hominy feed varies more compared to that of BR because the physical composition of MB normally depends on the efficiency of milling machines. Studies have shown wide variations for MB chemical components being 9-15% for CP; 5-7% for fat and 2-8% for CF (Jagadi *et al.*, 1987; Tiwari *et al.*, 2006; Dale, 2008; Bernard, 2010). This means that it is important to know the physical composition of the byproduct since this has a large influence on chemical composition. The average CP content of 12.84±1.16% for RS and WS obtained in this study was higher than the range of 9-10% reported in other studies (Doyoe *et al.*, 1966; Rohrbach and Kiriwagullu, 2007; Donkoh and Attoh-Kotoku, 2009; Bryden *et al.*, 2009), but was within the range of 8.9-13.6% reported by Perez-Maldonado and Rodriguez (2007). These findings when compared to other studies seem to indicate a wide range of CP content in sorghum varieties. These variations are mostly attributed to variety, soil type, growing conditions and time of harvest (Bryden *et al.*, 2009). The lower protein content in the RS a high tannin when compare low tannin variety observed in the present was also reported (Ebadi *et al.*, 2005; Dykes and Rooney, 2006). However the relationship between tannin and crude protein level is not straightforward since sometimes CP is low in low tannin varieties. The high CP content for sorghum varieties than values reported for maize grain was similar to findings reported by (Donkoh and Attoh-Kotoku, 2009). The high CP content of MB relative to that of maize grain clearly shows loss in nutritive value due to dehulling since the removed parts (pericarp and germ) contain about 74% of the total protein (Watson, 1987).

The trend for fat content in sorghum grains was similar to that of protein. The high fat content in MB (12.29%) compared to 1.5% for BR was probably due to the components contained in the by-product (Esmail, 2003; Nalwanga *et al.*, 2009). In most cases MB contains high amount of the germ which is an oil part of the grain. The underlying reasons for the slight difference in fat content between the RS and WS observed in the present study are unclear. The high and lowest ADF and NDF levels in MB and BR respectively were a reflection of the presence and absence of the bran components in the byproducts (Leisteine *et al.*, 2005; Dale, 2009; Bernard, 2010). The higher levels of ADF and NDF in RS compared to WS are to some extent associated with the presence of tannins in the latter (Ebadi *et al.*, 2005; Dykes and Rooney, 2006).

Dry matter content for oil seed meals and leaf meals with the exception of CSM observed in the present study were within the range of (89.1-91.6%) reported (Jagadi *et al.*, 1987; Perez-Maldonado and Rodriguez, 2007; Broin, 2007). The leaf and oil seed meals are supposed to be properly dried because lower levels might lead to spoilage as in cereals. Leaf meals are dried under shade so that they can retain most of the nutrients especially the vitamins (Ayssiwede *et al.*, 2010; Tiwari *et al.*, 2006; Attoh-Kotoku, 2009). The high DM content for curcubita seeds could have been due to longer storage period as this tends to lead in reduction in moisture content since some of these seeds are kept for more than 1 season. The crude protein content of 25% and above observed for the leaf meals and oil seed meals conformed to the fact that plant protein sources contain 20% CP or above (Waldroup and Smith, 2008). The CP values for the individual leaf meals observed in this study were mostly within the reported ranges MOLM (23.63-28.5%); GLM (15.6-26%) and LLM (21-29.9%) (Nieves *et al*., 2004; Broin, 2007; Ayssiwede *et al*., 2010; Olugbemi *et al*., 2010). The wide range of CP for individual leaf meals is mainly attributed to various factors such as stage of maturity of the leaves; physical composition with higher twigs portions decreasing protein content, soil fertility and climate (Ravindran and Ravindran, 1988). The higher CP content for MOLM confirmed reports from other studies that MOLM has higher nutritive value when compared to other leaf meals (Meulen *et al*., 1979; Amata and Bratte, 2008). Crude protein is generally high in oil seed meals and their by products and this was the case in the present study. The value of 46.6% CP for SBM obtained in the present study was within the range of 44-48% reported for SBM (Waldroup and Smith, 2008). The value of 31.4% CP in SCM obtained in the present study was slightly higher than the range of 24-28% reported elsewhere probably due to the fact that composition of most byproducts depends on the method of extraction and the components remaining behind after the extraction process. The CP content for the CSM obtained in the present study was within the range of various Curcubita species (28.68±2.38 to 40.49±2.75) reported (Mohammed, 2004; Achu *et al*., 2005). Their findings showed that the average CP for *Curcubita maxima* was 34.93±0.43 and it was noted that the composition was not influenced by ecological zone. The higher fat content in oil seed meals compared to leaf meals was a reflection of the physical properties of feed ingredients. Leaf meals are made up structural carbohydrates and proteins whereas seeds contain endosperm and the germ which is high in fat content. These structural differences are probably the main reason for the significant differences in fat content observed in the present study between leaf meals and oil seed meals. The high ANF observed in the present study in leaf meals and RS conforms to findings reported in other studies and reflects their limitation particularly in poultry diets (Meulen *et al*., 1979; Nieves *et al*., 2004; Medugu *et al*., 2010). ADF and NDF were highest in the leaf meals when compared to oil seed meals probably as already mentioned mainly due to the high content of complex carbohydrates in the leaves. The relationship between the OSI and total phenols observed in leaf meals was consistent with the findings of Dykes *et al*. (2005). However the underlying reasons for high OSI sorghums with low total phenols and tannins observed in the present study are unclear.

The distribution of TAA observed in the present study conformed to findings from other reports that most plant materials especially cereals are deficient in most EAA. The higher AA in SBM compared to other feed ingredients was in agreement with the fact SBM is a reference plant protein source with well balanced AA (Waldroup and Smith, 2008; Jagadi *et al*., 1987; Donkoh and Attoh-Kotoku, 2009). This fact shows that SBM can provide about 2/3 of the NRC (1994) AA requirements in poultry diets. However this is not the case with cereals which make up to 60-65% of the diet for example with the level of 0.2% lysine, cereals provide about 10% of the requirements. Following this AA supplementation is a common feature in cereal based diets. Various studies have shown that the content of AA is directly related to the level of protein a fact which might have contributed to the observed differences between the ingredient sources.

The mineral content of feed ingredients observed in the present study were within the levels reported by other workers (Amata and Bratte, 2008; Tiwari *et al*., 2006; Chumpawadee *et al*., 2007; Ayssiwede *et al*., 2010; Donkoh and Attoh-Kotoku, 2009; Djakalia *et al*., 2011). The higher meals in leaf meals observed in this study have been reported elsewhere. Sodium was very low (0.02-0.05%) in all feed ingredients and this shows why it is important to supplement sodium in the form of NaCl. It has been noted with these levels of Na in plant feed ingredient materials they can provide between 15-20% of the requirements at an inclusion level of 80% (Leeson and Summers, 2005). The differences in mineral content between feed ingredients observed in this study showing higher levels for leaf meals were in agreement to findings reported elsewhere.

Conclusion: The nutrient compositions of feed ingredients observed in the present study were within the ranges reported elsewhere. Significant differences between nutrient sources were observed. Cereals contained high energy but were deficient in minerals and TAA, this has an implication on feed formulation because cereals and by products form 60-70% of poultry diet. Depending on processing methods and types by products can have high or lower nutrient components. The presence of high ant-nutritional factors in leaf meals can limit their use in animal diets despite the nutritional value. Soybean has higher nutritional value when compared to other plant materials. The high oil stability index and total phenols need to be explored further since they might have an impact on the animal's health.

ACKNOWLEDGEMENTS

The authors would like to thank Novus International, Inc for providing funding and research facilities, AWARD (African Women in Agricultural Research and Development) for facilitating the research attachment program and Sokoine University of Agriculture for granting permission to Salome Mutayoba. The assistance of the lab technicians at Novus and Tanzania is highly appreciated.

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