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Nutrient Composition of Some Unconventional and Local Feed Resources Available in Senegal and Recoverable in Indigenous Chickens or Animal Feeding

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Abstract: This study was carried out to assess the nutrient composition of some unconventional and local feed resources available in Senegal so as to use them as protein supplement sources in the diets of indigenous chickens to enhance their productivity. Ten (10) unconventional and local ingredients from Senegal including leguminous leaves (*Leuceana leucocephala*, *Cassia tora*, *Moringa oleifera*, *Adansonia digitata*, *Sesbania rostrata*), cucurbit (*Citrullus vulgaris*) and roselle (*Hibiscus sabdariffa*) seeds, red and white cowpea (*Vigna unguiculata* seeds) and cockroaches (*Blatta orientalis*) were collected, sun-dried, processed into meal and analyzed for their chemical and macro-mineral composition using internationally established procedures. The results showed that the samples Dry Matter (DM) percent ranged from 89.3% (red cowpea) to 94.9% (*C. vulgaris*). The Crude Protein (CP) content ranged from 24.7% (white cowpea) to 61.9% (cockroaches meal), with *A. digitata* leaves having the lowest value (12.9%). Citrullus and Hibiscus seeds meal recorded the highest (38.8% and 18.9%) Ether Extract (EE) values, followed respectively by cockroaches (11.1%), Moringa (9.8%), Leuceana (6.4%) and Sesbania leaves meal (5.1%), while the others were below 4.5%. The crude fiber (CF) content was globally high in the leaves, ranging from 11.7% (*M. oleifera*) to 16.8% (*C. tora*) while that of seeds and cockroaches ranged from 1.9% (white cowpea) to 19% (Citrullus seeds). *A. digitata* leaves gave the highest ash content (25.2%), followed by Cassia (15.2%), Moringa (13.6%), Leuceana (11.4%) and Sesbania leaves (7.1%), while the others were below 5.6%. The metabolizable energy (ME) value calculated for seeds and cockroaches meal ranged from 3161 kcal/kg DM (cockroaches) to 4270 kcal/kg DM (*C. vulgaris*) and that of leaves from 1873 (*A. digitata*) to 2888.9 kcal/kg DM (*M. oleifera*). Cassia leaves contained the highest level of calcium (3.1%), followed by Adansonia and Leuceana (1.81%), Moringa and Sesbania leaves (1.41%), whilst cockroaches, Hibiscus and Citrullus seeds meal recorded respectively 0.93, 0.81 and 0.55% of phosphorus. These results showed that all the ingredients samples contained appreciable quantities of all dietary nutrients tested for which more or less make them partial or complete substitutes for the conventional feed sources.

Key words: Nutrient composition, indigenous chickens, unconventional feed resources, Senegal

INTRODUCTION

The ultimate aim of any livestock industry is the attainment of sustainable livestock production in the shortest time possible in order to give access any people to animal protein source with minimum cost. In developing countries of West Africa, particularly in Senegal, this has proved difficult because of the dependency on some conventional ingredients that are either imported and or expensive where they locally exist (Doumbia, 2002). The indigenous poultry farming, although very little concerned by development projects, accounts for 75-80% of poultry herd and is practiced by almost all peasants, including women and children of rural areas. It remains the most widespread or common way of livestock handling and constitutes an important pillar of food security improvement and socio-economic

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development despite the remarkable growth recorded in recent years in industrial poultry (Bebay, 2006; Traore, 2006).

But, the indigenous chickens' production is confronted to various constraints among which food is a major challenge. In addition to the lack of dietary supplement, village poultry faced quantitative and qualitative food shortage particularly in poor agricultural or household residues environment (Pousga, 2007; Sonaiya and Swan, 2004; Hofman, 2000; Bonfoh *et al.*, 1997; Buldgen *et al*., 1992). Moreover, the common protein ingredients (fish meal, groundnut cake and soybean) and others used in poultry feeding have become too expensive because of their excessive demand in Senegal (Doumbia, 2002). All this, consequently, has highly reduced access to these resources for traditional poultry compared to industrial poultry herders'. Thus, in order to allow indigenous poultry livestock to contribute effectively to the poverty alleviation and food security improvement, it is necessary and essential to increase their productivity by improving their strategies of feeding through unconventional and local feed resources' utilization. However, several studies carried out on leguminous leaves or by-products such as *Moringa oleifera* (Kakengi *et al.*, 2007; Foidl *et al.*, 2001; Makkar and Becker, 1997), *Cassia tora* (Nuha *et al*., 2010; Ousman *et al*., 2005; Mbaiguinam *et al*., 2005), *Leuceana leucocephala* (Aletor and Omodara, 1994; Hussain *et al.*, 1991; Ekpenyong, 1986; Akbar and Gupta, 1985; D'Mello and Fraser, 1981), *Sesbania rostrata* (Brown *et al*., 1987; Singh *et al.*, 1980) and *Adansonia digitata* (Bergeret, 1990; Mahamat-Silaye, 1981), *Vigna unguiculata* seeds (Defang *et al.*, 2008; Emiola *et al.*, 2007), *Citrullus vulgaris* seeds (Loukou *et al*., 2007; Shayo *et al.*, 1997), *Hibiscus sabdariffa* seeds (Cisse *et al*., 2009; Hainida *et al*., 2008; Yagoub *et al*., 2008; Rao, 1996) and invertebrates or insects (Adeniji, 2007; Ojewola and Udom, 2005; Awoniyi *et al*., 2003), have reported that they were important feed resources relatively rich in nutrients. Although the presence of anti-nutritional factors (mimosine, tannins, lectine, trypsin inhitors, phenols compounds, etc.) has often been mentioned as the handicap of the intensive utilization of some of them (D'Mello, 1992; 1982; Suliman *et al.*, 1987; Semenye, 1990), they have been used both in ruminants and monogastrics with various performance results depending on their nutritional value and inclusion level (Suliman *et al*., 2009; Atawodi *et al.*, 2008; Kakengi *et al.*, 2007; Sarwatt *et al.*, 2002; Tomas-Jinez *et al*., 1998; Shayo *et al.*, 1997; D'Mello and Acamovic, 1989; Ter Meulen *et al.*, 1984; Jones and Megarrity, 1983; Gupta *et al*., 1970).

In Senegal, all these previous resources are available in relatively high quantities. The leguminous leaves are naturally found in different regions of this country which also produce an important cowpea (*V. unguiculata*), cucurbits (*C. vulgaris*) and roselle (*H. sabdariffa*) seeds through fruit production. Furthermore, no study has been carried out on their nutritive value and use in poultry feeding, especially in indigenous Senegal chickens. It is in this context that the present study was undertaken to evaluate the nutrient content of these unconventional and local feed resources available in Senegal so as to use them as protein supplement sources in the diets of indigenous Senegal chickens.

MATERIALS AND METHODS

Ingredients collection and processing: The various leguminous leaves (*Leuceana leucocephala*, *Cassia tora*, *Moringa oleifera*, *Adansonia digitata*, *Sesbania rostrata*) used in this study were mainly collected in the region of Thiès, 70 km from Dakar, particularly in the High National Agricultural School of Thiès (ENSAT) and in the neighborhood villages fields. Branches of plants bearing leaves were cut and transported to the ENSAT where they were displayed evenly under a semi-open shed for 2 days. The branches and twigs were then removed and leaflets and leaves were retrieved. They were sun-dried during 1-2 days until they become soft crispy while still retaining the greenish coloration. Indeed, the sun drying was able to reduce or eliminate the potential labile toxic factors such as mimosine, lectine and others factors present in some leguminous plants leaves (Wee and Wang, 1987; Tangendjaja *et al.*, 1984; D'Mello and Fraser, 1981). These sun-dried leaves were then processed into meal using a grinder mesh of 4 mm in diameter. The seeds of *Citrullus vulgaris* (syn., *C. lanatus*) and *Hibiscus sabdariffa* were collected from Niayes zone of Dakar, Thiès and Saint Louis while those of *Vigna unguiculata* (white and red variety) were bought at the local markets of Dakar and Thiès. After collection, the different seeds were sun-dried for one day and processed into meal using the previous grinder mesh. But, the cockle surrounding the *C. lanatus* seeds were not removed before grinding these seeds. The cockroaches (*Blatta orientalis*) were obtained by pulverizing the cleaning septic and household with insecticide. After this treatment, they were quickly collected in transparent plastic bottle which was immerged in hot water (100^{o}C) for around 5-10 min. The killed cockroaches were then sun-dried for 3-4 days before processing into meal and packaged in plastic bags.

The leguminous leaves and different seeds meals obtained after processing were separately packaged in plastic bags and stored until use. 42 samples of the different meals from these unconventional or local ingredients were subjected to chemical analyses and energy contents determination.

Proximate analyses of various test ingredients: Chemical analyses were carried out in the laboratories of food and animal nutrition of Inter-states School of Sciences and Veterinary Medicine (EISMV) of Dakar and of the ENSAT (Senegal) and in the laboratory of animal nutrition of Veterinary Medicine Faculty of Liege University (Belgium) from February to September 2009. The analyses were concerned the determination of dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), neutral detergent fiber (NDF), total ash, nitrogen free extract (NFE) and macro-mineral (calcium, phosphorus, sodium and potassium).

The DM and total ash of different samples were obtained according to standard methods of the French Association for Standardization, AFNOR (1977). The CP and EE contents were determined respectively based on the Kjeldahl method (N*6.25) and the reflux extraction method for 6 hours with diethyl ether or petroleum ether using the Soxhlex apparatus described by the same standard. The CF determination was carried out following AFNOR (1993) standard based on the Weende's method, while that of the NDF was based on the method of Van Soest and Wine (1967). The NFE content was determined per simple deduction between the DM content and other nutrient (CP, CF, EE, Ash) contents.

The calcium, sodium and potassium were measured according to the photometric absorption method of AFNOR (1984) and the total phosphorus determination was done using the spectrophotometric absorption method at 430 nm as described by AFNOR (1980). All analyses on samples for each of these parameters were performed in duplicates and parameters were calculated based on dry matter.

The energy contents of ingredients were calculated according to the regression equations of Sauvant *et al*. (2004) for gross energy (GE) value and that of Sibbald *et al*. (1980) cited by Leclercq *et al*. (1984), for the metabolizable energy (ME) value of leaves and seeds meals for poultry. The ME content of cockroaches meal was calculated according to the regression equation of Bourdon *et al.* (1984) applied to fish meal.

Statistical analyses: The data obtained were subjected to descriptive analysis using the Statistical Package for Social Science (SPSS). The results expressed in percentage of dry matter (% DM) were presented as mean±standard deviation.

RESULTS

The chemical composition and energy contents of the various ingredients analyses were reported in Table 1. The Dry Matter (DM) content of the tested materials ranged from 89.3% (red *Vigna unguiculata*) to 94.9% (*Citrullus vulgaris*). Except this last material which had the highest percent DM among the seed meal, the DM content of all leguminous leaves meal (91.1-92.4%) was higher than that of seeds and cockroaches meal (89.3-90.3%).

The Crude Protein (CP) content of samples ranged from 12.9% (*Adansonia digitata* leaves meal) to 61.9% (cockroaches meal). Of all the leaves meal samples evaluated, *Moringa oleifera* leaves gave the highest percent CP (28.5%). This was followed by *Cassia tora* leaves (27.4%), *Sesbania rostrata* leaves (27.1%) and *Leuceana leucocepha* leaves (25%). Concerning the seed meal, *Hibiscus sabdariffa* had the highest CP content (27.3%), followed by red *Vigna unguiculata* (26.9%), *Citrullus vulgaris* (25.4%) and white *Vigna unguiculata* seeds (24.7%). The tested materials such as *C. vulgaris* and *H. sabdarifa* seeds meal recorded the highest Ether Extract (EE) values, 38.8% and 18.9% respectively. Cockroaches' meal, moringa, leuceana and sesbania leaves meal had an appreciable EE content of 11.1, 9.8, 6.4 and 5.1% respectively while the others were below 4.5%.

The Crude Fiber (CF) content was globally high in the leaves and ranged from 11.7% (*M. oleifera*) to 16.8% (*C. tora*) while that of *V. unguiculata* white and red seeds and cockroaches was low, 1.9, 4.8 and 4.1% respectively. Citrullus and Hibiscus seeds meal had CF content of 19 and 10.7%. The Neutral Detergent Fiber (NDF) content ranged from 15.1% (*M. oleifera*) to 43.5% (*H. sabdariffa*). Of all leaves meal analyzed, the percent NDF was lower (15.1-29.9%) than that of seeds meal (32.4-43.5%).

For Nitrogen Free Extract (NFE), except for Citrullus seeds and cockroaches meal which had the lowest values (14.2 and 17.4%), the other ingredients contained a relatively high percent NFE, ranging from 36.3% (*M. oleifera*) to 68.6% (white *V. unguiculata* seeds). *Adansonia digitata* leaves gave the highest total ash content (25.2%), followed by *C. tora* (15.2%), *M. oleifera* (13.6%), *L. leucocephala* (11.4%) and *S. rostrata* (7.1%), while the others were below 5.6%. The least value (2.6%) was obtained with Citrullus seeds meal.

The Gross Energy (GE) content was highest for *C. vulgaris* seeds meal (6603 kcal/kg DM), followed closely by cockroaches meal (5419 kcal/kg DM) and *H. sabdariffa* seeds meal (5391 kcal/kg DM). *Vigna unguiculata* (white and red) seeds meal and leaves meal contained an appreciable GE content, ranging from 4219 kcal/kg DM (*C. tora*) to 4634 kcal/kg DM (*S. rostrata*), except *A. digitata* leaves meal which recorded the least GE value (3554 kcal/kg DM). The Metabolizable Energy (ME) value recorded with cockroaches meal and seeds meal, ranged from 3161 kcal/kg DM (cockroaches) to 4270 kcal/kg DM (*C. vulgaris*) and was higher than those (1873-2888.9 kcal/kg DM) obtained in leaves meal. Moringa leaves meal gave the highest amount of ME (2889 kcal/kg DM), followed by Leuceana (2573.8 kcal/kg DM) and Sesbania leaves meal (2510.2 kcal/kg DM), while Cassia and Adansonia leaves meal did not contained more than 2050.5 and 1873 kcal/kg DM respectively.

The macro-mineral contents of various ingredient samples summarized in Table 2, showed that the

Table 1: Chemical composition and energy content of some unconventional and local feed resources available in Senegal and recoverable for poultry and animal nutrition

Composition	*L. leucocephala* (leaves meal)	*C. tora* (leaves meal)	*M. oleifera* (leaves meal)	*A. digitata* (leaves meal)	*S. rostrata* (leaves meal)	*Cit. vulgaris* (seed meal)	*H. sabdarifa* (seed meal)	*V. unguiculata* (White SM)	*V. unguiculata* (Red SM)	*B. orientalis* *(cockroaches)*
Samples	05	05	05	05	03	05	05	03	03	03
DM (%)	92.4 ± 0.2	92.2 ± 0.5	92.3 ± 0.2	91.1 ± 0.5	91.6 ± 0.1	94.9 ± 0.4	89.9 ± 0.4	90.3 ± 0.5	89.3 ± 0.4	89.4 ± 1.1
CP (% DM)	25.0 ± 0.8	27.4 ± 1.5	28.5 ± 1.71	12.9 ± 1.3	27.1 ± 0.6	25.4 ± 0.6	27.3 ± 1.0	24.7 ± 1.4	26.9 ± 2.7	61.9 ± 4.0
EE (% DM)	6.4 ± 0.5	3.8 ± 0.2	9.8 ± 0.8	4.2 ± 1.8	5.1 ± 0.2	38.8 ± 0.3	18.9 ± 1.3	1.7 ± 0.1	3.3 ± 1.1	11.1 ± 0.1
CF (% DM)	14.2 ± 0.5	16.8 ± 1.7	11.7 ± 3.6	14.4 ± 1.2	16.1 ± 0.8	19.0 ± 1.5	10.7 ± 0.9	1.9 ± 0.4	4.8 ± 1.2	4.1 ± 0.4
NDF (% DM)	22.4 ± 0.9	25.7 ± 1.3	15.1 ± 4.8	29.9 ± 3.0	26.6 ± 0.7	38.8 ± 2.9	43.5 ± 3.7	32.4 ± 4.3	33.5 ± 1.0	-
NFE (% DM)	43.1 ± 1.6	36.8 ± 1.0	36.3 ± 3.4	43.3 ± 5.4	44.5 ± 0.7	14.2 ± 0.9	37.7 ± 2.9	68.6 ± 1.0	61.2 ± 4.8	17.4 ± 4.7
Ash (% DM)	11.4 ± 0.3	15.2 ± 0.5	13.6 ± 1.1	25.2 ± 3.8	7.1 ± 0.1	2.6 ± 0.1	5.3 ± 0.5	3.1 ± 0.3	3.8 ± 0.2	5.5 ± 1.1
GE (kcal/kg DM)	4459.4 ± 24[1]	4218.9 ± 16[1]	4569.6 ± 60[1]	3554 ± 154[1]	4634 ± 14.3[1]	6603 ± 17.1[1]	5390.8 ± 62[1]	4465.4 ± 38[1]	4579.9 ± 119[1]	5419.2 ± 52[1]
ME (kcal/kg DM)	2573.8 ± 52.5[2]	2050.5±147[2]	2888.9 ±295[2]	1873.3±99[2]	2510.2 ± 72[2]	4269.9 ± 147[2]	3843.7 ± 92[2]	3749.1 ± 41[2]	3555.4 ± 39[2]	3160.7±167[3]

DM: Dry Matter; CP: Crude Protein; EE: Ether Extract; CF: Crude Fiber; NDF: Neutral Detergent fiber; NFE (Nitrogen Free Extract) = 100 - CP - EE - CF - ash; GE: Gross Energy; ME: Metabolizable Energy; SM: seed meal

[1]ME (kcal/kg DM) = 4134 + 14.73*CP + 52.39*EE + 9.25*CF - 44.60*Ash + F; (with F = 0) in [Sauvant *et al*., 2004]

[2]ME (kcal/kg DM) = 3951 + 54.4*EE – 40.8*Ash – 88.7*CF, in [Leclercq *et al*., 1984].

[3]ME (kcal/kg DM) = 39.5*CP + 64.5*EE, in [Bourdon *et al*., 1984]

Table 2: Macro minerals composition of some unconventional and local feed resources available in Senegal and recoverable for poultry and animal nutrition

Composition	*L. leucocephala* (leaves meal)	*C. tora* (leaves meal)	*M. oleifera* (leaves meal)	*A. digitata* (leaves meal)	*S. rostrata* (leaves meal)	*Cit. vulgaris* (seed meal)	*H. sabdarifa* (seed meal)	*V. unguiculata* (White SM)	*V. unguiculata* (Red SM)	*B. orientalis* *(cockroache*
Samples	05	05	05	05	03	05	05	03	03	03
Ca (% DM)	1.81 ± 0.10	3.14 ± 0.10	1.40 ± 0.13	1.812 ± 0.42	1.42 ± 0.06	0.012 ± 0.01	0.12 ± 0.0	0.060 ± 0.04	0.060 ± 0.05	0.075 ± 0.03
P (% DM)	0.20 ± 0.00	0.43 ± 0.01	0.30 ± 0.03	0.372 ± 0.07	0.23 ± 0.04	0.554 ± 0.20	0.81 ± 0.0	0.403 ± 0.01	0.407 ± 0.02	0.930 ± 0.07
Na (% DM)	0.01 ± 0.00	0.01 ± 0.00	0.20 ± 0.02	0.014 ± 0.01	0.32 ± 0.04	0.0 ± 0.0	0.0 ± 0.0	0.004 ± 0.0	0.0 ± 0.0	0.190 ± 0.00
K (% DM)	1.11 ± 0.03	1.30 ± 0.02	1.40 ± 0.06	0.630 ± 0.20	1.05 ± 0.05	0.470 ± 0.04	0.96 ± 0.02	0.943 ± 0.10	0.977 ± 0.05	0.740 ± 0.04

DM: Dry Matter; Ca: Calcium; P: Phosphorus; Na: Sodium; K: Potassium; SM: seed meal leguminous leaves meal appeared to be better sources of calcium for animal nutrition than seeds and cockroaches' meals. The Cassia leaves contained the highest level of calcium (3.1%), followed by Adansonia and Leuceana leaves (1.81%), Moringa and Sesbania leaves (1.41%), while that of other ingredients (seeds and cockroaches meal) ranged from 0.01% (*C. vulgaris*) to 0.12% (*H. sabdariffa*).

Except cockroaches' meal, Hibiscus and Citrullus seeds meal which recorded respectively 0.93, 0.81 and 0.55% of phosphorus, the other ingredients did not contained more than 0.40% of this mineral. Concerning sodium, only cockroaches' meal, Moringa and Sesbania leaves meal, contained about 0.20-0.30%. Most of the various ingredients analyzed were very poor in sodium, whilst potassium was present in an appreciable amount in all these tested materials, ranging from 0.47% (*C. vulgaris* seeds) to 1.40% (*M. oleifera* leaves).

DISCUSSION

The nutrient composition of Leuceana leaves are globally in agreement with those obtained by other authors (Dhar *et al.*, 2007; Reyes and Fermin, 2003; Aletor and Omodara, 1994; Ekpenyong, 1986; Akbar and Gupta, 1985). However, the Crude Protein (CP) content was higher than those (23% and 21.3% DM) obtained respectively by Onibi *et al.* (2008) and Hussain *et al.* (1991) and was inferior to those (28-29% DM) reported by Munguti *et al.* (2006), Farinu *et al.* (1992) and D'Mello and Fraser (1981). Ash content and Metabolizable Energy (ME) are relatively higher than those obtained by most of these authors. Moreover, the Crude Fiber (CF) content obtained was quite high, but still remains below that (15-19% DM) of Munguti *et al.* (2006), Aletor and Omodara (1994) and Akbar and Gupta (1985). In comparison to the composition of other leaves such as *Gliricidia sepium* (Ige *et al.* 2006; Odunsi *et al.*, 2002), *Centrosoma pubescens* (Nworgu and Fasogbon, 2007), *Manihot esculenta* (Iheukwumere *et al.*, 2008) and *Azolla pinnata* (Alalade and Iyayi, 2006; Basak *et al.*, 2002; Becerra *et al.*, 1995), Leuceana leaves contained similar levels of CP and CF but, were richer in Ether Extract (EE) and minerals, particularly in calcium and potassium. Furthermore, their nutrients and energy contents are lower than those of *M. oleifera* leaves (Kakengi *et al.*, 2007; Foidl *et al.*, 2001; Fuglie, 1999; Makkar and Becker, 1997; 1996).

In previous analyses of *C. tora* leaves, various levels of CP [20-25% by Nuha *et al*. (2010), Ousman *et al*. (2005), Mbaiguinam *et al*. (2005), Boussaid El Hadj (2004) and Mahamat-Silaye (1981), 13% by Ranjhan *et al*. (1971)], crude fiber [13.9%, 18-25% respectively by Ousman *et al*. (2005), Nuha *et al*. (2010) and Ranjhan *et al*. (1971)], neutral detergent fiber, NDF [56% by Mbaiguinam *et al*. (2005) and Boussaid El Hadj (2004)], calcium [2-2.82% by Mbaiguinam *et al*. (2005), Ousman *et al*. (2005), Boussaid El Hadj (2004), Mahamat-Silaye (1981), Ranjhan *et al*. (1971)] and phosphorus [0.28-0.93% by Mbaiguinam *et al*. (2005), Ousman *et al*. (2005), Boussaid El Hadj (2004), Ranjhan *et al*. (1971)] were obtained. Calcium (3.1%) and phosphorus (0.4%) content recorded in our study were in agreement with those (respectively 2.9-3% and 0.38-0.41%) obtained by Nuha *et al*. (2010). Ousman *et al*. (2005) and Ranjhan *et al*. (1971) have determined a high proportion of nitrogen-free extract (53.1% and 46.4%) against 36.3% in this study. If the CP content of Cassia leaves (27.4% DM) was globally comparable to those obtained by several authors on Moringa (Kalinganire *et al*., 2007; Reyes and Fermin, 2003; Fuglie, 1999), Leucaena (Munguti *et al.*, 2006; Akbar and Gupta, 1985) and Sesbania leaves (Brown *et al.*, 1987), their low ME is mainly due to their high CF and ash contents. Indeed, Cassia leaves are poor in EE and ME, but well supplied in CF and ash, particularly in calcium compared to the composition of Moringa (Kakengi *et al*., 2007; Ndong *et al*., 2007; Soliva *et al*., 2005; Foidl *et al.*, 2001; Makkar and Becker, 1996), Leuceana (Onibi *et al*., 2008; Munguti *et al.*; 2006; Reyes and Fermin, 2003; Hussain *et al.*, 1991; Satyanarayana Reddy *et al*.,1987; D'Mello and Fraser, 1981), Gliricidia (Ige *et al.* 2006; Odunsi *et al.*, 2002), Centrosoma (Nworgu and Fasogbon, 2007) or *A. pinnata* leaves (Alalade and Iyayi, 2006; Basak *et al.*, 2002; Becerra *et al.*, 1995; Tamang and Samanta, 1993).

Nutrients content of Moringa leaves in this study were globally comparable to those obtained by Olugbemi *et al*. (2010a; 2010b), Kalinganire *et al*. (2007), Foidl *et al*. (2001), Fuglie (1999) and Makkar and Becker (1996). However, CP content (29.25, 36.39 and 32.10%) obtained respectively by Nuhu (2010), Ndong *et al*. (2007) and Soliva *et al*. (2005), were higher than that (28.5%) of this study. The ME (2888.9 kcal/kg DM) was higher than those (2270 and 1878 kcal/kg DM) recorded respectively by Kakengi *et al*. (2007) and Makkar and Becker (1996). The CF contents (4.2, 7.3, 8.8 and 7.9%) obtained by Ndong *et al.* (2007), Afuang *et al*. (2003), Reyes and Fermin (2003) and Richter *et al*. (2003) are all lower than that of our study (11.7%), whilst that (19-22% DM) of Nuhu (2010), Kakengi *et al*. (2007) and Makkar and Becker (1996) were the highest. Compared to Leuceana (Onibi *et al*., 2008; Dhar *et al*. 2007; Reyes and Fermin, 2003; Aletor and Omodara, 1994; Hussain *et al*. 1991; Akbar and Gupta, 1985), Cassia (Nuha *et al*., 2010; Ousman *et al*., 2005; Mbaiguinam *et al*. 2005; Boussaid El Hadj, 2004), Gliricidia (Ige *et al*. 2006; Odunsi *et al*., 2002), cassava (Iheukwumere *et al*., 2008; Onibi *et al*., 2008) and *A. pinnata* leaves (Alalade and Iyayi, 2006; Basak *et al*., 2002; Becerra *et al*., 1995), Moringa leaves contained less CF, but more CP, EE and ME. However, except Leuceana, Adansonia and Cassia leaves which were the richest in calcium (1.8-3.1%) among the test leaves, Moringa leaves contained an appreciable amount of this mineral than others (Iheukwumere *et al*., 2008; Alalade and Iyayi, 2006; Mbaiguinam *et al*., 2005; Akbar and Gupta, 1985).

Nutrients content of *Sesbania rostrata* leaves meal were similar to those obtained by Brown *et al*. (1987), Gohl (1981) and Hutagalung (1981). However, the chemical results gave by Brewbaker (1986), NAS (1979) and Skerman (1977) for these leaves were higher than those of our study, particularly for CP (30.1-36.2% vs. 27.1%), ash (9.2-12.5% vs. 7.1%) and calcium (2.15-2.70% vs. 1.4%) contents. But, the CP value obtained (27.1%), was higher than those (19.4-21.3%) of Akkasaeng *et al.* (1989) and Singh *et al.* (1980). Unlike *A. digitata* leaves meal, Sesbania leaves appeared to be a relatively good source of protein and energy as well as Leuceana and Moringa leaves. The different variations in the rates of nutrients and energy observed in or between leaves samples can be explained not only by vegetable age or stage of development of species, but also by the source, the processing method and the type of leaves. According to Akbar and Gupta (1985), young leaves and leaflets are richer in crude protein than mature leaves while the later are in crude fiber, as well as leaflets with the presence of residual veins or twigs. Consequently, this could partially explain the low ME content of some tested leaves (*C. tora*, *A. digitata*) in addition to their low EE and high ash contents (Ndong *et al.*, 2007; Mahamat-Silaye, 1981).

Concerning cucurbit (*C. vulgaris)* seeds meal, our results in CP (25.4%), EE (38.8%) and CF (19%) contents were higher than those (respectively 16.8%, 24.4% and 31.8%) obtained in Central Tanzania by Shayo *et al*. (1997). The CP and EE content recorded were lower than those (29.8% and 56.67% in Côte d'Ivoire and 35.1% and 48.4% in Senegal) obtained respectively by Loukou *et al*. (2007) and Mahamat-Silaye (1981), whilst for CF and NFE contents, we have the highest values (19% vs. 2.87% and 14.2 vs. 8.87%). Compared to the composition of other varieties of cucurbits (*Cucumeropsis mannii* and *Cucumis melo*) analyzed by Loukou *et al.* (2007), the results are comparable except for NFE content. According to Badifu Ogunsua (1991) cited by Achigan Dako *et al*. (2006), *C. lanatus* seed meal contained 40-44% of EE, while Camara (1996) cited by Meite *et al.* (2008) found about 39.4% of CP content. The high variation between our results and those of previous authors could mainly due to the type of seeds used, because unlike to Loukou *et al.* (2007) and Mahamat-Silaye (1981), our seeds were not shelled before processing in to meal. This could increase the level of CF and decrease these of other nutrients content of the seeds.

Hibiscus seeds meal nutrient composition was similar to that obtained by Cisse *et al*. (2009). The crude protein (27.1%) content was in agreement with that (27-27.8%) obtained by Ahmed and Hudson (1982), but higher than those (18-25.4%) of Tomas-Jinez *et al.* (1998), Rao (1996) and Mahamat-Silaye (1981) and lower than those (28% and 30-33.4%) of APRC (1999) and El-Adawy and Khalil (1994). Indeed, previous studies had significantly shown that Hibiscus seeds contained high amounts of DM, CP, EE and CF. Egyptian Hibiscus seeds contain 91.4% DM, 34.0% protein, 22.3% EE and 15.3% CF (Samy, 1980). In Malaysia seeds 90.1%, 33.5%, 22.1%, 18.3% and 7.5% were respectively recorded for DM, CP, EE, CF and ash contents (Hainida *et al*., 2008), while Sudan seeds were composed of 32.28% CP, 19.9% lipids and 22.29% CF (Yagoub *et al*., 2008). Another study from India found that the seeds contain 92-94% DM, 18-22% CP, 19-22% lipids or ether extract, 39-42% CF and 5.4% ash (Rao, 1996). Latest findings by Suliman *et al*. (2009) found that the Sudan seeds contained around 95% DM, 28.82% CP, 16.24% EE and 15.13% CF. These differences may be related to geographical variations of the regions.

Nutrient content of *V. unguiculata* (red or white) seeds in this study was similar to that (24.57% CP, 2.7% CF, 1.30% EE and 3.60% ash) recorded in Cameroun by Defang *et al.* (2008). If our CP (24.70-26.9%) content was in agreement with that (26.85%) obtained by Emiola *et al*. (2007) for black common bean (*Phaseolus vulgaris*), this CP value was higher than those (21-23.60%) found by Defang *et al.* (2008) for *P. vulgaris* and Mahamat-Silaye (1981) for *V. unguiculata* and *Carnavalia ensiformis* seeds. However, *Mucuna pruriens* seeds meal contained relatively more nutrients (28-33% CP, 5-7% EE, 2.3-4.7% ash, 6.7-9% CF) than *V. unguiculata* seeds used in our study (Emiola *et al*., 2007; Emenalom and Udedibie, 2005; Emenalom *et al*., 2005). Compared to other leguminous seeds meal such as *Cajanus cajan* (Onu and Okongwu, 2006; Amaefule and Nwagbara, 2004), *Afzelia africana* (Ayanwale *et al*., 2007), Vigna seeds meal had quite similar rates of nutrients content except CF and ash for which they have the lowest value. Furthermore, the cockroaches (*Blatta orientalis*) meal, except its very low ash content, particularly calcium and sodium, had quite similar nutrients composition as fish meal (Ojewola and Udom, 2005; Bourdon *et al.*, 1984) and its CP content was higher than those of all the most unconventional animal sources: maggots, crayfish, shrimps, crabs, squilla, pellonula (Adeniji, 2007; Ojewola and Udom, 2005; Awoniyi *et al*., 2003). Citrullus and Hibiscus seeds meal, cockroaches' meal, Moringa, Leuceana or Sesbania leaves meal in a decreasing order recorded relatively appreciable EE values. This is an indication that the ingredients can supply a relatively sufficient energy in diets of animal to limit protein utilization as energy source. Therefore, the important ME obtained with seeds meal and cockroaches' meal in this study, could essentially be due to their high EE content (38.8% for *C. vulgaris* and 18.9% for *H. sabdariffa*), their low CF and ash contents (*V. unguiculata*), or to their high CP (61.9%) and EE (11.1%) contents (cockroaches). Although, most of the tested ingredients in our study appeared to be a relative good source of nutrients, some of them are known to contain various anti-nutritional factors that could limited their utilization in animal feeding. According to different authors (Nuha *et al.*, 2010; D'Mello, 1992; 1982; Makkar and Becker, 1997; Morimoto *et al*., 1988; Suliman *et al*., 1987; Acamovic and D'Mello, 1984; Ter Meulen *et al*., 1984), leguminous leaves or seeds meal are generally supplied in toxic factors such as mimosine, tannins and phenol compounds, trypsin inhibitor, lectine, saponine, phytates, oxalates, etc. which could affect animal health and performances.

Conclusion: Our study shows that there is a clear indication that all the ingredients samples contained appreciable quantities of all dietary nutrients tested for which more or less make them partial or complete substitutes for the conventional feed sources. Except *Adansonia digitata* leaves which were the poorest in regard to crude protein and energy content, the other ingredients were relatively rich in nutrients. Compared to the tested leguminous leaves meal, the seeds meal and cockroaches' meal were poorer in calcium and richer in energy than all these leaves. Therefore, the utilization of these resources in animal feed formulation, particularly in indigenous chicken feeding, should be encouraged in Senegal. However, feeding trials still needed to be conducted to establish digestibility and metabolic utilization, levels of inclusion, productive and economic efficiency of using these unconventional and local feed resources. This utilization must also be done carefully or needed removing precaution in order to take into account the potential anti-nutritional factors contained by some of them which could caused toxic effects to livestock.

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