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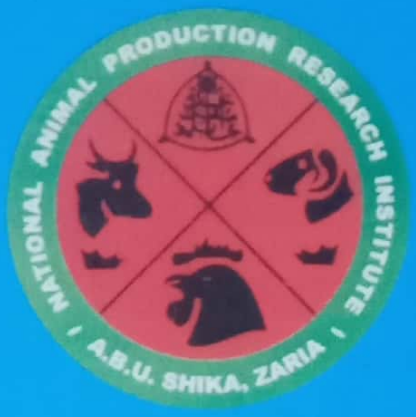

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NUTRITIONAL COMPOSITION OF SOME UNCONVENTIONAL PLANT PROTEIN SOURCES

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ABSTRACT

This study was conducted to determine the nutritional composition of some unconventional protein sources namely; pigeon pea, bambara groundnut, locust bean, sunflower and jack bean. The range of values obtained from the proximate composition of the seeds were; dry matter (94.56-96.64%), crude protein (18.70-28.90%), crude fat (2.72-23.98%), crude fibre (5.48-17.88%), ash (3.36-4.69%) and nitrogen free extract (31.56-59.51%). Among all seeds studied, jack bean had the highest crude protein value of 28.90% while sunflower seed recorded the lowest crude protein value of 18.70%. Results showed that sunflower seed had the highest crude fat content of 23.98% and jack bean recorded the lowest value of 2.72%. Locust bean was the most fibrous with the crude fibre content of 17.88% while the least fibrous among the seeds was bambara groundnut with 5.48% crude fibre value. Locust bean also recorded the highest concentration of ash (4.69%) whereas sunflower seed had the lowest value of 3.36%. Methionine and cystine were the most limiting amino acid for all the seeds analysed. Results revealed that pigeon pea seeds are rich sources of lysine and phenylalanine. Interestingly, locust bean had the highest concentration of leucine as well as isoleucine. In order to ensure food security, people who cannot afford the expensive staple protein food sources can opt for other non-conventional locally available and affordable substitute, in order to avoid protein malnutrition.

Keywords: Proximate composition, amino acid profile, unconventional plant protein sources

INTRODUCTION

The search for alternative sources of protein has generated a lot of research interests over the years. This may probably be due to the exorbitant prices of major staple plant protein foods of which are conventional sources like groundnut, cowpea, soybeans etc.

Non-conventional food or feed sources are those foodstuffs/feedstuffs that are not extensively or widely used for feeding human or his animals. In order to ensure food security, people who cannot afford the expensive staple protein food sources can opt for other non-conventional locally available and affordable substitute, in order to avoid protein malnutrition or a protein deficient diet. Hence the need for the evaluation of major nutritive constituents of these unconventional protein sources which are locally available but under exploited for inclusion in both human and animal diets. The unconventional plant protein sources analysed for the purpose of this study are pigeon pea, bambara groundnut, locust bean, sunflower and jack bean. These

seeds can become of prime importance in nutrition due to their relatively high crude protein composition (18.70-28.90%).

There is great possibility in the exploitation and utilization of novel or non-conventional plant protein sources. It is noteworthy, that there exist a huge number of species and varieties of plant protein sources that are under-utilized and yet to be extensively exploited for nutrition. Some of these novel sources may have promising and desirable nutritive quality for future dietary inclusion.

Proximate analysis is useful in the determination and evaluation of the potential nutritional quality of foodstuffs/feedstuffs. Extensive future use of non-conventional plant protein sources in nutrition is a possibility if efficiently and properly exploited (Akande, 2011). The high cost of conventional protein sources in developing countries as resulted in search for cheaper and available alternative protein sources. The objective of this study was to determine the nutritional composition of some unconventional plant protein sources that are locally available but under-exploited.

Nutritional composition of pigeon pea

There are variations in the chemical composition of pigeon pea seeds, which can be attributed to growth conditions, genotype and storage conditions (Salunkhe *et al.*, 1985; Amaefule and Onwudike, 2000). Pigeon pea is a rich source of protein, carbohydrate and minerals such as, phosphorus, magnesium, iron, sulphur, potassium and calcium. It is also rich in some vitamins, particularly, riboflavin, niacin, thiamine, and choline (Sinha, 1977). The protein content of commonly grown pigeon pea cultivars is in the range of 17.9 and 24.3g/100g for whole seed (Salunkhe *et al.*, 1986). The protein content of commonly grown pigeon pea cultivars is in the range of 17.9 and 24.3g/100g for whole seed (Salunkhe *et al.*, 1986). Wild species of pigeon pea have been found to be very promising sources of high protein and several high-protein genotypes have been developed with a protein content as high as 32.5% (Singh *et al.*, 1990). These high-protein genotypes contain protein content on average by nearly 20% more than the normal genotypes (Reddy *et al.*, 1979; Saxena *et al.*, 1987). The high-protein genotypes also contain significantly more (about 25%) sulphur-containing amino acids, (methionine and cystine) (Singh *et al.*, 1990). Pigeon pea seeds contain about 57.3 to 58.7% carbohydrate, 1.2 to 8.1% crude fibre and 0.6 to 3.8% lipids (Sinha, 1977).

Nutritional composition of bambara groundnut

The nutritional analyses carried out by Yao *et al* (2015) in Côte d'Ivoire revealed that bambara groundnut had 19% protein, 1.4% fat and 10% fibre. Bambara was reported to be a rich source of minerals, the major ones are particularly, phosphorus, magnesium and calcium, while the trace minerals also found in the seeds are zinc, iron and copper. Yao *et al.* (2015) referred to bambara groundnut as nutrient dense food.

Bambara groundnut has been reported to contain carbohydrates, lipids and protein in sufficient quantities (Brough *et al.*, 1993). Bambara groundnut as reported by Olomu (1995) contains 20.60% crude protein. It is high in lysine with fair amount of total sulphur amino acids. The proximate and mineral composition of bambara groundnut as determined by Omoikhoje and Arijeniwa (2004) is presented as follows: crude protein ranged from 18.92 - 21.67%, ether extract 6.45 - 7.47%, crude fibre 3.52 - 4.45, ash 2.75 - 4.56%, moisture content 6.80 - 11.20% and nitrogen free extract 45.93 - 59.04%. Results on the mineral composition indicated that

calcium ranged from 2.64 - 2.81%, phosphorus 0.06 - 0.08%, potassium 0.79 - 0.82%, sodium 0.004 - 0.005%, magnesium 0.65 - 0.68%, iron 151 - 160 ppm and copper 2.4 - 2.6 mg/kg DM (Omoikhoje and Arijeniwa, 2004). Bambara groundnut seeds have been reported by Temple and Alivu (1994) to contain 16 - 24% crude protein and about 6% ether extract with high proportions of lysine (6.6%) and methionine (1.3%). Leucine has been stated to be the most concentrated essential amino acid found in bambara groundnut (Olomu, 1995; Aremu *et al.*, 2006; Akande, 2009). Bambara groundnut is a well balanced food with a calorific value comparable with that of a high quality cereal grain (Barimila *et al.*, 1994).

Nutritional composition of locust bean

The crude protein content of locust bean seed varies between 25 and 35%. The average fat content is 20% (Olomu, 1995). Hassan and Umar (2005) reported that the protein content of locust bean seed (in percentage dry matter) of seeds with and without hull was found to be 28.20% and 32.40% respectively, while that of the pulp was 1.84%. The crude protein of 32.40% for locust bean seeds obtained by these workers is comparable with those obtained by other researchers. (Okpala, 1990; 31.60% CP;. Alabi, 1993; 35.00% CP and Obizoba, 1998; 34.30%).

Results obtained by Hassan and Umar (2005) revealed that the dehulled seeds of locust bean contain higher amount of amino acids than whole seeds except in glycine, phenylalanine, proline and threonine. However, with the exception of cystine and threonine, all other amino acids found in the pulp are lower than those in the seeds. The whole seed of locust bean is high in lysine with the value of 6.56g/100g protein but lower in methionine 1.62g/100g protein and cystine 1.23g/100g protein (Hassan and Umar, 2005).

Alabi *et al.* (2005) reported that the lipid content of locust bean was 16.86%. These researchers observed that the lipid found in locust bean contained saturated fatty acids and hence could solidify as fats at temperatures below 20°C. Oils derived from the cotyledons of the seeds have low iodine value of 1.05mg/100g, and low acid value of 1.90mg/100g. However, locust bean has high saponification value of 160.60mg/100g which makes locust bean oil useful for soap making (Aiyelaagbe *et al.*, 1996; Alabi *et al.*, 2004; Alabi *et al.*, 2005).

Nutritional composition of sunflower

NRC (1984) quoted sunflower seed meal (after oil extraction) figures as 23.3% protein, 31.6% crude fibre, 1% lysine, 0.5% methionine and 1543kcal/kg ME. Putnam *et al.* (1990) reported that sunflower oil accounts for 80% of the value of the sunflower crop. The primary fatty acids in the oil are oleic and linoleic (typically 90% unsaturated fatty acids) with the remainder consisting of palmitic and stearic saturated fatty acids. The major nutrients in sunflower seeds include protein, thiamine, vitamin E, iron, phosphorus, potassium, calcium and the essential fatty acids such as linoleic acid and oleic acid (Relf, 1997). According to the reports of the USDA Nutrient Database (2002), sunflower seeds are the best natural, whole food source of vitamin E, almost all of which is alpha-tocopherol, the most biologically active form.

Nutritional composition of jack bean

Jack bean is cultivated in India, Africa, Latin America, West Indies and Asia, it is considered an under exploited legume (Marimuthu and Gurumoorthi, 2013). The crude protein content of dry ripe jack bean seeds ranges from 26 to 32%. Udedibie (1990) reported that raw jack bean seeds contain 30% crude protein and 60% nitrogen free extract. Bressani *et al.* (1987) reported that jack bean contained about 1.8% ether extract and 8.5% crude fibre, 3.2% ash, 13.5% moisture,

26.0% crude protein and 46.1% carbohydrate. D'Mello *et al.* (1985) reported 2.12%, 2.80% and 9.24% for ether extract, ash and crude respectively. The gross energy content of 4.62kcal/g was reported by Udedibie and Madubuike (1988) for jack bean seeds. Jack bean is relatively low in the sulphur amino acid, methionine, but high in lysine. It contains significant amounts of thiamine, niacin, phosphorus, calcium and iron (Bressani, *et al.*,1987; D'Mello *et al.*, 1985; Udedibie and Nwaiwu, 1988; Leon *et al.*,1990).

MATERIALS AND METHODS

Proximate analysis

Proximate analyses of the five different plant proteins raw seeds namely: pigeon pea, bambara groundnut, locust bean, sunflower and jack bean seeds were carried out using the methods outlined by the Association of Official Analytical Chemists (AOAC, 1990). The proximate compositions of the five plant protein seeds are presented in Table 1.

Amino acid analysis

The amino acid compositions of the samples were determined using the method described by Spackman *et al.* (1958). The samples were dried to constant weight and defatted. A known weight of the defatted sample was hydrolysed under vacuum with 7ml of 6N HCl in a sealed pyrex tube at 105°C for 22 hours. Immediately after cooling, it was filtered through non-absorbent cotton wool. The filtrate was dried at 40°C using rotary evaporator. The amino acids in the flask were diluted with 5ml of acetate buffer (pH 2.0) and 5 to 10 microlitre was loaded into the cartridge of Technicon Sequential Multisample amino acid analyzer (TSM). The steam carrying the amino acid reagent mixture went through a heating bath where development of the coloured reaction product occurred. The absorbance was proportional to the concentration of each amino acid and was measured by colorimeter.

Table 1: Proximate compositions (%) of raw seeds of some unconventional plant protein sources

Content	Pigeon Pea	Bambara groundnut	Locust bean	Sunflower seeds	Jack Bean	Standard Deviation
Dry matter	95.89	95.24	96.22	96.64	94.56	0.82
Crude Protein	21.03	20.05	25.41	18.70	28.90	4.23
Crude fat	4.43	7.15	16.68	23.98	2.72	9.05
Crude fibre	7.16	5.48	17.88	12.92	7.80	5.09
Ash	3.76	3.40	4.69	3.36	3.73	0.54
Nitrogen free extract	59.51	59.16	31.56	37.68	51.41	12.70

RESULTS AND DISCUSSION

Proximate compositions of raw seeds of some unconventional plant protein sources

The range of values obtained from the proximate analyses of the seeds were; for dry matter (94.56-96.64%), crude protein (18.70-28.90%), crude fat (2.72-23.98%) crude fibre (5.48-17.88%), ash (3.36-4.69%) and nitrogen free extract (31.56-59.51%).

Among all non-conventional seeds analysed, jack bean recorded the highest crude protein value of 28.90% while sunflower seed had the lowest crude protein value of 18.70%. This result is close to the earlier reports of Apata and Ologhobo (1994) that jack bean recorded the highest crude protein of 27.7% among the unconventional plant protein sources analysed. Observation from the results showed that sunflower seed recorded the highest crude fat content of 23.98% this was followed by locust bean with the value of 16.68% which is very close to value of 16.86% reported by Alabi *et al* (2005) for locust bean. Jack bean however, had the lowest value of 2.72% for crude fat. Locust bean was the most fibrous with a crude fibre value of 17.88% while the least fibrous among the seeds was bambara groundnut with 5.48% crude fibre value. Locust bean also recorded the highest concentration of ash (4.69%) this was followed by the value of 3.76% for pigeon pea seeds. The result of the ash content obtained for pigeon pea in this study falls within the range of 3.70% and 3.90% reported by Apata and Ologhobo (1994). Sunflower seed however, had the lowest ash value of 3.36%.

Observation from results showed that among the non-conventional seeds studied the seeds of pigeon pea and bambara groundnut were closest in terms of nutrient composition (proximate composition) or similar in most of the proximate content. This similarities were exhibited in the following proximate content; dry matter: 95.89% for pigeon pea and 95.24% for bambara groundnut, crude protein: 21.03% for pigeon pea and 20.05% for bambara groundnut, ash: 3.76% for pigeon pea and 3.40% bambara groundnut, nitrogen free extract: 59.51% for pigeon pea and 59.16% for bambara groundnut. However, there were two exceptions, that is, in the crude fat content: in which 4.43% was recorded for pigeon pea and 7.15% was recorded for bambara groundnut and crude fibre contents in which pigeon pea had the value of 7.16% and bambara groundnut recorded the value of 5.48%.

Amino acid profiles of raw seeds of some unconventional plant protein sources

The sulphur-containing amino acids (methionine and cystine) were found to be the most limiting from the results obtained for all unconventional plant protein seeds analysed in this study. Methionine was found to be the first limiting amino acid among all the seeds. Jack bean recorded the lowest value of 0.46 g/16gN and the highest was found to be locust bean with the value of 1.49g/16gN for methionine. Cystine the second limiting amino acid recorded the lowest value of 1.19g/16gN for pigeon pea, while sunflower seed had the highest value of 1.48g/16gN, closely followed by 1.38g/16gN for jack bean and then 1.32g/16gN for locust beam. The relatively low concentrations of methionine and cystine in legumes and most plant protein seeds has been well documented by researchers (Doku *et al*., 1978; Apata and Ologhobo, 1994; Kessler *et al*., 1990; Olomu, 1995; Fabiyi, 1999; Akande 2004 ; Aremu *et al*., 2006).

Leucine was found to be the most concentrated essential amino acid in all of the seeds studied. Notably, for leucine locust bean recorded the highest value of 8.42g/16gN, whereas jack bean had the lowest value of 2.93g/16gN. Interestingly, for isoleucine, locust bean also recorded the highest value of 4.78g/16gN and jack bean had the lowest value of 1.84g/16gN as well.

For lysine pigeon pea had the highest concentration of 7.79 g/16gN while jack bean recorded the value of 4.42 g/16gN. Although Pigeon pea is deficient in methionine and cystine the sulphur-containing amino acids, it is however, rich in lysine (Singh and Diwakar, 1993). It is worth noting, that pigeon pea also had the highest level of phenylalanine among the seeds studied. This is in accordance with the results obtained by Apata and Ologhobo (1994). Their results showed that pigeon pea seeds recorded the highest concentration of phenylalanine among all the seeds analysed. It is therefore, evident that pigeon pea is a good source of phenylalanine.

The level of arginine was in the range of 2.98g/16gN and 6.97g/16gN for the seeds of jackbean and sunflower respectively. Histidine concentration in the seeds was observed to range from 4.91g/16gN in sunflower seeds and 6.23g/16gN in the seeds of jack bean. The level of valine was moderate, ranging between 2.62g/16gN in jack bean and 5.85g/16gN in pigeon pea.

For the non-essential amino acids for all the unconventional seeds, glutamic acid level was the highest with the value of 15.76g/16gN for bambara followed by sunflower with the value of 13.98g/16gN, then the value of 13.59g/16gN for locust bean, while the lowest value of 7.60g/16gN was recorded for jack bean.

Table 2:Amino acid profiles of raw seeds of some unconventional plant protein sources (g/16gN)

Amino Acids	Pigeon pea	Bambara groundnut	Locust bean	Sunflower seed	Jack bean	SD
Lysine	7.79	5.93	5.78	4.91	4.42	1.29
Histidine	3.66	2.95	2.55	2.49	6.23	1.56
Arginine	5.86	6.41	5.66	6.97	2.98	1.54
Aspartic acid	11.56	12.95	9.09	10.33	5.21	2.95
Threonine	3.12	3.11	3.38	2.52	5.31	1.07
Serine	3.59	4.46	3.37	4.04	3.72	0.42
Glutamic acid	9.23	15.76	13.59	13.98	7.60	3.45
Proline	3.17	3.60	3.15	3.13	0.82	1.11
Glycine	3.07	3.01	3.48	4.13	3.86	0.49
Alanine	3.79	3.52	3.25	4.10	4.16	0.39
Cystine	1.19	1.25	1.32	1.48	1.35	0.11
Valine	5.85	4.51	4.41	4.39	2.62	1.15
Methionine	1.19	1.04	1.49	1.22	0.46	0.38
Isoleucine	3.47	4.56	4.78	4.02	1.84	1.17
Leucine	6.78	7.76	8.42	6.70	2.93	2.13
Tyrosine	2.63	3.19	3.32	3.00	2.21	0.45
Phenylalanine	6.15	5.43	4.49	5.05	2.17	1.52
Tryptophan	ND	ND	ND	ND	ND	ND

ND = Not determined
SD = Standard deviation

CONCLUSION AND RECCOMMEDATION

Results from the nutritional information and analysis obtained in this research study revealed the potentials of the nutritive quality of all the seeds for use in both human and animal nutrition. Proper processing of all the seeds is however, essential before incorporation in diets. In part of the world were conventional protein sources are highly expensive, all the processed non-conventional plant sources are recommended for dietary inclusion. The ultimate goal is ensuring food security through the utilization of unconventional plant protein as alternative protein source when the conventional protein food sources are not affordable or available

Pigeon pea, bambara groundnut, locust bean, sunflower and jack bean seeds are all categorized as under-exploited group of proteins, this is due to the fact that they still not widely or extensively used. Notwithstanding, these promising plant proteins have great potentials for wide usage as dietary proteins when properly processed. There is therefore, clear indications of the potentiality of these seeds for improving the nutritional status of people and livestock as well as ensuring food security for those who cannot afford the costly conventional protein sources.

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