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Nutritional food content of seed and effects of five different growing media on the seed germination and seedling growth of *Afzelia africana* SM Caesalpiniaceae

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Nutritional food content of seed and effect of five different growing media: Top forest soil (TS), sawdust (SD), 2:1 mixture of; TS+SD, TS+composted poultry manure (TS+PM) and 2:1:1 mixture of TS+SD+PM on the seed germination and seedling growth of *Afzelia Africana* SM Caesalpiniaceae were investigated. Thirteen chemical food nutrients were detected in the species seed. These occurred in varying percentages. The mixed growing media (2:1:1 mixture of TS+SD+PM, 2:1 mixture of TS+SD and TS+PM) consistently had: higher percentages of: water holding capacity and nitrogen than the single media (TS and SD). Shorter periods of initial and final seed germination were achieved when seeds were sown in the mixed growing media than in the single growing media. The highest percentage seed germination (87.4%) was achieved when seeds were sown in 2:1:1 mixture of TS+SD+PM growing medium, while the poorest percentage seed germination (30.5%) was obtained when seeds were sown in the TS growing medium, the control. Comparatively, the mixed media induced higher percentage seed germination responses than the single growing media. After four weeks growth in the nursery, values of seedling growth parameters showed that seedlings grown in the mixed growing media had better growth attributes than seedlings grown for the same period in the single media. The results also showed that the best growth attributes were developed by seedlings grown in 2:1:1 mixture of TS+SD+PM (mean: Seedling height 22.4cm., number of leaves, 22 and mean leaf area 120.6cm2).

Key words: *Afzelia Africana*, seed nutrient content, growing media, seed germination, and seedling growth attributes.

INTRODUCTION

In most developing countries, extensive research have been done on the exotic/introduced food crop species like *Manihot spp.* (cassava), *Mangifera indica* (mango), *Zea mays*, (maize), *Triticum durum* (wheat), *Musa spp.,* etc. Similar research activities on the indigenous food crops like *Afzelia Africana, Myranthus arboreus, Discorea bulbifera, Treculia africana, Brachystagia,* etc are either scare or lacking. Okafor (1983) reported that lack of

research activities on the indigenous food crop species were due to late appreciation of the values of their resources, except revenue generation for the resource poor rural dwellers, lack of knowledge of their propagation methods and lack of information on their nutritional contents. Currently, most of these valuable indigenous food crop species are endangered while some like *Discorea bulbifera* has gone extinct. Nzekwe (2006) reported that the endangered status of most indigenous tree food crop species appear related to depletion of their natural forest habitat by man's various activities like; lumbering, slash and –burn agricultural activities and fire outbreak. Above all, research activities on the indigenous food crops have not been included in most nations' research activities or in any arm of national agricultural programmes.

With the present hunger, poverty, disease and unemployment in Nigeria, there is an urgent need to reveal the nutritional food content of edible parts of the indigenous food crops and also provide information on their propagation requirements, so as to facilitate their conservation and full biotechnological exploitation of their resources. Among the popularly utilized food crop species capable of contributing to the socio-economy of the ever increasing rural population, *A. Africana SM. Caesalpiniaceae* was chosen as the study species, with the following objectives; first, assessment of the effects of five different growing media on the germination of the seeds, so as to obtain information on the medium/media that can be relied upon for obtaining high percentage seed germination, as well influence the production of high quality seedlings which when established in the field, can contribute to the conservation of the species for full biotechnological exploitation of the species resources. Second, determination of the species' seed chemical nutrient contents, in order to obtain, information on the possible contribution of the seed to human healthy growth and development when consumed as food condiment.

A. Africana S.M. Caesalpinaeae is a medium size woody tree of the tropical rainforest zone of Nigeria (Okafor, 1983). The tree is dichotomously branched, deciduous and flowers between August and November, while the fruits ripen between December and April. The fruit (A pod), green when Juvenile and black when ripe, is kidney shaped. The seed, capsule shaped has red/yellow "cap" at the microphylar region, partially covering the black seed (fig. 1). The seed is roasted/fried to remove the seed coat, after which the cream coloured cotyledons are powdered before use as soup condiment/seasonal/ thickener. The seed imparts sweet taste and aroma to soup, thus *Afzelia* preparations taste good (Ejiofor and Okafor, 1997). In addition to the use of the seed in preparing soup, inter-state trade on the seed generates substantial revenue for the resource poor rural dwellers and the middle men traders. *Afzelia* is nitrogen fixing species and thus could potentially play a useful role in agricultural system (Palm, 1995). The species is planted in allies where it fixes nitrogen thus returns nutrient to the soil (Palm, 1995). Locally, the species is not widely cultivated due to lack of information on its propagation requirement (Okafor, 1983).

Despite popular demand for the seeds, the species has not been purposely cultivated like other cash crops, but the trees are protected in farms where they are used for staking climbing food crops like *Telfairia spp.* There are no reports on the species propagation methods and the chemical nutrient contents, hence justifying the present study. The species is under exploited and endangered. The main source of the seeds, the most desired part of the species, is still from the few trees in the fast disappearing forests.

MATERIALS AND METHODS

The twig and mature fruits of the species were obtained from protected trees in the fruit nursery of the National Horticultural Research Institute (NIHORT), Okigwe, Imo state, in April 2012. Okigwe is located between Lat. 05°29'N and Long. 07'31E, at an altitude of 122 mm above sea level, with an annual rainfall of 2000 mm. Okigwe is in the humid zone of the tropical rainforest, with distinct dry and wet seasons. The materials were identified and confirmed at the herbarium of the Department of Plant Science and Biotechnology, University of Nigeria, Nsukka, following the procedure described by Hutchinson and Dalziel (1964). Two thousand and five seeds (Figure 1) obtained from the trees were split into two parts of 1000 seeds each. The first batch (1000 seeds) was used for the analysis of the seed chemical nutrient contents, while the second batch (1000 seeds) was used to assess the effects of five different media on seed germination, seedling growth and development. The chemical food nutrient contents of the seeds were analysed in the Food Science laboratory of the Department of Crop Science, University of Nigeria, Nsukka. Prior to use, the seeds for germination study were subjected to viability test by soaking them in water for 15 to 25 min. Seeds that floated were discarded, being considered non-viable, while seeds that sank were used for the study. A total of 675 seed of uniform size were selected after soaking in water. Five media, namely, sawdust (SD), garden soil (TS), 2:1 mixture of garden soil and sawdust (TS + SD), 2:1:1 mixture of garden soil, sawdust and poultry manure (TS +SD + PM) and 2:1 mixture of garden soil and poultry manure (TS + PM), were used. Garden soil (TS) was used as the control. Topsoil was collected around the Botanic Garden of the Department of Plant Science and Biotechnology, University of Nigeria, Nsukka, while sawdust was collected from Nsukka Urban timber market. After enquiry, sawdust of a softwood species, *Ceiba pentardra* was

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Abbreviations: SD, Sawdust; **TS,** garden soil; **PM,** poultry manure.

Figure 1. *Afzelia africana* seeds.

Figure 2. Germinated *Afzelia* seeds showing hook-shaped hypocotyls and stretched hypocotyls.

collected. Poultry manure was purchased from the poultry farm of the Department of Animal Science, University of Nigeria Nuskka. Prior to use, the poultry droppings were exposed for 3 weeks to compost. In formulating the mixed media, 2:1 mixture of: TS +SD and TS +PM, 100 kg of TS was thoroughly mixed with 50 kg each of SD and PM respectively. 2:1:1 mixture of TS + SD + PM medium was formulated by thoroughly mixing 150 kg of TS and 50 kg each of SD and PM. Prior to potting, samples of each medium were taken for physicochemical analysis, with emphasis on their water holding capacity and nitrogen contents. Each medium was filled in twenty five medium size black poly pots perforated at the sides for drainage of excess water, after which seeds were sown to the depth of about 2 to 2.5 cm and at the rate of three seeds per poly pot. Each treatment (medium) received 75 seeds and was replicated 5 times. Thus, 5 poly pots gathered together constituted a replication. The experiment, a completely randomized design (CRD), was carried out on an open, elevated concrete platform in the Botanic Garden, Department of Plant Science and Biotechnology, University of Nigeria, Nsukka. The replications were displayed in a completely randomized manner. The seeds were considered germinated when the cotyledons become exposed or the seedlings grew to about 1 cm above the medium. Germinated seeds were randomly sampled and their morphology observed (Figure 2). Seven days after seed germination, the seedlings were thinned down to a seedling per poly-pot. The periods of first and last seed germination were recorded.

Table 1. Percentage water holding capacity and Nitrogen content of the media assessed for the seed germination of *Afzelia africana*.

Potting (% Media)	Some media physicochemical properties	
	% Water holding capacity	% Nitrogen
TS	25.2	0.002
SD	16.5	0.001
2:1 TS+SD	7.5	0.003
TS+PM	70.5	0.010
2:1:1 TS+SD+PM	84.6	0.050

Key: TS = Topsoil, SD = Sawdust, PM = Poultry manure.

Table 2. Periods of initial and final seed germination in the five different media seed germination periods (days).

Potting media	Initial	Final
TS	12-14	38-42
SD	12-14	39-40
2:1 TS+SD	7-9	28-30
2:1 TS+PM	10-12	22-24
2:1:1 TS+SD+PM	7-9	18-20

Madia interpretation in table 1.

Table 3. Effects of media on percentage germination of the seeds of *Afzelia africana*.

Potting media	% Seed germination
TS	30.5^{c}
SD	33.6^{c}
2:1 TS+SD	68.5^{ab}
2:1 TS+PM	56.3^{b}
2:1:1 TS+SD+PM	87.4^{a}
X	52.28
SE	21.44

Values with the same alphabet(s) are not significantly different from one another (P = 0.05). Media interpretation in table 1.

At the termination of the seed germination, the seedlings were allowed further four weeks growth after which, some of their growth parameters (seedling height, number of leaves and leaf area) were determined. Heights of 10 seedlings of each treatment were determined using meter rule, and the mean recorded. Similarly, mean number of leaves of 10 seedlings from each treatment was recorded after counting. Leaf area was determined by tracing out the leaf on a standard graph paper calibrated in cm^2, after which, the number of cm^2 covered by the leaf were counted. For each treatment, mean of ten seedlings was recorded. Data obtained in the seed germination and in some seedling growth parameters were subjected to the analysis of variance (Steel and Torrie, 1980) and the means were separated by Duncans Multiple Range test (DMRT).

RESULTS

Results of the physicochemical properties of the five different media (Table 1) show that the mixed media, TS + SD, TS + PM and TS + SD + PM consistently had higher percentages of water holding capacity and total nitrogen contents than the single media, TS and SD. The results further showthat the medium, SD had the least values of the two physicochemical properties. The initial seed germination (Table 2) was observed 7 to 9 days after sowing in 2:1:1 TS + SD + PM, 2:1: TS + SD media and 10 to 12 days later in TS + PM medium, while the single media; TS and SD took the longest period, 12 to 14 days to germinate. Irrespective of medium and the period of initial seed germination, germinated seeds developed hook-shaped hypocotyl that later carried the cotyledons above the medium as the hypocotyl stretched out. Final seed germination showed that seeds sown in the mixed media took shorter period than seeds sown in the single media to accomplish germination. The effects of media on percentage germination are summarized in Table 3. Generally, higher percentage germination responses were obtained when seeds were sown in the mixed media; 2:1 mixture TS +SD, TS + PM and 2:1:1 mixture of TS + SD + PM, than in the single media; TS and SD. The highest percentage seed germination (87.40 ± 21.4%) was achieved when seeds were sown in 2:1:1 mixture of TS + SD + PM medium, and the least, (30.5 ± 21.4%) when seeds were sown in TS medium, the control. Effects of media on the development of the seedling growth parameters; (Figure 3 and Table 4); seedling height, number of leaves and leaf area, showed variations. Seedlings grown in the mixed media; TS + SD + PM, TS + PM and TS + SD for four weeks produced higher values of all the growths parameters assessed than seedlings grown in single media, TS and SD. Seedlings grown in 2:1:1 mixture of TS + SD + PM consistently produced seedlings with the highest values of all the growth parameters assessed; while seedlings grown for the same period in SD medium produced the least.

Figure 3. *Afzelia* seedlings at the end of the study (4 months).

Table 4. Mean Values of Some growth Parameters of *Afzelia africana* seedling grown for 4 weeks in the nursery.

Media	Seedling weight (cm)	Number of leaves	Leaf area (cm^2)
TS	16.5^{d}	19.5^{b}	120.6^{b}
SD	14.7^{cd}	18.5^{c}	118.7^{b}
TS+SD	17.5^{bc}	20.5^{b}	120.8^{b}
TS+SD	19.5^{b}	22.0^{ab}	180.4^{a}
TS+SD+PM	22.4^{a}	24.5^{a}	196.3^{a}
X	18.12	20.6	147.36
SE	2.64	2.65	33.85

Values with the same alphabets along the vertical column are not significantly different (P = 0.05); media interpretation as in table 1.

The results of the analysis of the chemical food nutrient content of the seed of *A. africana* (Table 5) showed that the seed contained appreciable amount of 13 basic chemical food nutrients required for human healthy growth and development.

DISCUSSION

Detailed information on the requirements of most indigenous food tree crops in the tropics for seed germination, seedling growth and development are scarce (Okafor, 1983; Mbakwe and Nzekwe, 2005). Numerous earlier reports (Bruckner, 1997; Smith, 1998; Wilson et al., 2001; Baiyeri, 2003) showed that materials used in formulating potting media significantly determine the physicochemical properties of the media. Hence variations in the ratio of base materials used in formulating the five media involved in this study appear to explain the differences in their percentage water holding capacity and nitrogen contents. The medium, mixture of 2:1:1 TS + SD + PM, which had the highest proportion of poultry manure (PM), also had the highest percentage water holding capacity and nitrogen content. This was followed by the other mixed media; 2:1: TS + SD and TS + PM, while the single media, TS and SD, had the least. Smith (1998) pointed out that single media have numerous macro-pore spaces that encourage water loss

Table 5. Chemical nutrient, food contents of the seed of *Afzelia africana*.

Nutrient contents	Concentration %
Carbohydrates	38.36
Crude protein	23.29
Fat	25.95
Crude fibre	1.60
Moisture	9.10
Ash	3.30
Calcium (Ca)	0.18
Magnesium (Mg)	0.47
Sodium (Na)	0.023
Potassium (K)	0.390
Iron (Fe)	0.75 6 mg/100 g
Vitamin B	0.005 mg/100 g
Vitamin A	108.66 1 u

by drainage. The author reported that single media can be amended by the addition of organic matter which reduces the macro-pores to numerous micro-pores, known for the retention of large quantity of absorbed water and good aeration. The large quantity of water retained (as early as water was applied) by mixed media probably created water vapour saturated atmosphere around the seed, thus making water constantly available within soils inter spaces.

In this study, the short periods of initial germination, duration of seed germination and high percentage seed germination responses obtained in the mixed media; 2:1; 1 TS +SD+ PM, 2:1, TS + SD and TS + PM appear related to the existence of water vapour saturated environments of the seeds sown in them, which in turn reflected the variations in the media physicochemical properties. The long periods of initial and final seed germination, observed in the single media, TS and SD, could probably be due to low water holding capacity, following water losses by drainage, and the period expended before water vapour saturated atmosphere was created as well as poor aeration. Baiyeri (2003) pointed out that medium of low water holding capacity is prone to poor aeration. The high percentage seed germination obtained when seeds were sown in 2:1:1 mixture of TS + SD + PMI (87.4%) thus, implied that the medium satisfied the qualities of good potting media. The base materials are readily available; the technique of formulating the medium is non-technical and can be easily adopted by local nurserymen and farmers. The medium hence appears recommended for routine propagation of the species.

The results of the determination of seedling growth parameters (seedling height, number of leaves and leaf area) showed that despite variations, seedlings grown for4 months in 2:1:1 mixture of TS+SD+PM medium consistently produced seedlings with superior values of all the growth parameters, followed by seedlings grown in the other two mixed media, TS+SD and TS+PM. The results appear reflective of the physicochemical properties of the media, particularly their nitrogen contents, which is high in the mixture of 2:1:1 TS+SD+PM. Noggle and Fritz (1976) reported that high nitrogen content of growth media favours vegetative growth of plants. Chemical food nutrient contents of *A. africana* (Table 5) showed that the carbohydrate content (36.76%) was higher than the values reported by Ejikeme et al. (2010) for *A. africana* seeds from Abakiliki (30.1%), Enugu (33.2%) and Nsukka (32.2%) in the Eastern part of Nigeria. The value was however higher than those reported for oil seeds such as cotton seed (21.9%), flax seed/linseed (34.3%), peanut (12.5%), rape seed (8.3%), sesamon seed (0.9%) and sunflower seed (Food Standards Agency and Institute of Food Research, 2002). Carbohydrates provide nutritional energy value of 17 kcal/g when consumed in food as: sweetening, gel or paste-forming, thickening agents, stabilizers and precursors for aroma and colouring substances (Belitz et al., 2009). The energy value (473.75 kcal) of *A. Africana* seed was relatively low. Considering the fact that *A. africana* is used mainly for soup thickening, it is a healthier alternative for diabetics and slimmers than cocoyam flour with 72.38 to 79.48% carbohydrate content (Onyishi, 2012).

The crude protein (23.29%) and fat (25.95%) were lower than the ranges (26.29 to 26.60% and 32.06 to 34.58%, respectively) detected in *A. africana* from Enugu, Nsukka and Abakiliki by Ejikeme et al., (2010). The high protein content which surpassed that of some legumes such as African yam bean, pigeon pea and cowpea would contribute in the reduction of protein malnutrition being experienced in developing countries. The protein content fell within the range 17 to 40% reported for legumes (Bojňanská et al., 2012). It however, contrasted with the 7 to 13% of cereals (Bojňanská, 2004), and was nearly equal to the upper level of protein range of meats (18 to 25%) (Čuboň et al., 2011). The fat content was found to be lower than the values recorded for peanut (46%), sesamon seed (58%) and sun flower (47.5%) (Food Standards Agency and Institute of Food Research, 2002) used mainly for vegetable oil production. The level of fat in *A. africana* seed would reduce oil requirement in food products formulated with its addition. Onyechi et al. (2013) reported that *Afzelia* snacks are healthier snacks for diabetics than the *Detarium* snacks because of its lower fat content. However, the fat content of snacks made from different cultivars of African yam beans (1.93%) (Odenigbo, 2001) were lower, compared to *Detarium* (11.11 to 14.87%) and A*fzelia* (11.62 to 14.21%) snacks (Onyechi et al., 2013). The level of crude fibre (1.6%) detected was low compared with gourd seeds (2.8%) and soybeans (4.28%) reported by Ogungbenle (2006) and Temple et al. (1991), respectively. Fiber increases the endogenous excretion of energy-containing nutrients, the excretion of bacteria,

and affects the digestion and absorption of nutrients (Miles, 2013). Utilizing *A. Africana* seed in food formulations will definitely increase the fiber content of the diet, which has been shown by Kelsay et al. (1978) to decrease the availability (apparent digestibility) of the energy containing nutrients, and thus the energy of the diet.

The moisture content (9.1%) was found to be higher than the values (5.88%) and (7.45%) reported by Adebayo and Ojo (2013) and Ejikeme et al. (2010). According to the Australian Oilseeds Federation (2013) the most appropriate storage conditions for oilseeds are to maintain the temperature of the seed below 20°C and seed moisture less than 7%.The sample contained sufficient amount of ash (3.30%) that was within the range of ash (2.88 and 3.2%) detected by Ejikeme et al. (2010), implying that it is rich in mineral elements. The iron content of the seed is 0.756 mg/100 g, while the recommended daily intake of iron is about 15 mg. Iron deficiency has been identified as the most common nutritional deficiency disease on the planet, particularly among pregnant women than infants and young children being the two most vulnerable demographic groups (Theuer, 2008). This situation which may be combated by altering dietary practices (Ziegler and Fomon, 1996) will be alleviated by frequent consumption of iron rich foods. The sodium content (0.023 mg/100 g) was low compared to 25, 20 and 3 mg reported for cotton, sesame and sunflower seeds, respectively. The American Diabetes Association (2002) reported that the amount of sodium in the diet should be limited since sodium helps to increase blood pressure and has the tendency to retain fluids. The level of calcium detected (0.18%) in *Afzelia* was also low, but would contribute to the concentration of calcium in the diet if used as a thickener. Calcium is very important for strong bone formation, essential for maintaining total body health, needed not just to keep the bones and teeth strong but to ensure proper functioning of muscles, nerves and also needed for blood clot (Bell et al., 1996).

The value recorded for potassium (0.390%) was not up to the level (1350 mg) detected in cotton seed (US Department of Agriculture, Agricultural Research Service, 2003) and the 3.5 mg US RDA for both men and women. Potassium is the principal cation in intracellular fluid and functions in acid-base balance, regulation of osmotic pressure, conduction of nerve impulse, muscle contraction particularly the cardiac muscle, cell membrane function and Na+/K+-ATPase (Soetan et al., 2010). A high level of potassium provides a protective effect in instances of excessive sodium intakes (Dzomeku et al., 2006). The magnesium content (0.47%) was found to be lower than the values recorded for the range of magnesium (63 to 440 mg) of major oilseeds (Food Standards Agency and Institute of Food Research, 2002) and the US Recommended Daily Allowance of 350 mg for men and 280 mg for women. Magnesium is an activator of many enzyme systems and maintains the electrical potential in the nerves (Adeyeye and Agesin, 2007). It also works with calcium to assist in muscle contraction, blood clotting, and the regulation of blood pressure and lung functions (Swaminathan, 2003). The value of these minerals were however lower than those reported by Adebayo and Ojo, (2013) for fresh *A. Africana* seed flour from Ekiti State, Nigeria; K (1580 mg/100 g), Fe (2.6 mg/100 g), Ca (340 mg/100 g) and Mg (1.6 mg/100 g), which may probably be due to geographical location and varying agronomic conditions. The level of mineral elements in *Afzelia* seed in this study suggest that the species seed flour when consumed in diet (soup) can significantly complement the availability of the mineral elements from other components of the diet, such as vegetables and meat. Thus, *A. africana* can be a cheap source of obtaining mineral elements for human healthy growth and development, particularly among rural dwellers.

Vitamin contents of *A. Africana* observed in this study varied with that earlier reported. Pro-vitamin A (108.66 IU) was found to be below the recommended daily intake of pro-vitamin A (6.0 to 12.0 mg) (Belitz et al., 2009). Vitamin A is essential for growth, healthy eyes as well as structuring and functioning of the cells of the skin (Ihekoronye and Ngoddy, 1985). The vitamin B_2 content of the seed, which is also important in carbohydrate and protein metabolism, was 0.005 mg/100 g. The values were however lower than 0.3 to 1.6 mg (Belitz et al., 2009) recommended daily intake of vitamin B_2 and the values (0.023 /100 to 0.028 mg/100 g) reported by Ologunde et al. (2011) for cashew nuts from three Nigerian states. Based on the results of this study, it can be concluded that the species can be propagated by sowing the seeds in and growing the seedlings in 2:1:1 TS + SD + PM medium; that the seed of *Afzelia* when eaten can supplement for most of the basic nutrients required for healthy growth and development of man, particularly rural dwellers, whose diet is dominated by carbohydrate.

Conflict of interests

The authors have not declared any conflict of interest.

REFERENCE

Adebayo SF, Ojo OC (2012). Nutrient composition and functional properties of *Afzelia africana* seed. IOSR J. Environ. Sci. Toxicol. Food Technol. (IOSR-JESTFT) 6(5):0103.

Adeyeye EI, Agesin OO (2007). Dehulling the African Yam Bean (*Sphenostylis stenocarpa* Hochst. ex A. Rich) Seeds: Any Nutritional Importance? Note I. Bangladesh J. Sci. Ind. Res. 42(2):163-174.

American Diabetes Association (2002). Evidence based nutrition principles and recommendations for the treatment of diabetes and released complications. Diabetes 25(1):550-560.

Australian Oilseeds Federation (2013). Safe storage for oilseeds.The Australian Oilseeds Federation.

Baiyeri KP (2003). Evaluation of nursery media for seedling emergence and early seedling growth of two tropical tree species. Moor J. Agric. Res. 4(1):60-65.

Belitz HD, Grosch W, Schieberle P (2009). Food Chemistry.Springer-Verlag, Berlin Heidelberg, Germany pp. 403-420.
Bell L, Halstenson CE, Macres M, Keane WF (1996). Cholesterol lowering effects of calcium carbonate in patients with mild to moderate hypercholesteromia. Arch. Int. Med. J. 152:2441-2444.
Bojňanská T (2004). Quality of ceareals and pulses as raw materials for food processing. Habilitation thesis. Nitra: SPU, P. 139.
Bojňanská T, Frančáková H, Líšková M, Tokár M (2012). Legumes – the alternative raw materials for bread production. J. Microbiol. Biotechnol. Food Sci. 1:876-886.
Bruckner U (1997). Physical properties of different potting media and substrate mixture, especially air and water capacity. Acta Horticultureae. 450: 263-270.
Čuboň J, Kačániová M, Haščík P, Foltys P, baláž B, Prívarová L (2011). Analýzazákladnéhozloženiaaaminokyselinovejskladbymäsateliat z ekologickejprodukcie. In Proteiny 2011 (Zborníkpríspevků VI. ročníkumedzinárodí conference).Zlín: UTB, 2011, pp. 40-52.
Dzomeku BM, Bam RK, Abu-Kwarteng EE, Ankomah AA (2006). Comparative study on the nutritional values of FHIA-21 (Tetraploid Hybrid) and 'apem' (Triploid French plantain) in Ghana. J. Plant Sci. 1:181-191.
Ejikeme PM, Obasi LN, Egbuonu AC (2010). Physico-chemical and toxicological studies on *Afzeliaafricana* seed and oil. Afr. J. Biotechnol. 9(13):1959-1963.
Ejiofor MAN, Okafor JC (1997). Prospects for commercial exploitation of Nigerian indigenous trees, vegetables and seeds through food and industrial products formulation. Int. Tree Crops J. 9:119-129.
Food Standards Agency and Institute of Food Research (2002). McCance and Widdowson's The Composition of Foods, Sixth Summary Edition. Royal Society of Chemistry, Cambridge.
Hutchinson J, Daziel JM (1964). Flora of Tropical West Africa Vol.II Crown Agent for Oversea Government and Administration Millbank. London 54 p.
Ihekoronye AI Ngoddy PO (1985). Integrated Food Science and Technology for the Tropics *(*pp. 265). London: Macmillan Publ. Ltd.
Kelsay JL, Behall KM Prather, ES (1978). Effect of fiber from fruits and vegetables on metabolic responses of human subjects.L Bowel transit time, number of defecations, fecal weight, urinary excretion of energy and nitrogen and apparent digestibilities of energy, nitrogen and fat. Am. Clin. Nutr. 31:1149-1153.
Mbakwe RC, Nzekwe U (2005). The effects of drying on the seed germination of depulped and undepulped fruits of *hvingia wombolu.* Vermeosen*.* J. Trop. Agric. Res. 13:32-35.
Miles CN (1992). Fiber increases the endogenous excretion of energy-containing nutrients, the excretion of bacteria, and affect the digestion and absorption of nutrients. Hum. Clin. Nutr. pp. 306-311.
Noggle GR, Fritz GJ (1976). Introductory Plant Physiology. Prentice – Hall Inc. New Jersey. 688 p.
Nzekwe, U. (2006). The role of plant bioresources in the development of Biotechnology in Nigeria. Invited paper, 19th Annual Conference Biotechnology Society of Nigeria, 12-18th November, 2006. University of Jos, Jos Nigeria. P. 13.
Odenigbo UM (2001) Incorporation of *afzelia Africana* [akparata] in dietary managements of type 2 diabetes mellitus in Nnewi, Nigeria. PhD thesis.
Ogungbenle HN (2006). Chemical Composition, Functional properties and amino acid composition of some edible seeds. Rivista. Italiana. Delle. SostanzaMarzo. 14:81-86.
Okafor JC (1983). Horticulturally promising indigenous wild plant species of Nigerian forest zone. Acta Horticulturae 123:211-221.
Ologunde MO, Omosebi MO, Ariyo O, Olunlade BA, Abolaji RA (2011). Preliminary nutritional evaluation of cashew nuts from different locations in Nigeria. Cont. J. Food Sci. Technol. 5(2):32-36.
Onyechi AU, Ibeanu VN, Eme PE, Ossai CC (2013). Nutrient, Phytochemical Composition and Sensory Evaluation of Formulated Diabetic Snacks made from Nigeria foods, *Afzelia Africana* and *Detarium Microcapium* seed flour. Int. J. Basic Appl. Sci. 13(02):40-44.
Onyishi O (2012). Effect of processing methods on the chemical composition and selected functional properties of cocoyam corm (*Colocasia esculenta*). PGD project report, Dept. of Food Science and Technology, University of Nigeria, Nsukka, Enugu State, Nigeria. P. 24.
Palm CA (1995). Contribution of agro-forestry trees to nutrient requirements of intercropped plants. Agroforest. Syst. 30:105-124.
Smith CW (1998). The big book of gardening secrets. Story publishers Canada. 341 p.
Soetan KO, Olaiya OC, Oyewole OE (2010). The importance of mineral elements for humans, domestic animals and plants: A review. African Journal of Food Science, 4(5):200-222.
Steel GD, Torrie JA (1980). Pprinciples and procedure of statistics: A biometrical approach, 2nd edition, McGraw-Hill Book Company, Inc. New York 6331, P. 31.
Swaminathan R (2003). Magnesium Metabolism and its Disorders. Clin Biochem. Rev. 24(2):47-66.
Temple VJ, Odewumi L, Joseph K (1991). Soybean and Soybean based diets. Poceedings of the 3rdregional workshop onrural development, Jos, Nigeria. pp. 45 - 50.
Theuer RC (2008). Iron-fortified infant cereals. Food Reviews International, 24(3):277-310.
U.S Department of Agriculture, Agricultural Research Service (2003). USDA National Nutrient Database for Standard Reference, Release16.Nutrient Data Laboratory.
Wilson SB, Sloffela PJ, Graetz DA (2001). Use of compost as a media amendment for containerized production of two subtropical perennials. J. Environ. Hortic. 13(1):37-42.
Ziegler EE, Fomon SJ (1996). Strategies for the prevention of iron deficiency: iron in infant formulas and baby foods. Nutr. Rev. 54(11):348-354.