

Full Length Research Paper

Proximate nutritional composition, characterization of some selected physicochemical properties and comparative compositional analysis of *Trichilia emetica* oilseeds with some selected commercial oilseeds

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The proximate nutritional composition, characterization some selected of physicochemical properties and comparative assessment of *Trichilia emetica* oilseeds with some selected commercial oilseeds were compared in this study. The results revealed the percentage crude lipid, crude fiber, ash, crude protein, and total carbohydrate contents of the oilseeds as 65.81, 15.28, 3.4, 5.21, and 22.43, respectively. The oil is odorless and solid at room temperature, with golden yellow color. The acid value (8.13 mgNaOH/g), saponification value (180.09 mgKOH/g), iodine value (60.15 mgI₂/g) and peroxide value (0.56 meqO₂/kg) of the seeds oil. The studied characteristics of the seeds oil was compared favorably with most conventional vegetable oils and seeds oil. The results suggest that the seeds examined may be nutritionally potent and also viable source of seeds oil judging by the oil yield. The data also showed that the seeds oil was edible inferring from the low acid value. Industrially, the results revealed the seeds oil has a great potential in cosmetic, candle and soap making industries because of the high saponification value. It was also shown that to be non-drying due to low iodine value which also suggested that the oil contain few unsaturated bonds and therefore have low susceptibility to oxidative rancidity and deterioration as confirmed by the low per oxidation value which serves as indicators of the presence or high levels of anti-oxidants in the oil.

Key words: Proximate composition, *trichilia emetica* oil seeds, physico-chemical.

INTRODUCTION

The genus name "*Trichilia*" is derived from Greek "tricho" referring to the 3-lobed fruits and the epithet "emetica" refers to the emetic properties of the tree (Allaby, 1998; Orwa et al., 2009a). *Trichilia emetica* Vahl (Meliaceae), also known as the Natal mahogany, is an evergreen tree

reaching 20 m but occasionally even up to 35 m in height (Allaby, 1998; Orwa et al., 2009a). It has red-brown or grey-brown bark and the leaves are dark glossy green on the upper surface and covered with brownish hairs on the lower surface. The flowers are small, creamy to pale

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yellow-green, and fragrant. The furry, rounded, red-brown fruit capsules (3 cm across); contain 3 to 6 shiny black seeds (1.4 to 1.8 cm) with a large fleshy scarlet or orange-red aril (Orwa et al., 2009a).

T. emetica is widely distributed and grows naturally throughout sub-Saharan Africa extending from KwaZulu-Natal in the south, through Swaziland, Ethiopia, Mpumalanga and Limpopo Provinces (South Africa), into Zimbabwe and northwards into Cameroon, Sudan and Uganda (Germishuizen and Meyer, 2003). It has a preference for areas with a high rainfall and well-drained rich alluvial or sandy soil and is therefore abundant along coastal areas (Cronquist, 1981; Orwa et al., 2009a). *T. emetica* is a coveted multipurpose tree which has been used throughout Africa for several centuries. The seeds are rich in fat and produce good quality oil used for cosmetic purposes such as in the manufacturing of natural soaps (Von Breitenbach, 1965; Orwa et al., 2009a). The oil is rich in palmitic, stearic, oleic and linoleic fatty acids. Research has shown that it contains limonoids that are known to have antimicrobial and anti-inflammatory properties. A traditional use by the South Africans was to apply the oil on cuts and wounds, to heal bones and soothe the pain caused by rheumatism. *T. emetica* oil is rich in essential fatty acids and has nourishing, revitalizing effects on the skin and hair. In some instances, *T. emetica* oil is combined with coconut oil to provide emollient and moisturizing effects. *T. emetica* oil is listed as a possible active from a botanical source included in a patent filed by the Estee Lauder Companies Inc. describing a powder make-up product containing skin treatment actives.

T. emetica oil seeds yield a solid butter as room temperature and which melts to an oil at 30°C. The oil content of the kernels is higher than many other oilseeds with a content of between 55-65%. Mafura butter is a highly moisturizing butter that is extracted from the seeds of the Mafura tree (also known as *Trichilia emetica* or *Natal mahogany*). The Butter is widely used in the Southern African region, especially in Mozambique and Zimbabwe, as non-drying oil that quickly absorbs in the skin, softens and improves the elasticity of the skin, essential fatty acids contribute towards maintaining a healthy skin, encourages regeneration of cells without clogging pores, has antimicrobial and anti-inflammatory properties, spreads easily on the skin hence can also be used in massage products, heals and nourishes dry cracked skin, excellent as a hair conditioner, ideal moisturizer to strengthen and softens natural hair and alleviates dry and itchy scalp ([www. PhytoAfrica.com](http://www.PhytoAfrica.com)).

Gas chromatography was used to analyze methyl esters of the glycerides of *T. emetica* to determine the fatty acid profile of the oil. It was determined that the oil is rich in fatty acids containing high proportions of palmitic and oleic acids, with lower proportions of linoleic, linolenic and stearic acids indicated in (Engelter and Wehmeyer, 1970; Khumalo et al., 2002; Van der Vossen and Mkamilo, 2007). There is a paucity of scientific studies related to

the use of *T. emetica* seed oil. However, it is known to be rich in palmitic and oleic acids which have proved to be good skin permeation enhancers (Kim et al., 2008). In a previous study anti-oxidant activity was correlated to high oleic acid content and it may be plausible to predict that the high levels of oleic acid in *T. emetica* seed oil will exhibit good anti-oxidant properties (Talcott et al., 2005).

The nutritive and calorific values of seeds make them good source of edible oils and fats diets (Odoemelam, 2005; Akubugwo et al., 2008). There has been an increase in the world production of oilseeds over the last 30 years (Murphy, 1994). This would appear to be related to the increasing demand for oilseed products and by products. Most oilseeds are cultivated primarily for their oil and meal. Since oil is always at a higher price per ton than the cake, the demand for oil rather than the cake is high. The oil from most oilseeds can be used for edible purposes such as cooking (e.g., groundnut, cashew, palm kernel oils, etc.). About 80% of the world production of vegetable oils is for human consumption. The remaining 20% is shared between animal and chemical industries (Murphy, 1994).

Numerous researchers (Akpan et al., 1999; Yusuf et al., 2006; Kyari, 2008; Akubugwo et al., 2008), among others have carried out a lot of analytical works on seeds primarily because of extensive and increasing demands for them both human consumption and numerous industrial applications. Because of the high demand and economic importance of these oilseeds to the chemical industry, attentions have therefore been focused on underutilized oilseeds viz., *T. emetica* oil seeds grown in Tepi, Ethiopia for possible development and use. As far as my knowledge is concerned, no detailed study of the physicochemical properties of the oilseeds of *T. emetica* oilseeds has been carried out so far in Ethiopia. The objective this study was therefore to evaluate proximate nutritional composition analysis, characterization of some selected physicochemical properties and comparative assessment of *T. emetica* oilseeds cultivated in Tepi area, Ethiopia.

MATERIALS AND METHODS

Collection of oilseeds: The oilseeds of *T. emetica* were obtained from the Tepi province in Ethiopia in the year 2013. Plant material was identified by Ethiopian Institute of Agricultural Research Tepi national Spice Research Center, Tepi, Ethiopia. Oilseeds were transported to the laboratory in polypropylene bags and kept at room temperature. They were cleaned with tap water to remove the impurities (Figures 1 and 2).

Compositional analysis of oilseeds

The recommended methods of the association of official analytical chemists (AOAC, 1997) was used to determine the chemical composition of *T. emetica* oilseeds including ash, crude protein, crude fat, energy, carbohydrate and crude fiber. A total lipid (crude fat) was determined by continuous extraction in a Soxhlet



Figure 1. *Trichilia emetica* oilseeds before removing the husk (directly collected from local market).



Figure 2. *Trichilia emetica* oilseeds after removed the external cover, cleaned with water and dried.

apparatus using hexane as solvent. After evaporation of the solvent, the oil content was determined gravimetrically. Ash was determined by incinerating the sample at 550°C in a muffle furnace.

Crude protein was calculated from the nitrogen content measured by Kjeldahl method with Gerhardt model Vat 20 instrument using a factor 6.25. Crude fiber was determined according to the

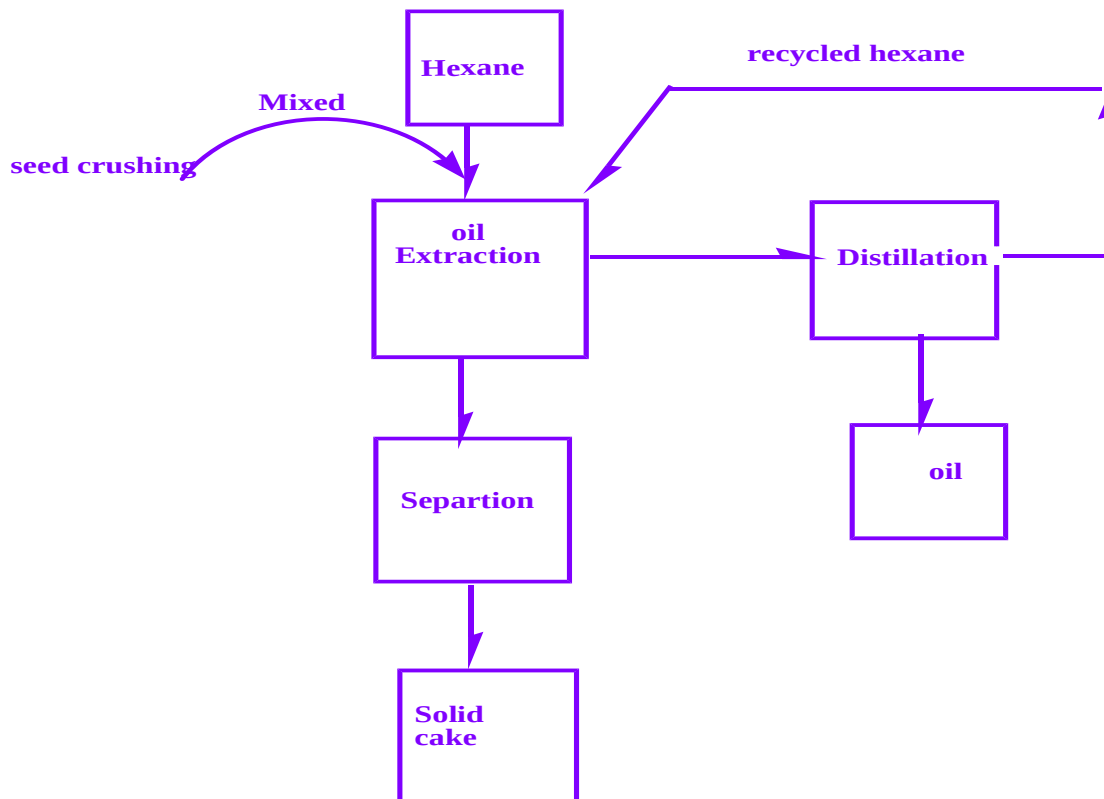


Figure 3. Oil extraction flow chart using hexane solvent.

gravimetric procedure. Total carbohydrate was estimated as the difference between 100 and the sum total of the proximate composition of each sample. All the analyses were performed in triplicate.

Extraction of seed oil

A known weight of the oilseeds was grounded into powder using an electrical coffee mill grinder machine (Nima, Japan) to increase surface area for oil extraction processes. Thereafter oil was extracted from this *T. emetica* oilseeds powder with n-hexane using a Soxhlet extractor. The solvent (hexane) and oil were separated using distillation at a temperature of slightly higher than the boiling temperature of hexane, which is recovered again for further extraction with fresh hexane (Figure 3). The oil was stored in the chemistry laboratory room for physico-chemical properties analysis. Physicochemical parameters of the seed oil: Standard method was used to determine the physical and chemical properties of the seeds oil, which includes the peroxide value, iodine value, acid value, saponification value, value and refractive index (AOAC, 1997).

RESULTS AND DISCUSSION

The results of proximate nutritional composition analysis of the whole dried *T. emetica* oilseeds are presented in Table 1. Traditional societies have always exploited edible wild plants to provide adequate nutrition, food

security and income generation (Dhellot et al., 2006a,b; Antia et al., 2006; Akubugwo et al., 2007a,b; Akubugwo et al., 2008). These wild plants not only provides raw materials for industries but also serve as indispensable constituent of human diet supplying the body with minerals, vitamins and certain hormone precursors, in addition to protein and energy (Fleuret, 1979; Akubugwo and Ugbogu, 2007), the crude fiber content of *T. emetica* oilseeds is 15.28%, which is higher than 0.8 to 6.29% reported for most tropical plant seeds in Africa (Ekop, 2007; Akubugwo et al., 2007a; Akpambang et al., 2008). Adequate intake of dietary fiber can lower cholesterol level, risk of coronary heart diseases, hypertension, constipation, diabetes, colon and breast cancer (Rao et al., 1998; Ishida et al., 2000). Thus, the oilseeds of *T. emetica* tree could be regarded as valuable source of dietary fiber in human nutrition. Ash contents which are indices of mineral contents in biota are compared favorably with those in seeds of *Amaranthus hybridus* va.1 and var.2 (4.86 and 4.02%, respectively) (Dhellot et al., 2006) and *Prunus amygdalus* (3.34%) (Akpambang et al., 2008). In the present study, the ash content of *T. emetica* oilseeds is 3.4%. The crude protein content oilseed is 5.21% and lower than *A. hybridus* va.1 and var.2 (17.60 and 18.99%, respectively). However, the value compared favorably with that of *Telferia occidentalis* (7.0%) (Ekop, 2007). Plant protein still

Table 1. Proximate nutritional composition analysis of the whole *Trichilia emetica* oilseeds.

Components	Percentage
Dry matter	97.02 ± 0.58
Crude fat (lipid)	65.81 ± 0.06
Crude fiber	15.28 ± 0.09
Ash	3.4 ± 0.12
Crude protein	5.21 ± 0.019
Energy (Kcal/mole)	703.98 ± 0.45
Carbohydrate	22.43 ± 0.16
Protein	5.21 ± 0.12

Table 2. Physical properties of oil extracted from *Trichilia emetica* oilseeds and compared with some selected commercial oils seeds.

Oilseed parameter	<i>Trichilia emetica</i> seeds	<i>Cocos nucifera</i> seeds	<i>Colocynthis citrullus</i> seeds
Percentage oil yield	65.15%	47.8%	50.4%
State at room temperature	Solid	liquid	Liquid
Color	Golden yellow	Pale yellow	Pale yellow
Odor	Agreeable	Agreeable	Agreeable
Refractive index	1.47	1.465	1.471

remains a veritable source of food nutrient for the less privileged population in developing countries, including Ethiopia where the cost of animal protein is beyond their income per capital. Thus, oilseeds should be incorporated in human and animal nutrition to supplement protein. The crude lipid content of the oilseeds is 65.81% which exceed that of some common edible oils such as cottonseed (22 to 24%), safflower (30 to 35%), soybean (18 to 22%), rapeseed (40 to 48%), and olive (12 to 50%) (Nichols and Sanderson 2003) and unconventional oilseeds such as *Canarium schwenfurthii* fruits (36.1%) and *Balanites aegyptiaca* almonds (48.3%) (Nzikou, et al., 2006). Thus, the plant oilseeds studied is rich source of lipids. Therefore, the *T. emetica* oilseeds can be considered as a potential source of vegetable oil for domestic and industrial purposes after purifications. The carbohydrate content of oilseeds in the present study is 22.43%. This value was much higher than 5.6% reported by (Lazos, 1986) for pumpkin. However, compared favorably with the value of cashew nuts (26.2%) and sesame (26.0%) (Achu et al., 2005). Thus, the oilseed is a good source of carbohydrate.

The estimated calorific values of the *T. emetica* oilseed is 703.98 Kcal/100g which is higher than values reported for *Solanum nigrum* L. var. *virginicum* seed (403.54 Kcal/100g) (Akubugwo et al., 2007a), *T. occidentalis* (60.53 Kcal/100g) *Mucuna ureans* (381.5 Kcal/100g) (Ekop, 2007). This value implicated that *T. emetica* oilseed as rich source of energy.

Table 2 showed the physical properties of seeds oil extracted from *T. emetica* oilseeds and compared with

some selected commercial oils seeds from the literature (pervious research work). The percentage of oil yield *T. emetica* seeds is higher than the other two seeds. In addition to this, the oil had yellow color, solid at room temperature and agreeable odor (Figure 4). The refractive index of the oil is 1.47. This value compared favorably with *Colocynthis citrullus* (1.47), *Cucumeropsis* (1.47) and *Prunus amygdalus* (1.47) (Akpambang et al., 2008).

The chemical properties of the oil extracted from *T. emetica* oilseeds as compared to those commercial available oils are shown in Table 3. The acid value of the seed oil (8.13 mgNaOH/g) compared favorably with the range, 1.20-8.41 mgNaOH/g reported for *T. occidentalis*, *Citrillus vulgaris*, *C. citrullus*, *Pentaclethra macrophylla* and *Treculia Africana* (Yusuf et al., 2006; Akubugwo et al., 2008; Akpambang et al., 2008). However, this acid value is lower than that reported for *Persea gratesima* (11.46 mgNaOH/g) and *Cocos nucifera* (11.31 mgNaOH/g) from Isiala Ngawa (Akubugwo et al., 2008), *Cucumeropsis edulis* (9.36 mgNaOH/g) and *Prunus amygdalus* (9.66 mgNaOH/g) (Akpambang et al., 2008) and as well as some conventional oils (Palm kernel and Kulikuli). Acid value is used as an indicator for edibility of oil and suitability for use in paint industry. The acid value of the seeds oil studied fell within allowable limits for edible oils (Codex Alimentarius Commission, 1982). Therefore, the oil may be edible after refining.

The saponification value of the seeds oil 180.09 mgKOH/g and this value compared favorably with sunflower (182.23 mgKOH/g) and *wangasa* (186.53



Figure 4. Crude *Trichilia emetica* seeds oil (initially the oil is liquid and solidified after six days).

Table 3. Chemical parameters of the oil extracted from *T. emetica* seeds oil as compared with those from commercial available.

Source of oilseed	Parameters			
	Acid values (mgNaOH/g)	Saponification value (mgNaOH/g)	Iodine value (mgI/g oil)	Peroxide values (meqO ₂ /kg)
Trichilia emetica oilseed	8.13	180.09	60.15	0.56
Palm kernel	25.62	258.78	127.03	0.39
Kulikuli	12.53	194.95	111.99	1.60
Colocynthis citrullus	6.17	201.03	111.46	2.72
Controller	6.73	196.35	118.76	1.13
Soya bean	4.30	192.45	97.29	0.37
Sunflower	0.953	182.23	119.92	6.32

mgKOH/g). However, the saponification value of the oil is higher than those reported for *Detarium microcarpum* (123.3 mgKOH/g) (Akubugwo et al., 2008), *T. occidentalis* (158.40 mgKOH/g) (Kyari, 2008). The relative high saponification value recorded for *T. emetica* seeds oil is indicative that it has a potential for use in the industries especially in cosmetics and soap making industries. The iodine value of *T. emetica* seeds oil in the present study is 60.15 mgI₂/g, which is lower than many

commercial oils (Table 3). The relative low iodine number of the oil seeds may be indicative of the presence of a few unsaturated bonds and low susceptibility to oxidative rancidity (Eka, 1980). The peroxide value is 0.56 meqO₂/kg for *T. emetica* seeds oil. This value compared favorably with the range 0.231 to 1.6 obtained for the studied conventional oils. Peroxide values are used as indicator of deterioration of oils. Fresh oils have peroxide values less than 10 meqO₂/kg (Codex Alimentarius

Commission, 1982) while values above 20 indicate rancid taste and disagreeable odor (Pearson, 1976). The low peroxide value of this seeds oil indicative of low level of oxidative rancidity of the oil and also suggests the presence or high levels of antioxidant.

Conclusions

The proximate nutritional composition, characterization of some selected physicochemical properties and comparative composition analysis of *T. emetica* oilseeds and seeds oil with some selected commercial oilseeds were compared with other commercial oil seeds from literature in this study. *T. emetica* oil seeds have higher yield of oil (65%), which is comparable to the oil yield of some commercial seed oils such as cottonseed, safflower, soybean, rapeseed and olive oil. Many of the physico-chemical properties of the seed oil studied have close similarity with other commercial seed oils. The results obtained from this study could be used as baseline data to develop *T. emetica* seed oil for both domestic and industrial purposes and also for promotion and cultivation of this tree with a sustainable manner in the Tepi area for large scale production of oil.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

- Achu MB, Fokou E, Tchiegang C, Fotso, M, Tchouanguep MF (2005). Nutritive value of some cucurbitaceae oilseeds from different regions in Cameroon. *Afr. J. Biotech.* 4:1329–1334.
- Akapambang VO, Oderinde E, Izuagie IA, (2008). Comparative compositional analysis of on two varieties of melon (*Colocynthiscitrullus* and *Cucumeropsis*) and a variety of almond (*Prunusamygdalu*). *Res. J. Agric. Biological. Sci.* 4:639-642.
- Akan UG, Jimoh A, Mohammed AD (1999). Extraction, characterization and modification of castor seed oil. *Leonardo J. Sci.* 4:1-8.
- Akubugwo IE, Ugbo AE (2007). Physicochemical studies on oils from five selected Nigerian plant seeds. *Pak. J. Nutr.* 6:75-78. <http://dx.doi.org/10.3923/pjn.2007.75.78>
- Akubugwo IE, Obasi AN, Ginika SC (2007a). Nutritional potential of the leaves and seeds of black nightshade –*Solanum nigrum* L. *Varvirginicum* from afikpo-Nigeria. *Pak. J. Nutr.* 6:323-326. <http://dx.doi.org/10.3923/pjn.2007.323.326>
- Akubugwo IE, Obasi NA, Chinyere GC, Ugbo AE (2007b). Nutritional and chemical value of *Amaranthus hybridus* L. leaves from Afipo, Nigeria. *Afr. J. Biotechnol.* 6:2833-2839.
- Akubugwo IE, Chinyere GC, Ugbo AE (2008). Comparative studies on oils from some common plant seeds in Nigeria. *Pak. J. Nutr.* 7:570-573. <http://dx.doi.org/10.3923/pjn.2008.570.573>
- Allaby A (1998) A dictionary of plant sciences. Oxford University Press, London.
- Antia BS, Akpan EJ, Okon PA, Umoren IU (2006). Nutritive and anti-nutritive evaluation of sweet potatoes (*Ipomoea batatas*) leaves. *Pak. J. Nutr.* 5:166-168. <http://dx.doi.org/10.3923/pjn.2006.166.168>
- AOAC (1997). Methods of Analysis of Association of Official Agricultural Chemist. 17th edn., Association of Official Analytical Chemists, Washington, DC. pp. 684-697.
- Codex Alimentarius Commission (1982). Recommended Internal Standard for edible fats and oils. Edn. FAO/WHO, Rome, 1(11):1-179.
- Cronquist A (1981). An integrated system of classification of flowering plants. Columbia University Press, New York. PMID:6117027.
- Dhellot JR, Matouba E, Maloumbi MG, Nzikou JM, Ngoma DGS (2006a). Extraction chemical composition and nutritional characterization of vegetable oils: Case of *Amaranthus hybridus* (va1. and 2) of Congo. *Afr. J. Biotechnol.* 5:1095-1101.
- Dhellot JR, Matouba E, Maloumbi MG, Nzikou JM, Ngoma DGS (2006b). Extraction and nutritional properties of *Solanum nigrum* L. seed oil. *Afr. J. Biotechnol.* 5:987-991.
- Eka OU (1980). Proximate composition of bush mango tree and some properties of dikafat. *Nig. J. Nutr. Sci.* 1:33-36.
- Ekop AS (2007). Determination of chemical composition of Gnetum Africana (AFANG) seeds. *Pak. J. Nutr.* 6:40-43. <http://dx.doi.org/10.3923/pjn.2007.40.43>
- Engelter C, Wehmeyer AS (1970). Fatty acid composition of oils of some edible seeds of wild plants. *J. Agric. Food Chem.* 18:25–26. <http://dx.doi.org/10.1021/jf60167a025>
- Fleuret A (1979). The role of wild foliage plants in the diet. *Ecol. Food Nutr.* 8:87-93. <http://dx.doi.org/10.1080/03670244.1979.9990549>
- Germishuizen, G, Meyer, NL (Eds.), (2003). Plants of Southern Africa: an annotated checklist. Strelitzia 14. National Botanical Institute, Pretoria. PMID:16468931.
- Ishida H, Suzuno H, Sugiyama N, Innami S, Tadokoro T, Maekawa A (2000). Nutritional evolution of chemical component of leaves, stalkd and stem of sweet potatoes (*Ipomoea bataspor*). *Food Chem.* 68:359-367. [http://dx.doi.org/10.1016/S0308-8146\(99\)00206-X](http://dx.doi.org/10.1016/S0308-8146(99)00206-X)
- Khumalo LW, Majoko L, Read JS, Ncube I (2002). Characterisation of some underutilised vegetable oils and their evaluation as starting material for lipase-catalysed production of cocoa butter equivalents. *Indust. Crop Prod.* 16:237–244. [http://dx.doi.org/10.1016/S0926-6690\(02\)00051-1](http://dx.doi.org/10.1016/S0926-6690(02)00051-1)
- Kim MJ, Doh HJ, Choi MK, Chung SJ, Shim CK, Kim DD, Kim JS, Yong CS, Choi HG (2008). Skin permeation enhancement of diclofenac by fatty acids. *Drug Delivery* 15:373–379. <http://dx.doi.org/10.1080/10717540802006898> PMID:18686081.
- Kyari MZ (2008). Extraction and characterization of seed oils. *Int. Agrophysics*, 22:139-142.
- Lazos ES (1986). Nutritional, Fatty acid, and Oil Characteristics of Pumpkin and Melon Seeds. *J. Food Sci.* 51:1382–1383. 11.
- Murphy DJ (1994). Designer Oil Crops. VCH Press, Weinheim.
- Nichols DS, Sanderson K (2003). The Nomenclature, Structure, and Properties of food Lipids. In Chemical and Functional Properties of Food Lipids (Z.E. Sikorski, and A. Kolakowska, eds.) CRC Press, pp. 29–59. PMID:12514362.
- Nzikou JM, Mvoula-Tsieri M, Matouba E, Ouamba JM, Kapseu C, Parmentier M, Desobry S (2006). A study on gumbo seed grown in Congo Brazzaville for its food and Industrial applications. *Afr. J. Biotechnol.* 5:2469-2475.
- Odoemelam, SA. (2005). Proximate composition and selected physicochemical properties of the seeds of African oil bean (*Pentaclethra marcophylla*). *Pak. J. Nutr.* 4:382-383. <http://dx.doi.org/10.3923/pjn.2005.382.383>
- Orwa C, Mutua A, Kindt R, Jamnadass R, Simons A (2009a). *Trichilia emetica*. Agroforestry database: a tree reference and selection guide version 4.0. Available at: <http://www.worldagroforestry.org/af/treedb/>. [Accessed on: 30/04/2011].
- Pearson D (1976). Chemical analysis of Food. 7thEdn., Church Hill Livingstone, London, UK, 72-73:38-143, 488-496.
- Rao CV, Newmark HL, Reddy BS (1998). Chemo-preventive effect of Squalene on colon cancer. *Carcinogenesis*, 19:287-290. <http://dx.doi.org/10.1093/carcin/19.2.287>
- Talcott ST, Duncan CE, Del Pozo-Insfran D, Gorbet DW (2005). Polyphenolic and antioxidant changes during storage of normal, mid, and high oleic acid peanuts. *Food Chem.* 89:77–84. <http://dx.doi.org/10.1016/j.foodchem.2004.02.020>
- www.pyhtoAfrica.com. [Accessed on: 5/6/ 2014]
- Van der Vossen HAM, Mkamilo GS (2007). Vegetable oils of tropical

Africa, conclusions and recommendations based on PROTA 14: 'Vegetable oils'. Available on: PROTA (Plant Resources of Tropical Africa/Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands http://www.prota.co.ke/en/publications-a-resources/publications/doc_view/32-vegetableoils?tmpl=component&format=raw. [Accessed on: 30/04/2011].

Von Breitenbach F (1965). The indigenous trees of Southern Africa. Department of Forestry, Pretoria.

Yusuf AA, Adewuyi S, Lasisi A (2006). Physicochemical composition of leaves, meals and oils fluted pumpkin (*Telfairia occidentalis*) and melon (*Citrillus vulgaris*). Agric. J. 1:32-35.1.