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Chemical qualities of oils from some fresh and market vegetable crops within Kwara State of Nigeria

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Abstract

The potential of Nigeria leading Africa and the world in the area of biofuel and oleochemical production was examined by evaluating the oil yield and chemical qualities of oil extracted from fresh and market sample of some naturally abundant vegetables (*Mangifera indica, Prunus dulcis Miller, Ricinnus communis, and Elaeis guineensis)* in Nigeria. Moisture, ash, and crude fat composition, including the free fatty acid, acid and saponification values of the oils were determined, high mineral composition of almond was observed compared to other vegetables. Moisture content of 5.006, 3.500, 4.870, 37.002, 9.147, and 63.650%; crude fat of 59.195, 67.807, 33.490, 32.303, and 12.511, and 0.939%; and ash levels of 4.605, 2.833, 1.903, 1.728, and 1.305% were reported for seeds obtained from almond, castor, palm kernel, groundnut, mango and kola nuts respectively. Polymerization and esterification of fatty acids induced by the hot ambient storage conditions used by our marketer was attributed to the higher molecular weight of fatty acids in market sample for groundnut and palm oil over the corresponding fresh sample. High level of ash content (4.605%) for almond seed was observed, making a good source of mineral nutrition to consumers. Due to their high oil yield and abundance, oils from almond seed and castor seed, in addition to palm oil and groundnut oil may be considered as Nigeria potential asset for biofuel and oleochemical production.

Keywords: Oil palm seed, Mango seed, Sweet almond seed, Castor seed

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INTRODUCTION

Nigeria is one of the countries of the world with a variety of oil seeds notably groundnut, oil palm, soyabean and cotton seeds. The economic importance of oil crops has made it necessary that they be properly investigated, to ascertain their oil quality parameters, since this is an important criterion for marketing and processing seed oil[1]. Vegetable oils are used principally for food (mostly as shortening, margarines, and salad and cooking oils) and in the manufacture of soap and detergents, in paints and varnishes, and for a variety of other industrial items[2]. Oil is found in large amounts usually in the seeds of the plants and occasionally in the fleshy part of the fruits, as in the olive and the oil palm. Seeds may contain 1-60% oil. The oil is a reserve of high-energy food for use by the germinating seed, and large amounts of oil are associated with large amount of protein.

Fuel derived from vegetable oil is relatively a new concept worldwide but the idea has been around for as long as the diesel engine itself. Biodiesel "referred to as a miracle fuel" is a fuel that can be made from any fat or vegetable oil[3]. It is usually produced from soyabean oil in the U.S. (due to its abundance) and it works in any diesel engine with few or no modifications and can be blended with diesel at any level[3]. Over the last 20years, there has been considerable progress in utilization of vegetable oils and their derivatives in the formulation of biolubricants[4]. The versatility of vegetable-based fluids and downstream esters is now recognized in research projects in many areas where a number of applications may not have been previously possible, but where modification of the equipment or process designs themselves can enable potential advantages for users[4]. The products offer low toxicity, low evaporation rates, low emissions and rapid biodegradability[4].

The health and nutritional benefit of vegetable oil (e.g. coconut oil) especially as an antiviral, antibacterial and antiprotozoal monoglyceride used by humans or animals to destroy lipid-coated viruses such as HIV had been reported since the oil is metabolized in the body to release monolaurin[5]. Its importance in food industries as biodiesel had also been reported[5]. Uses of oil palm produce in oleochemicals, biodesiel and potent cleaning agent (methyl ester sulphonates) productions had been reported[6]. Technologies to produce polyols from palm oil and palm kernel oil that are economically competitive to petroleum-based polyols had also been developed[6].

Castor oil from *Ricinus communis* is used in the production of synthetic resins, plastics, fibers, paints varnishes, and various chemicals including drying oil and plasticizers. In addition to the uses, castor oil and its derivatives are used in cosmetics, hair oils, fungi static (fungus growth–inhibiting) compounds, embalming fluid, printing inks, soap, lubricants, greases and hydraulic fluids, dyeing aids , and textile finishing materials[7]. Castor oil consists of almost entirely of the triglycerides ricinoleic acid. Although it has been taken internally as a cathartic, its use can be harmful. The fruits are attractive but often are removed before they mature because of the poison ricin concentrated in their mottled, beanlike seeds[7].

Toxalbumins are highly toxic protein molecules that are produced by only a small number of plants. Ricin, a toxalbumin from the castor bean is one of the most toxic substances known[8] since it is poisonous as with the beans it is used as fertilizer[2]. The first electricity ever seen had been reported for castor oil in Brazil[9]. The growing interest in biodiesel in some European countries led Brasil ecodiesel to hope that large quantities might be exported, as is now beginning to happen with the alcohol from sugar cane, which can also be used to run vehicles.

Nigeria has the potential of leading the world, and sustains its leading role in Africa in the area of oleochemical and biodiesel production from vegetable oil. Some potential seed (okra, baobab, sour sap, ogbono, 'Gawasa' Hausa, oilbean seed, pumkin fruit, walnut, and African bread fruit) had earlier been reported[10]. This work also assessed the oil qualities of some other potential oil crops in Nigeria.

MATERIALS AND METHODS:

A fresh oil palm seed (*Elaeis guineensis*)**,** the market samples of the palm oil and groundnut oil were purchased from Ganmo local market at the outskirt of Ilorin metropolis. Sweet almond (*Prunus dulcis Miller*)**,** mango seed (*Mangifera indica*) and castor seeds (*Ricinus communis)* were harvested/or collected within NSPRI yard, the fresh oil palm seeds were boiled for 30mins to extract the oil. The floating oil was thereafter decanted and used as fresh palm oil. The resultant kernel collected was broken to collect the seed. This seeds were grinded using mortar and pestle and was used as samples for oil analysis. Three replications were used for each analysis carried out.

Moisture content was analyzed by air oven method of AOAC[11] and ash content was determined by igniting the samples at 600^{o}C in a muffle furnace, the inorganic residues obtained were thereafter expressed as percentage ash content. Crude fat was determined by grating the samples, and 5.0g of the grated samples were weighed into a thimble. 250ml round bottom flask that had been previously dried at 103^{o}C for 30mins and cooled was accurately weighed.

Oils from the samples were extracted with petroleum spirit as solvent, using soxhlet apparatus for six hours. The extracted oils were heated in an oven for 30mins at 103^{o}C to evaporate the remaining solvent. The samples were allowed to cool in a desiccator for 3mins after discontinuing the heating process, and weighed. The resultant oils were afterward expressed as percentage of the original sample.

Saponification value

5.0g of oil samples were put in a glass resistant to alkali action. 25ml of potassium hydroxide was afterward added to it and boiled under reflux for 60mins while shaking at intervals. 0.5ml of phenolphthalein was added as an indicator, this was titrated against 0.5N hydrochloric acid while the solution was still hot to determine the excess of alkali. The results were subjected to calculation and expressed in mg per g oil sample.

Free fatty acid and acid value determination

5.0g of the extracted oil were weighed into conical flask (f1); 50ml of absolute ethanol was afterwards put into another flask (f2). The ethanol was boiled to boiling point and then neutralized with 0.1N potassium hydroxide using 0.5ml phenolphthalein indicator. The neutralized ethanol was then poured into flask (f1) and heated to boiling point. While as hot as possible, the solution was titrated against 0.1N potassium hydroxide until when the addition of a single drop produces a slight but definite color change (pink) persisting for at least 15seconds. The results were subjected to calculation and expressed in mg per g oil sample.

RESULTS AND DISCUSSION

The qualities of some vegetable oil are as indicated in Table 1. Crude fat for almond, castor seed, palm kernel, and fresh groundnuts were between the ranges 32.203-67.807%. These amounts may be considered economical for commercial production of oil in Nigeria. That of mango seed (13.511%) is however low to be considered an oilseed for commercial purposes, but its uses may not be discourage due to its high level of wastages. The oil yield (32.303%) from groundnuts (*Arachis hypogaea*) in this study is comparable to that reported for less matured groundnut, but less than that reported for fully matured groundnut (40-50%)[12].

Saponification values had been reported to be inversely related to the average molecular weight of the fatty acids in the oil fractions[1]. Oil fractions with saponification values of 200mgKOH/ g and above had been reported to possess low molecular weight fatty acids[1]. Therefore, our work reveals that oils from almond nut, and palm kernel with saponification value of 163.398-191.976 mgKOH/g oil possessed very low molecular weight fatty acids. Closely higher in molecular weight is that from fresh palm oil with saponification value of 94.406 mgKOH/g oil. While that of castor oil, market sample for both groundnut and palm oil consists of very high molecular weight fatty acids. The molecular weight of fatty acids in the market sample of groundnut and palm oil were evidently higher than that of their corresponding fresh sample. The increase in molecular weight may be due to the hot ambient storage conditions used by our marketers, the oils are usually stored in aluminium container for about one year prior to marketing.

Table 1: Chemical Qualities of Some Nigerian Oilseed crops

Oilseed	Moisture content (%)	Ash content (%)	Crude fat (%)	Free fatty acid (mgKOH/g)	Acidity value (mgKOH/g)	Saponification value (mgKOH/g)
Almond nut	5.006 ± 0.093	4.605± 0.001	59.195± .675	0.388± 0.050	0.770± 0.099	163.398± 15.800
Castor seed (Wild)	3.500 ± 0.057	2.833± 0.061	67.807± 0.618	0.141± 0.000	0.279± 0.000	5.582 ± 0.107
Palm Kernel seed	4.870 ± 0.141	1.903± 0.039	33.490± 6.162	5.297± 0.885	0.834± 0.004	191.976± 3.164
Fresh groundnut	37.002 ± 0.409	1.728± 0.272	32.303± 0.488	18.225± 0.071	36.142± 0.141	199.196± 6.965
Mango seed	9.147± 0.178	2.732± 0.794	13.511± 3.967	ND	ND	ND
Kolanuts	63.650± 1.811	1.305± 0.272	0.939± 0.108	ND	ND	ND
Fresh palm oil (hot water extract)				3.924± 0.050	8.584± 0.109	94.406± 1.249
Palm oil (market sample)				4.926± 0.092	10.776± 0.201	3.502± 0.991
Groundnut oil (market sample)				0.174± 0.047	0.345± 0.093	11.146± 3.904

ND = not determined

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This storage conditions may induce esterification, and/ or polymerization of the unsaturated fatty acids present in the oils. Polyunsaturated fatty acids are very susceptible to polymerization and gum formation caused by oxidation during storage, or by a complex oxidative and thermal polymerization at the higher temperature and pressure of combustion[13]. The increase in unsaturated fatty acids (palmitic, stearic, and oleic acids) was also reported in bath oils upon frying[14], this may be induced by the heat generated during frying.

Acid value represents free fatty acid content due to enzymatic activity and is usually indicative of spoilage. Its maximum acceptable level is 4mgKOH/g oil[15], below which the oil is acceptable for consumption. Free fatty acids (FFA) are not present to any significant level in healthy plant cells, but FFA levels of up to 15% (more in very bad cases) is usually found in commercial crude vegetable oils whether pressed or solvent extracted[16]. These FFAs are present as a consequence of cell damage in vegetable tissue during harvesting, storage, transportion, and must be removed during refining. The cell damage can also be caused by bruising of fruit, seed freezing and thawing cycling, hot conditions or microbial activity (e.g. fungal growth) [16].

The high moisture content of groundnut (37.002%) may be responsible for its high perishability, which may explain the high levels of FFA and acid value reported in this work, despite using a freshly harvested groundnut. Textural factors including crispness and firmness are influenced by moisture content. Low levels of moisture and presence of low levels of polyunsaturated fatty acids in almond had been attributed to its relatively long shelf-life[17]. The 5.006% moisture content and 59.195% oil yield reported in this work for almond is higher than the 4.4% and 52.2% earlier reported for its moisture content and oil yield respectively[17]. The result indicates high level of ash content (4.605%) for almond seed making it a good source of mineral nutrition to consumers.

The oil yield levels (13.511%) reported in this work for mango seed may be useful in food industries but cannot be considered economical as oilseed when compared to other vegetable oil. This value is however slightly higher than the 11.0% earlier reported for the kernel[18]. However, the mango seed (kernel) is still underutilized in Nigeria, they are discarded after eaten the pulp and skin. There is need for more research on its usefulness for human and livestock feed.

In conclusion, this result may be useful in forming future oilseed standards in Nigeria. Oils from almond seed, and castor seed in addition to palm oil, and groundnut oil due to their high oil yield and abundance may be considered as Nigeria potential asset for biofuel and oleochemical production.

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