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Comparative Analysis of Seed Oils of *Momordica charantia, Citrullus colocynthis* and *Adenopus breviflorus* for Food and Industrial Applications

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Abstract:
This study investigated the physico-chemical properties and fatty acids composition of Momordica charantia, Citrullus colocynthis and Adenopus breviflorus oils with the aim to increase their utilization. The relative viscosity, specific gravity, pH, acid value, iodine value and saponification values of the seed oils were determined using standard methods. The seed oils were analyzed for fatty acid composition using Gas chromatograph based on Flame ionization detector (GC-FID).The results of the physico-chemical analysis showed that the oil could find application in the industry especially for the manufacture of products such as paints, liquid soaps, shampoos, cosmetics etc. and may be edible. Predominant fatty acids in all the three plants were in the order: palmitic acid (C16:0) < stearic acid (C18:0) < Oleic acid (C18:1) < Linoleic acid C18:2. It is thus concluded that the plants are good sources of unsaturated fatty acids. Hence, these plants could be explored for consumption and industrial applications

Keywords: *Physicochemical, Momordica charantia, Citrullus colocynthis, Adenopus breviflorus, Seed oils, Fatty acids*

1. Introduction

Throughout the world, especially in developing countries, wild plants make an important contribution to the life of local communities. They play a significant role as source of fuel wood, in medicines, dyes, fibres, shelter, religious and ceremonial uses. However, the importance of wild plants in subsistence agriculture in developing world as food supplement and as a means of survival had been overlooked and their consumption is still underestimated (FAO, 1999). In general, wild plant resources are often ignored and received little recognition from developing communities (Scoones *et al,* 1992). The reason is probably due to lack of information about the extent of their use as food and other economic importance. In view of their importance as alternative sources of plant food, there is, therefore, the need to evaluate some of the wild plant species as sources of food and other uses.

Fats and oils constitute one of the three main classes of foodstuffs, the others being carbohydrates and proteins. In recent time, the place of fats and oils in our diet received a great deal of attention because of the possible role of saturated fats in cardiovascular diseases. Fats and oils are the greatest and most concentrated storehouse of energy for animals. In humans for instance, the total amount of the carbohydrate stored in the liver contains only enough energy to keep the body going for about fifteen hours (Richards *et al.,* 1967). The processing of oil from the wild plant seeds would therefore be quite economical and the defatted residues would consequently yield rich protein meal which could be processed further into livestock feeds or the protein isolated and purified for food purposes (Woodroof, 1994). Most indigenous herb plants have multiple uses and play a vital role in crop diversification and households system.

Momordica charantia, commonly known as bitter melon, and referred to as "*Ejirin"* in South-Western Nigeria, is a wildly grown tropical and subtropical flowering vine of the family *Cucurbitaceae*. The bitter melon oil is obtained from the dried seeds of the plant. The seeds and the pith appear white in unripe fruit which becomes red on ripening. It is fleshy and watery like cucumber, chayote or green ball pepper (Nadkarmik, 1993). This oil has been traditionally used as massage therapy to lubricate the skin and also considered by many to be effective emollient oil. Studies have indicated that the fruit and leaf extracts have medicinal properties such as anti-diabetic, anti-tumorous, anti-cancer, anti-inflammatory, anti-viral and cholesterol lowering effect (Ahmed *et al*, 2001; Taylor, 2002).

Citrullus colocynthis, another wildly grown plant in Nigeria, commonly called bitter apple or bitter gourd and locally known as *Bara* in South-Western Nigeria*,* belongs to the melon family of *Cucurbitaceae*. The plant produces 40 – 60 fruits every year (Tackholm, 1974). The seeds from the fruit of bitter apple had been used medicinally since ancient times. Its traditional use includes the treatment of diabetes, microbial disease etc. (Nmila *et al.,* 2000). *Adenopus breviflorous, (*locally called *"Ikirikiri"* in part of South-Western Nigeria, is also a member of the *Cucurbitaceace* family. The leaves are simple, alternate and palmate veined (Dutta, 1995). The fruit appears green with bitter pulp due to the presence of tetracyclic triterpenoid (Kar, 2007). The seeds numbered up to 400 in an average sized fruit and contained fixed oil. The plant grows wild and is particularly abundant in Southern Nigeria. However, there is paucity of information about the uses of the seed oils. Studies have shown that *Momordica charantia*, *Citrullus colocynthis* and *Adenopus*

breviflorus are some of the wild plant species commonly used for medicinal purposes in Nigeria (Elizabeth, 1994; Weihrauch and Teter, 1994; Nmila *et al.,* 2000; Kumar, *et al,* 2010). They are considered as weeds in the study area as they as not cultivated by farmers and therefore, the comparative analysis was carried out in view of exploring the possibility of their use as food and for domestic purposes.

2. Material and Methods

2.1. Sample Collection and Preparation

Momordica charantia, *Citrullus colocynthis* and *Adenopus breviflorus* were collected between September and November, 2015 within the surrounding of Adekunle Ajasin University, Akungba, Ondo State, Nigeria and identified in the Department of Plant Science and Biotechnology of the University. The seeds were air-dried, cleaned, milled and reduced into powder using the Kenwood-grain blender and stored in plastics containers for analysis. All chemicals and reagents used in this study were of analytical grade. The extracting solvents used were of High Pressure Liquid Chromatography (HPLC) grade. All sampling apparatus, glassware and bottles were thoroughly washed with detergent solution, concentrated nitric acid, rinsed with acetone prior to their usage.

2.2. Extraction, Physico-chemical and Gas Chromatographic Analyses of the Seed Oils

The dried seeds of each plant were ground and the oils extracted with n-hexane in triplicates using Soxhlet apparatus according to method described by AOAC (1990) at a temperature of 70 – 80 ^{0}C for 8 hours. The oil was recovered using rotary evaporator. The relative viscosity, specific gravity, pH, acid value, iodine value, and saponification values of the seed oils were determined according to the procedure of AOAC (1990) while the fatty acid methyl esters (FAMEs) were prepared according to the method described by Christie (1982). The FAMEs were injected into Gas Chromatograph (type Hewlett Packed (HP) 6890 Series GC System) equipped with Flame Ionization Detector (FID) under the following conditions: column capillary 30.0m; carrier gas is H_2, flow rate at 50 mL / minute; Column temperature is 190 ^{0}C; injection temperature is 225 ^{0}C and detector temperature is 250 ^{0}C; and the sample size is 1µl. The fatty acids were identified by comparing their retention time with those of known standard fatty acids.

3. Results and Discussion

3.1. Physico-chemical Analysis

Table 1 shows the physico-chemical properties of *Momordica charantia, Citrullus colocynthis* and *Adenopus breviflorus* seed oils. The colours of the seed oils ranged from are orange, yellow and greenish orange respectively, and were without objectionable odour. The colour of *A. breviflorus* seed oil is more pleasing compared to the greenish-yellow colour oil of *Citrullus colocynthis*. The pH values of oils ranged from 6.4, 6.1 and 6.7 respectively implying slightly acidic oil. The specific gravities of samples (0.87, 0.98 and 0. 85) respectively indicate that the oils were less dense than water. The value obtained for *Citrullus colocynthis* (0.984) is close to that of cashew nut oil (0.964) reported by Aremu *et al.*(2006a). The table also revealed that the acid value of *Momordica charantia* seed oil (8.302 mgKOH/g) is twice higher than that of *Adenopus breviflorus* (4.38 mgKOH/g) and *Citrullus colocynthis* (4.47 mgKOH/g). Acid value is used as an important indicator oil quality for edibility and suitability for use in the paint and soap industries (Akumbugwo *et al.,* 2008). The lower the free fatty acids (FFA) value, the better the quality of oils (Hegstead *et al.,* 1993). It therefore implies that the seed oils of *Adenopus breviflorus* and *Citrullus colocynthis* are of better quality than that of *Momordica charantia.* However, the acid value of seed oils in the three plants studied is appreciably higher than *Anarcadium occidentallis* (0.82mg KOH/g) reported by Aremu *et al.,* 2006a). The low acid values obtained for *Adenopus breviflorus* and *Citrullus colocynthis* oils suggests that the oils may be edible while that of *Momordica charantia* seed may be suitable for production of paints, liquid soaps and raw material for biodiesel production etc

The iodine value for *Momordica charantia* oil (103.25 mg iodine/g), *Citrullus colocynthis* (119.29 $\pm$ 0.4 mg iodine/g) and *Adenopus breviflorus* (208.12 $\pm$ 0.02 mg iodine/g) are as shown in Table 1. The iodine value for *Citrullus colocynthis* oil is relatively close to the values of bambara groundnut oils (120.0 – 121.0mg iodine/g) reported by Aremu *et al.,* (2006b). The iodine values in the table also place *Momordica charantia* and *Citrullus colocynthis* oils in the non-drying oil group while *Adenopus breviflorus* in drying oil group since non-drying oils have iodine values in the range of 100 – 140 mg iodine/g. This is also indicative of the presence of at least an unsaturated bond and non-susceptibility to oxidative rancidity (Eka, 1986). Therefore, *Adenopus breviflorus* oil also contains more unsaturated carbon bonds and can be used in oil paint industry. The peroxide values of *Momordica charantia* and *Citrullus colocynthis* oils are shown in Table 1. *Momordica charantia* and *Citrullus colocynthis* values were 8.50 $\pm$ 0.09 Meq/g, 7.90 $\pm$ 0.6 Meq/g, and 3.75 $\pm$ 0.1 Meq/g respectively and are relatively lower than that of *Adenopus breviflorus*. Peroxide value is an indicative of deterioration level of oils (Akumbugwo *et al.,* 2008). Therefore, the shelf-life of *Adenopus breviflorus* oil will be considerably higher than others studied. Since the oils in all the three plants have peroxide values below 10.0 Meq/g, which is the maximum permissible peroxide level of oils (WHO/FAO, 1994), suggests that the oils will have good shelf life (low rancidity) and may be edible.

The saponification value of *Citrullus colocynthis* oil (205.46 mgKOH/g) is relatively higher than *Mormodica charantia* oil (184.08 mgKOH/g) while *Adrenopus breviflorus* oil *(*138.20 mg KOH/g) was comparatively lower. The three saponification values are comparatively lower than some vegetable oils, such as coconut oil (233 mgKOH/g) and palm kernel oil (247 mgKOH/g) reported by Aremu *et al.,* (2006b). Therefore, the value obtained for *C. colocynthis* oil indicated that the oil contained high proportion of lower fatty acids and hence, suggesting its less suitablility for domestic cooking than *M. charantia*. Also *A. breviflorus* oils may be useful as an industrial oil especially in the formulation of hair relaxers, shampoos, liquid soaps and body cream etc. (Pearson, 1976). The higher

percentage oil yield (47.02%) of *M. charantia* compared to both *C. colocynthis* (39.10%) and *A. breviflorus* (34.71%) also draws attention to its application in either food and pharmarceutical (cosmetics) industries.

3.2. Chromatographic Analysis of the Seed Oils for Free Fatty Acid Composition

The results of the chromatographic analysis of the seed oils of *M. charantia, C. colocynthis and A. breviflorus* are presented in Figure 1 and Table 2. Figure 1 showed that seed oils of the three plants consist predominately of unsaturated fatty acids of Carbon-18 such as Linoleic acid (C18:2) followed by Oleic acid (C18:1), and linolenic acid in trace amount while saturated fatty acids such as Palmitic (C16:0) and Stearic (C180) are present in moderate quantities. Other saturated fatty acids (S.F.A) such as Lauric acid (C12:0), Myristics (C14:0), Margaric (C17:0), Arachidic (C20:0), Behenic (C22:0) and monounsaturated fatty acids (M.U.F.A) such as Palmitoleic acid (C16:1) are present in trace amount while others are below detection limit.

However, *M. charantia* is richer in saturated fatty acids than *C. colocynthis* and *A. breviflorus*. *A. breviflorus* oil has higher Linolenic, (C18:3) with 0.72%; the linolenic acid contents of *Citrullus colocynthis* and *Momordica charantia* seed oils are 0.36% and 0.27% respectively. The Linoleic acid (C18:2) values in *A. breviflorus, C. colocynthis* and *M. charantia* are 61.18%, 60.37%, and 56.58% respectively. These values are comparatively higher than the value (39.485%) reported for watermelon by Xiaonan *et al* (2011) also higher than sesame oil (41.3%) reported by Riegel's (1997 and other legumes seed oils reported by Adeyeye *et al*., (1999), Oshodi *et. al.,* (1993) and Southgate, (1985). *A. breviflorus* oil contains Margaric (C17:0) (0.09%) and Arachidic acid (C20:0) (0.11%) while Palmitoleic acid (C16:1) is completely absent. The saturated fatty acids were generally lower than the unsaturated fatty acids even though the Omega-3 is considerably low in all the three plants. However, the Omega-6 (ω6) and Omega-3 (ω3) ratio (ω6/ω3) is appreciably high as against the WHO recommendation value of 10% (WHO/FAO, 1990). The ratio in this study is 20.96%, 17.00% and 84.97% for *Citrullus colocynthis*, *Mormodica charantia* and *Adrenopus breviflorus* oil respectively. The values for *Citrullus colocynthis* and Mormodica *charantia* are lower than 24.52% for soya beans oils and much higher than 0.11% reported for cashew nuts oils by Aremu *et al.,* (2007). The predominance of the unsaturated fatty acids suggests that the seed oils of the three plants may be edible as they may not likely increase the risk of cardiovascular diseases (CVD) while the low level or absence of monounsaturated fatty acids (palmitoleic) suggests that the oils may not be toxic.

4. Conclusions

It is concluded that *A. breviflorus, C. colocynthis* and *M. charantia* plants that grow wildly in many parts of Nigeria could be exploited as a good source of edible oils and for industrial applications. No appreciable difference was observed in the unsaturated fatty acid content of the plants. However, there is the need for further investigation on their palatability, toxicity, cholesterol levels (to reduce the risk of cardiovascular complications) among other edible oil qualities before their consumption could be strongly recommended.

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Annexure

PARAMETERS	*Momordica charantia*	*C. colocynthis*	*A. breviflorus*
Colours	Orange	Greenish-Yellow	Yellow
pH	6.4	6.1	6.7
Specific Gravity (cm^{-3})	0.869 ± 0.1	0.984 ± 0.1	0. 846 ± 0.1
Acid Value (mgKOH/g)	8.302 ± 2.0	4.47 ± 0.02	4.38 ± 0.04
Iodine Value (mg (Iodine/g)	103.25 ± 5.5	119.29 ± 0.4	208.12 ± 0.02
Peroxide Value (Meq/g)	8.50 ± 0.09	7.90 ± 0.6	3.75 ± 0.1
Saponification Value (mg KOH/g)	184.08 ± 0.94	205.46 ± 0.04	138.27 ± 0.06
Free Fatty Acid (as oleic acid) (%)	2.14 ± 0.04	2.82 ± 0.02	2.14 ± 0.08
Yield of Oil (%)	47. 02	39.10	34.71

Table1: Some physico-chemical properties of the seed oils.
Values represent mean ± standard deviation of values obtained from triplicate determinations.

Fatty Acid	*M . charantia* (%)	*C. colocynthis* (%)	*A. breviflorus* (%)
Myristic (C14:0)	0.32	0.19	0.08
Palmitic (C16:0)	11.33	10.91	10.90
Palmitoleic (C16:1)	0.03	0.35	ND
Margaric (C17:0)	ND	ND	0.09
Stearic (C18:0)	13.02	9.66	9.43
Oleic (C18:1 ω9)	18.39	18.47	17.25
Linoleic (C18:2 ω6)	56.58	60.37	61.18
Linolenic (C18:3 ω3)	0.27	0.36	0.72
Arachidic Acid (C20:0)	ND	ND	0.11
Behemic Acid (C22:0)	0.06	ND	0.23
Saturated Fatty Acid (S.F.A.)	25.27	20.76	20.84
Monounsaturated Fatty Acid (M.U.F.A.)	18.42	18.82	17.84
Poly Unsaturated Fatty Acid (P.U.F.A.)	58.85	60.73	61.90
O/L i.e. Oleic/Linoleic ratio	0.33	0.31	0.28
ω6/ ω3	20.956	17.00	84.97

Table 2: Comparison of fatty acids concentration of the seed oils of Mormodica. Charantia, Citrillus. colocynthis and Adenopus breviflorus.
ND: Below detection limit.

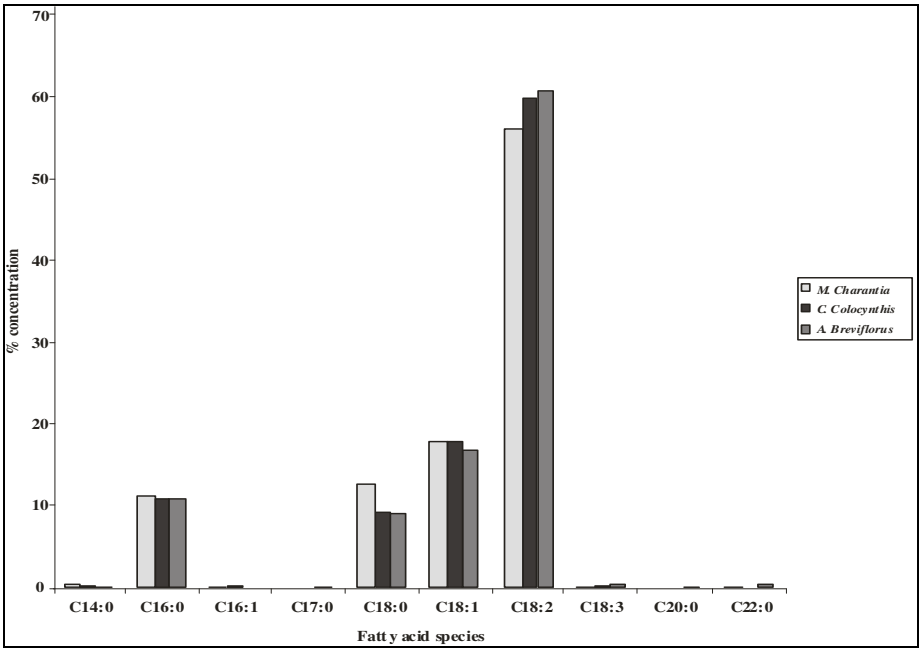

Figure 1: Concentrations of fatty acids in M. charantia, C. colosynthis and A. breviflorus seed oils.