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## Characterization of Isopropanol Extracted Vegetable Oils

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**Abstract:** Samples of crushed seeds and grains of fourteen vegetables—*Zea mays*, *Penisetum americanum*, *Sorghum bicolor*, *Citrullus lanatus*, *Citrullus coloncythis*, *Cocos nucifera*, *Elaeis guineensis*, *Sesame indica*, *Theobroma cacao*, *Arachis hypogea*, *Butyrospermum paradoxum*, *Telefaria occidentalis*, *Mangifera indica* and *Irvingia gabonensis* were extracted for their oils using isopropanol as solvent. The oils obtained were characterized by determining their physicochemical properties. The results obtained were: oil yields (3.7-61.0%); pH (4.00-6.28); specific gravities (0.812-0.965); viscosities (5.52-108.03 Cs); refractive indices (1.435-1.477); acid values (0.66-86.02 mg KOH g<sup>-1</sup> Oil); percentage free fatty acid (0.33-43.27); Saponification value (159.04-289.50 mg KOH g<sup>-1</sup> Oil); ester values (91.65-287.90 mg KOH g<sup>-1</sup> Oil); percent unsaponifiables (0.10-4.90); iodine values (13.5-135.4 WIJ's) and peroxide values (1.7-19.4 mg Eq kg<sup>-1</sup>). These results show that the oils extracted with isopropanol had deep colours and odours and higher % unsaponifiables than oils extracted with regular extraction solvents like hexane and petroleum ether. Isopropanol extracted oils were also more viscous and showed increased stability as observed from longer shelf life and the fact that most of the oils did not have characteristic rancid odours even after storage at average room temperature (28°C) and ambient humidity for six years.

**Key words:** Vegetable oils, isopropanol, characterization, shelf life, stability

### INTRODUCTION

Vegetable oils and fats are useful in foods, pharmaceuticals, toiletries and cosmetics industries. Vegetable oil shelf life has become a major focal point in recent research (Proctor and Bowen, 1996) and any methods of extraction which, increases stability is encouraged.

Solvents used for the extraction of oil from seeds, are non-toxic, easy to remove, not soluble in water and a good solvent for oils. Such solvents must be cheap and non-explosive. It is impossible however, to find a solvent that satisfies all of the above criteria. Hexane the usual solvent for extraction of oil, is substantially free from nitrogen or sulphur containing compounds and unsaturated hydrocarbon and have a residue which is less than 0.001% on evaporation (Bernadin, 1976). It is sufficiently stable to be reused indefinitely in addition it is cheap and available in practically unlimited quantity. The only serious disadvantage is its high flammability. It also extracts only non-polar components of the vegetable leaving the polar ones.

Isopropanol however, would extract some polar and higher molecular weight compounds especially the natural antioxidants and pigments in the seed resulting in

extended shelf life. Isopropanol is also sufficiently harmless in character. It is twice as toxic as ethanol, 4/5 as toxic as n-propanol and only 4/5 as toxic as phenyl methanol. It is also reported in literature (Grant, 1921) that no subsequent blindness or defects occur as a result of its use.

Isopropanol has not been routinely used to extract vegetable oils as hexane though is as good as hexane for extraction of oils. It is in an effort to produce vegetable oils with longer shelf life that isopropanol has been used as solvent in this study. One of the vegetables (*Arachis hypogea*) was also extracted with hexane to serve as a comparison.

### MATERIALS AND METHODS

Specific weights of the particular test sample, was taken and crushed with a mechanical crusher. The sample was then packed into a soxhlet extractor and the oil extracted from it by refluxing for 16 h with hexane or isopropanol. After the extraction process, the solvent was recovered by distillation. Trace solvent was removed by vacuum distillation and the oil allowed to cool in a desiccator and then weighed. Percentage oil was then calculated.

**Physicochemical analysis of oils and fats:** Determination of pH, specific gravity, refractive index, acid value, free fatty acid value, saponification value, % unsaponifiables, iodine value and peroxide values were carried out using standard analytical methods (Paqut and Hautfenne, 1987).

## RESULTS AND DISCUSSION

The percentage oil yield from the oil-bearing seed varied from 3.7-61.0% (Table 1). The least quantity of oil was obtained from white corn and the largest from coconut. This range is in agreement with values obtained by earlier researchers (Kapseu and Parmentier, 1997). On the basis of oil yield most of the vegetables were suitable for industrial applications, as any oil-bearing seeds that can produce up to 30% oil are regarded as suitable (Matchet, 1963). The cake obtained from the extracted samples may be used for agricultural, domestic or industrial purposes, for example the production of groundnut cake a delicacy common in Nigeria, while the cake from corn can be used for laundry starch and that from wild mango can be used as viscosity controller.

The colours of the vegetable oils and fats ranged from colorless to golden brown (Table 1). Colours in the oils/fats are most likely due to the presence of natural pigments like carotenoids, tocopherols and their derivatives (Tooley, 1971). All the vegetable lipids were acidic in nature, with pH ranging from 4.0-6.28 (Table 1). This makes them compatible with the skin's acid mantle, which is about 5.5 (Reiger, 1989), if they were to be used in the cosmetic industry. The vegetable oils have sweet smell, with the exception of sorghum, millet, wild mango and fluted pumpkin seed oils, which had more pronounced organic odours. The presence of some functional groups that may be responsible for these odours, were confirmed by IR absorptions between 700 and 1000  $\text{cm}^{-1}$ .

The specific gravities of the oils varied from 0.812 - 0.965 and the viscosities from 5.52-108.03 Cs (Table 1). As expected the trend observed in viscosities and specific gravities are similar. The increase in specific gravities for some oils is probably as a result of increase in chain length (Christie, 1986). Isopropanol, extracted oil contains more compounds than the hexane-extracted oil as shown by the lower specific gravity of the hexane extracted groundnut oil (Table 1). This trend is expected as isopropanol is more polar than hexane and may have extracted some polar compounds in addition to the usual non polar ones. These polar compounds may be high molecular weight compounds and may be the reason for the increased stability observed in isopropanol extracted oils.

The acid values of the oils are quite low (0.66-16.13 mg KOH  $\text{g}^{-1}$  Oil), with the exception of the value for sheanut fat (86.02 mg KOH  $\text{g}^{-1}$  Oil). In general, this is indicative of the good non-degraded state of the lipids. The higher values observed for sheanut fat (Table 2), may be due to bad seed storage methods as the sheanut was bought from the open market. The acid values obtained for the other oils were within limits for industrially useful oils, and compare favourably with the acid values reported in literature for other hexane-extracted oils (Al-Khalifa, 1996).

The Saponification values ranged from 159.04-289.50 mg KOH  $\text{g}^{-1}$  Oil (Table 2). These values are in agreement with literature values (Omogbai, 1990.). The values are also indicative of good soap forming abilities of some of the lipids. The soap forming abilities are in the decreasing order melon > coconut > water melon > millet > Palm kernel > Hexane extracted groundnut > Isopropanol extracted groundnut > beniseed > yellow corn > white corn > fluted pumpkin > sheanut > sorghum > wild mango > mango.

The ester values indicate the amount of glycerides present in the lipids. These glycerides can be saponified during alkaline hydrolysis of the lipids or they can be used to produce fatty acids during acid hydrolysis. These fatty acids can then be used for various industrial purposes. The glycerides can also act as emollients and help condition the skin when used in skin care products (Gans, 1987).

The unsaponifiable matter content of the lipids are between 4.9% as for sheanut and 0.01% for coconut oil (Table 2). This fraction is a good source of emulsifiers and stabilizers and viscosity controllers for the food, pharmaceutical and cosmetics industries. That the unsaponifiable fraction of an oil, provide essential moisture to the skin, increasing the ratio of soluble to insoluble collagen in the skin (Helme, 1990). The unsaponifiable fractions obtained for most of the isopropanol -extracted oils were higher than those reported in literature for hexane-extracted oils (Cao *et al.*, 1993 ). The lipids with more intense odours appear to have higher % unsaponifiable matter, showing that some of the matter may be of aromatic organic origin (Table 1 and 2).

Iodine values of the lipids are from 13.5-135.4 Wij's (Table 2). White corn oil had the highest iodine value, while coconut oil had the lowest. This shows that iodine value is an indication of the level of unsaturation present in the lipid. Comparing these iodine values, an indication of the expected stability order of the lipids is observed. Oils with higher level of unsaturation will expectedly be involved in chemical reactions that will involve double bonds that are present in the unsaturated fatty acids leading to the formation of polymeric compounds. The lipids examined in this study fell into two groups as

**Table 1: Physical characteristics of the lipids**

Oil/Fat type	% Yield	Colour	pH	Specific gravity	Viscosity (Cs)	Refractive index
White Corn	3.7±0.0	Colourless	5.24±0.0	0.812	5.52±0.05	1.476±0.0
Yellow Corn	3.9±0.1	Golden yellow	5.24±0.0	0.813	5.75±0.01	1.477±0.0
Millet	10.1±0.1	Golden brown	4.15±0.0	0.830	7.79±0.03	1.459±0.0
Sorghum	8.6±0.1	Yellow	4.15±0.3	0.855	13.46±0.03	1.425±0.0
Palm Kerne	38.2±0.1	Yellow	5.00±0.1	0.872	49.82±0.01	1.449±0.1
Coconut	61.0±0.1	Off-White	4.00±0.1	0.881	50.34±0.01	1.448±0.0
Beniseed	45.0±0.0	Yellow	5.20±0.2	0.885	52.50±0.02	1.472±0.0
Groundnut [I]	45.0±0.0	Yellow	6.00±0.0	0.895	93.60±0.02	1.462±0.0
Groundnut [H]	45.0±0.0	Pale yellow	6.00±0.0	0.879	40.36±0.02	1.460±0.0
Cocoa	45.0±0.0	Cream	4.35±0.0	0.886	86.65±0.08	1.454±0.0
Melon	40.0±0.0	Yellow	5.92±0.0	0.897	108.03±0.01	1.462±0.0
Water Melon	45.0±0.0	Pale yellow	5.93±0.0	0.885	52.29±0.01	1.435±0.0
Mango	24.6±0.0	Brown	4.77±0.0	0.965	82.75±0.03	1.469±0.0
WildMango	49.8±0.0	White	6.26±0.0	0.884	10.14±0.06	1.439±0.0
Fluted Pumpkin	34.4±0.1	Brown	6.28±0.0	0.898	15.41±0.05	1.470±0.0
Sheanut	48.6±0.0	Pale yellow	5.65±0.1	0.865	75.43±0.07	1.473±0.0
Paraffin	-	Colourless	7.97±0.0	0.855	10.12±0.02	1.476±0.0

Groundnut[H]–Hexane extracted groundnut oil Groundnut[I] – Isopropanol extracted groundnut oil

**Table 2: Chemical characteristics of the lipids**

Oil/ Fat type	Acid value (mg KOH g <sup>-1</sup> )	%Free fatty acid as oleic	Saponification value (mg KOH g <sup>-1</sup> )	Ester value (mg KOH g <sup>-1</sup> )	% Unsaponifiable	Iodine value (WIJ's)	Peroxide value (mg Eq Kg <sup>-1</sup> )
WhiteCorn	1.60±0.01	0.80±0.05	208.35±0.05	206.75±0.00	0.88±0.05	135.4±0.01	1.7±0.01
Yellow	1.65±0.01	0.83±0.01	208.45±0.01	206.80±0.01	0.93±0.01	135.0±0.01	1.8±0.02
Millet	12.60±0.02	6.34±0.00	253.15±0.05	240.55±0.05	2.62±0.03	105.0±0.05	12.5±0.05
Sorghum	16.13±0.03	8.11±0.01	174.88±0.04	158.78±0.02	2.80±0.01	121.3±0.01	13.2±0.01
Water melon	2.24±0.01	1.13±0.03	264.42±0.02	261.18±0.01	0.82±0.02	112.0±0.01	2.2±0.05
Melon	1.65±0.01	0.83±0.03	289.50±0.01	287.90±0.00	0.64±0.01	113.0±0.01	1.9±0.01
Coconut	1.66±0.01	0.84±0.02	274.34±0.01	272.68±0.02	0.10±0.02	13.5±0.01	1.9±0.02
Palm kernel	0.66±0.02	0.33±0.03	249.96±0.05	249.33±0.01	0.19±0.01	16.4±0.02	
NDCocoa	3.30±0.01	1.66±0.01	186.30±0.01	183.00±0.00	0.30±0.05	20.2±0.05	2.8±0.00
Groundnut I	3.77±0.02	1.90±0.02	246.87±0.02	243.10±0.05	0.37±0.01	98.0±0.05	2.8±0.05
Groundnut H	1.65±0.05	0.83±0.06	247.95±0.03	246.30±0.01	0.27±0.02	100.0±0.05	1.9±0.05
Beniseed	8.25±0.02	4.15±0.05	245.76±0.01	237.51±0.01	1.23±0.05	110.0±0.01	4.2±0.03
Mango	6.73±0.01	3.57±0.01	159.04±0.05	152.31±0.01	1.62±0.02	48.5±0.02	10.2±0.05
Wild mango	11.22±0.02	5.95±0.02	170.26±0.03	159.04±0.05	0.43±0.01	40.3±0.05	13.8±0.05
Fluted pumpkin	184.46±0.05	3.76±0.05	184.46±0.02	176.98±0.03	0.35±0.01	30.2±0.01	12.2±0.03
Sheanut	86.02±0.05	43.27±0.05	177.67±0.03	91.65±0.02	4.90±0.02	35.3±0.02	19.4±0.01

Groundnut[I] – Isopropanol extracted groundnut oil, Groundnut[H] – Hexane extracted groundnut oil, ND – Non detectable

shown by their iodine values, the non-drying oils and the semi-drying oils. The non-drying oils include all the lipids with iodine values from 0-100 and the semi-drying oils include all the lipids with iodine values above 100. The semi-drying oils become more viscous on standing or exposure to air, corn oil became very viscous and gummy by the expiration of the fifth year.

Peroxide values ranged from non-detectable as in palm kernel oil to 19.4 meq kg<sup>-1</sup> Oil as in sheanut. These values indicate that most of the lipids were relatively non-degraded at extraction. The values for mango, wild mango, millet, sorghum, fluted pumpkin and sheanut were relatively high when compared with others. These higher values may be due to bad storage methods adopted in the stores of open markets where the seeds were procured.

The oils were stored in bottles with screw caps and kept at ambient temperature and humidity. After 6 years

the changes observed included slightly paler colours, slight increases in viscosity with exception of corn oil where marked increase in viscosity was observed. Rancid smells were only noticed with this oil and the oil of fluted pumpkin.

In conclusion, the isopropanol extracted oils were shown to be more stable, having extended shelf life (six years) than the usual three years for vegetable oils extracted by other methods (Helme, 1990).

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