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Comparative Analysis of Effect of Alternative Solvents on Extraction of *Moringa oleifera* Seed Oil

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Abstract This paper study Comparative analysis of *Moringa oleifera* seed oil using alternative solvents (Petroleum ether and Acetone). The influence of different conditions and physicochemical parameters using petroleum ether and acetone were analysed statistically. The results of the physicochemical properties for petroleum ether and acetone are as follows; Peroxide value: (1.16 mEq/kg and 0.84 mEq/kg), free fatty Acid value: (1.14 mgKOH/g and 1.08 mgKOH/g), Saponification value: (200.67 mgKOH/g oil and 253.32 mgKOH/g oil), Iodine value: (86.03 mgiodine/100g and 85.35 mgiodine/100g), Specific gravity☹ 0.91 and 0.90) respectively. The coefficient of determination (R^2) value obtained from ANOVA showed that petroleum ether is a good alternative solvent to acetone.

Keywords *Moringa oleifera*, extraction efficiency, seed oil, solvent

1. Introduction

Generally, oils and fats from seeds and nuts constitute an essential part of man's diet. Seed oils and oils of vegetables are receiving growing interest due to their high concentration of bioactive lipid components such as polyunsaturated fatty acids and phytosterols, which have shown various health benefits. Fats and oils, and their several lipid components are extensively used in the food and also in cosmetics, pharmaceutical, oleochemicals and other industries. The production of oil from oilseeds is an important business, and agronomists are continuing to investigate ways to improve the oil output of the seeds as well as ways to control the composition of the oil itself.

Moringa oleifera Lam belongs to a single genus family Moringaceae which has fourteen species [1]. It is known commonly as Ben oil tree or drumstick tree in English language, 'Okwe oyibo' in Igbo, 'Gawara' or 'Habiwal' in Hausa and 'Adagba maloye' or 'Ewe Igbale' in Yoruba grows rapidly in most regions and climatic conditions of Nigeria and many countries in tropical Africa [2].

Moringa seeds are effective against skin-infecting bacteria Staphylococcus aureus and Pseudomonas aeruginosa. The plant seeds contain hypotensive activity, strong antioxidant activity and chelating property against arsenic toxicity [4]. It has an impressive range of medicinal uses with high nutritional value. Mature seeds yield 38–40% edible oil called ben oil from its high concentration of behenic acid. Ben oil is more stable than canola oil, soybean oil, and palm oil when used in frying [5]. Blending Ben oil with sunflower oil and soybean oil enhances the oxidative stability of the mixture. Comparing its chemical properties, Moringa seed oil is considered equivalent to olive oil, and may be used for human consumption. Also, the oil from Moringa seeds has shown the strongest anti-fungal activity against a zoophilic dematophyte caused marked inflammatory reactions in humans [6]. Several groups are trying to obtain biodiesel from vegetable oils, especially *Jatropha curcas*, and from waste cooking-oil. As an alternative source of oil, Moringa seeds have been proposed as a potential source to complement the

mentioned feedstock. The refined oil is clear, odourless and resists rancidity. The seeds oil can also be used as a natural source of behenic acid, which has been used as an oil structuring and solidifying agent in margarine, shortening, and foods containing semi-solid and solid fats, eliminating the need to hydrogenate the oil [6].

A common method used to remove oil from the oil seeds is solvent extraction. Solvent extraction methods use large volumes of solvent and long extraction times to remove the oil from the seeds. Once the oil is removed, the weight percent of oil in the seeds can be determined and the composition of the oils can be studied.

Solvent is the commonly used commercial technique to recover oil from oil seeds. Presently, hexane is the preferred solvent throughout the world due to its extraction efficiency and ease of availability, yet hexane has been categorised as hazardous air pollution (HAP) by the US Environmental Protection Agency and is included in the list of toxic chemicals [7]. The maximum permissible limit for hexane in oil and the meal are 5 ppm and 10 ppm respectively [8]. These problems have attracted researchers to find suitable alternative solvents. This paper compares the effect of petroleum ether and acetone on extraction of *Moringa oleifera* seed oil.

2. Materials and Methods

Sample Preparation

The Moringa seeds used were bought from Gboko in Benue state, and were taken to Chemical Engineering Laboratory, University of Port Harcourt, Rivers state, Nigeria. All the chemicals used in this work were of reagent grade and were sourced from the laboratory, where the extraction is carried out. The Moringa seeds were dehusked and blended. The blended seeds were sieved into the different sample sizes. The weighed samples were then dried.

2.1. Oil Extraction

The oil sample was extracted from the crushed sample by soxhlet extractor using petroleum ether and acetone of analar grade, boiling range, 45-56 ºC for 120 min.

Figure 2.1: Desheled Moringa oleifera

2.2. Determination of Physicochemical Parameters

Several indices are used for the determination of oil quality. For the purpose of this experiment; saponification value, iodine value, specific gravity and peroxide value were determined using the methods of AOAC [9].

3. Results

3.1. Effect of Particle Size on Oil Yield

Particle size is an important parameter in extraction of oil process. Smaller the size of solid particles, the greater the interfacial area between the solid and the liquid and therefore increases the oil extraction yield [10]. The maximum moringa oil extraction of 33.59% was obtained at 0.5mm particle size with 250ml of solvent for 2 hrs. It was observed from table 3.1 that oil extraction yield was gradually increased from 29.12% to 33.59% (for petroleum

ether) and from 28.34% to 31.71% (for acetone) with decrease in particle size from 2mm to 0.5mm. Different researchers have studied the effect of particle size for the extraction of oil from different biomass [11] and has been observed that oil yield increases with decrease in particle size. As the particle size increases, it is difficult for the solvent to reach core of the biomass to leach oil and the oil yield decreases. Figure 3.1 gives a diagrammatical view of particle size vs yield.

Table 3.1: Effect of particle size on oil yield

Particle size	Extraction with Petroleum ether		Extraction with Acetone	
	Mass of oil (g)	% yield	Mass of oil (g)	% yield
0.5 mm	30.23	33.59	28.54	31.71
1 mm	28.12	31.24	27.47	30.52
2 mm	26.21	29.12	25.51	28.34

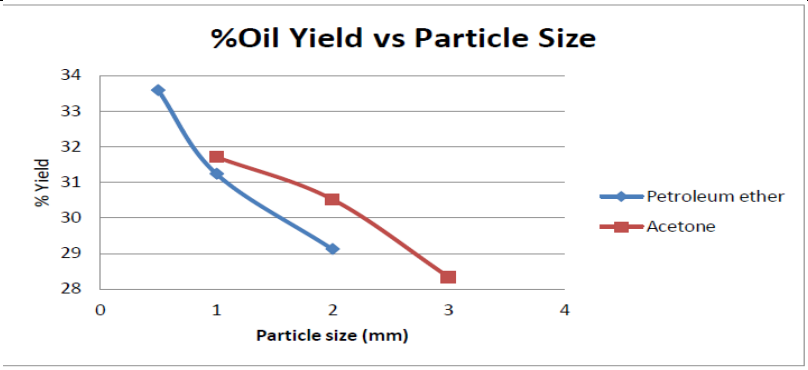

Figure 3.1: Effect of particle size on oil yield

3.2. Effect of Time on Oil Yield

The extraction time is also called residence time or contact time. This is very important in solvent extraction of oil because it helps in choosing the most optimal time of extraction [12]. In this research work, extraction time of 30, 50, 70, 90 and 120 minutes was used. The result is shown in table 3.2 and also presented in figure 3.2.

Table 3.2: Effect of time on oil yield

Time	Extraction with Petroleum ether		Extraction with Acetone	
(min.)	Mass of oil (g)	% yield	Mass of oil (g)	% yield
30	5.26	26.31	5.03	25.16
50	5.90	29.52	5.62	28.10
70	6.27	31.34	5.85	29.25
90	6.64	33.19	6.02	30.10
120	6.76	33.82	6.18	30.91

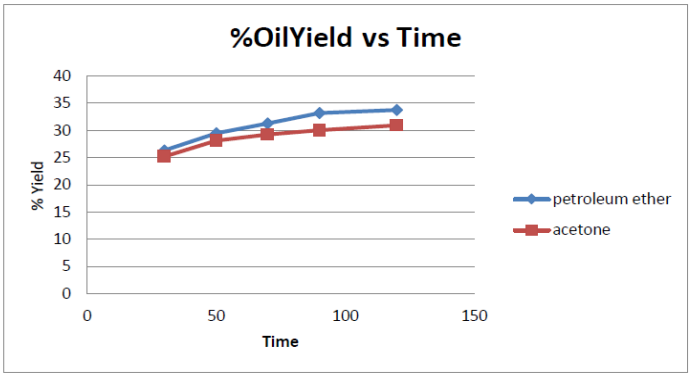

Figure 3.2: Effect of time on oil yield

3.3. Physicochemical Analysis Result of the Oils

Table 3.3: Physicochemical Properties of extracted oil

S/N	Property	petroleum ether	Acetone
1.	Colour	Golden Yellow	Golden Yellow
2.	Specific Gravity	0.91	0.90
3.	Solubility in water	Insoluble in water at room temperature	Insoluble in water at room temperature
4.	Physical State	Liquid at room temperature	Liquid at room temperature
5.	Free Fatty Acid (mgKOH/g)	1.14	1.08
6.	Saponification value (mg KOH/g oil)	200.67	253.32
7.	Peroxide Value(meq/kg)	1.16	0.84
8.	Iodine Value(mg iodine/100g)	86.03	85.35

3.3.1. Peroxide Value

Peroxide value is an indication of level deterioration of oil. It correlates with the extent to which oxidative rancidity has taken place in oil, and thus a measure of the shelf-life of the vegetable oil. The peroxide values were 1.16meq/kg from sample A and 0.84meq/kg from sample B but fell within the literature values 8.1 meq/kg [13] and the standard specifications (10meq/kg) by (FAO/WHO, 2009). In general, as rancidity develops, the peroxide value increases. The lower peroxide values are only indicative of higher stability to oxidation. Therefore, the best oil sample in terms of resistance to rancidity is the oil yield extract using acetone.

3.3.2. Free Fatty Acid Value

The FFA value is a general measure of oil quality. The low values of 1.14 and 1.08 from petroleum ether and acetone respectively shows that the oil is edible. From the results, acetone gave a lower value meaning acetone is a preferably edible oil extracting solvent than petroleum ether.

3.3.3. Saponification Value

Saponification value shows that oil may have a potential for use in soap making and cosmetics industry. The extracted oil saponification values obtained were 200.67mg KOH/g oil from sample A and 253.32mg KOH/g oil from sample B. This result is in agreement with Adejumo *et al*., 2013 [14].

3.3.4. Iodine Value

The iodine values obtained from oil sample A was 86.03mgiodine/100g while that of sample B was 85.35mgiodine/100g. The range of iodine values as quoted in literature are in the range of 65.75-69.45 mgIodine/100g [6, 15], 66.63-72.40 mgIodine/100g [14]. These iodine values gave the indication of high level of unsaturation in the moringa oil samples. The iodine values were slightly higher in oil extracts from sample A than sample B. Higher iodine value of oil may render it unstable, free for oxidation and susceptible to hydrolysis which ultimately results in reduced shelf life of the oil. Since iodine value of the oil was less than 100, it can be classified as a non-drying oil. This means that the oil has a low content of unsaturated fatty acids.

3.4. Statistical Analysis

3.4.1. Effect of Particle Size on the Oil Yield

For the ANOVA result, considering extraction method as a factor of variance in the oil yield. The extraction factor was located in columns of the table. Each treatment, percentage oil yield with petroleum ether and acetone, contained a column of data for the 3 block groups (Particle sizes of 0.5mm, 1mm and 2mm) that were recorded from the experiment. According to the analysis in table 3.4, the F-Statistic, 8.928103 was smaller than the critical F, 18.51282 and our p-value is 0.096127 which was larger than the assumed α (level of significance) of 0.05. Given the results, the null hypothesis was accepted since the oil yield by each of the extraction methods are significantly similar.

Table 3.4: ANOVA: Two-Factor without Replication: Effect of Particle Size on the Oil Yield

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
0.5	2	65.3	32.65	1.7672
1	2	61.76	30.88	0.2592
2	2	57.46	28.73	0.3042
Oil Yield(petroleum ether)	3	93.95	31.31667	4.999633
Oil Yield(Acetone)	3	90.57	30.19	2.9209

ANOVA

Source of Variation	**SS**	**df**	**MS**	**F**	**p-value**	**F crit**
Rows	15.41453	2	7.707267	36.13911	0.026926	19
Columns	1.904067	1	1.904067	8.928103	0.096127	18.51282
Error	0.426533	2	0.213267			
Total	17.74513	5				

A closer examination of the summary statistics in table 3.4 shows that the two averages 31.31667 (oil yield by petroleum ether) and 30.19 (oil yield by acetone) are closer, this casual examination substantiates the results of the Analysis of Variance (ANOVA). On the other hand, considering particle size as a factor in the oil yield analysis, a closer examination of source of variation statistics in table 3.4 shows that the F-Statistic, 36.13911 was much larger than the critical F, 19 and our p-value was 0.026926 which was smaller than the assumed α (level of significance) of 0.05. Given the results, oil yield with respect to particle sizes were significantly different. It evident that the choice of extraction methods compared (petroleum ether and acetone) do not significantly affect the oil yield given different particle sizes.

3.4.2. Effect of Time on the Oil Yield

The extraction factor was located in columns of the table. Each treatment, percentage oil yield with petroleum ether and acetone, contained a column of data for the 5 block groups (time of 30, 50, 70, 90 and 120min) that were recorded from the experiment. According to the analysis in table 3.5, the F-Statistic, 30.34247 was much larger than the critical F, 7.708647 and our p-value was 0.005299 which is smaller than the assumed α (level of significance) of 0.05. Given the results, the null hypothesis is rejected since the oil yield by each of the extraction methods are significantly different.

Table 3.5: ANOVA: Two-Factor without Replication: Effect of Time on Oil Yield

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
30	2	51.47	25.735	0.66125
50	2	57.62	28.81	1.0082
70	2	60.59	30.295	2.18405
90	2	63.29	31.645	4.77405
120	2	64.73	32.365	4.23405
Oil Yield (petroleum ether)	5	154.18	30.836	9.22903
Oil Yield(acetone)	5	143.52	28.704	5.00953

ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*p-value*	*F crit*

Rows	55.4562	4	13.86405	37.01917	0.002039	6.388233
Columns	11.36356	1	11.36356	30.34247	0.005299	7.708647
Error	1.49804	4	0.37451			
Total	68.3178	9				

A closer examination of source of variation statistics in table 3.5 shows that the F-Statistic, 37.01917 is much larger than the critical F, 6.388233 and our p-value is 0.002039 which is smaller than the assumed α (level of significance) of 0.05. Given the results, percentage oil yield with respect to time of extraction are very significantly different. It was deduced that the choice of extraction methods compared (petroleum ether and acetone) significantly affect the oil yield given different extraction times.

Conclusion

Moringa oleifera seed is rich in important food properties compared to some other oil seeds. The parameters studied showed that it is edible and non–drying. Petroleum ether, a green and safe solvent with less hazardous issues than acetone is a better substitute for n-hexane as a solvent for extracting Moringaoil.

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