Optimization of Oil Extraction from *Moringa Olifera* Seed to Ameliorate Oil Consumption Deficiency

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Abstract

The geometric increase in Nigeria's population has placed a high demand on both the domestic and industrial utilization of vegetable oil consumption, so the need to increase the production of quality oil from alternatives sources. Moringa oleifera seed is identified as a source of quality oil; through scholars' investigations into its proximate composition. Premixed on this, the extraction and optimization of oil from Moringa oleifera seeds was ascertained by this work. The dried seeds Moringa oleiofera were grounded into a paste; the solvent extraction method was employed. The experiment was designed in three levels, done in 17 experimental runs, the variable independent factors were; sample weight, extraction time, and solvent volume. The experimental results and values for the optimization of the oil were determined using the Box-Behnken experimental design. The three variables are significant in oil yield obtained in relation to predicted and residual values of Response Surface Methodology (RSM). The predicted value of the RSM was close to the oil yield percentage gotten. The highest oil yield was 37.5 and the predicted was 38.0. The sample weight was 20, solvent volume 150, and time was 45min. The optimum value for yield revealed that the oil was economical and that Moringa oleifera seed oil which is of high quality is good for both domestic and industrial use to ameliorate the deficiency of oil consumption in Nigeria.

Keywords: *Moringa oleifera Seed, Extraction, Optimization, Deficiency, Oil yield,*

1. Introduction

The need for oil consumption has increased in recent times especially in Nigeria where the population is growing exponentially; Nigeria having the height population in the black nation of the world with a growing percentage of 3.02 per annum as estimated by the United Nations estimates of 2009 (Odusina, 2011; National Bureau of Statistics, 2009). This increases pressure and high demand on the uses of vegetable oils, hence the need to take advantage plants/crops that can yield oil to meet the global needs on food and energy (Nielsen, 1994).

Recently, several oil-producing seeds are developed, with many to be discovered, but their chemical compositions are not known, this limits their applications (Adejumo *et al.*, 2013). Therefore, scholars have researched and also researching and developing the identity, characteristic, suitability, extraction, optimization, applicability, and cost-effectiveness on production methods of some these useful vegetable oils (Efeovbokhan *et al.*, 2015). Moringa seed oil is one to be noted among this vegetable seed oil which includes The useful vegetable oils sources are; coconut oil, palm kernel oil, melon oil, groundnut oil, dikanut oil. (Onyeike and Acheru, 2002.)

Moringa oil is derived from the seeds which are removed from the pods harvested from Moringa tree. The trees' origin is traced to the India, precisely; Agra and Oudh which is South of the Himalayas (Mughal *et al.*, 1999; Nielsen, 1994). The Moringa tree has capacity of militating against has weather condition and climate change. It has been reported that the Moringa tree absorbs carbon dioxide (CO2) than the general vegetation in twenty folds. (Aqilah, 2013). This shows that the tree can grow in various parts of Nigeria. It is well adapted and has a vital significant economic importance in nutritional, industrial, and medicinal applications (Kildiran *et al.*, 1996). Every part of the Moringa tree is rich in nutritional values like the leaf, is rich in protein, minerals, β-carotene, and antioxidant compounds are also used in traditional medicine (Leone et al 2015; Leone et al 2015; Leone et al 2016).

The importance of *Moringa oleifera* was noted by Fahey (2001), as having a nutritional value, industrial advantage, medicinal potential, and agricultural advantage. It is potent in preventing diseases like nutrient deficiency, cancer, anemia, it is also use for purification dirty water. Moreover, Moringa oil can replace olive oil because of its nutritional value, it is use in cooking, and for industrial uses, like; biodiesel, cosmetics, topical cleanser, moisturizer for skin and hair, antioxidant, anti-inflammatory (Corey Whelam, 2021) and as lubricant. In addition, its seed cake can be used in wastewater management as coagulant (Ndabigengesere *et al.*, 1998) or as an organic fertilizer (Emmanuel *et al.*, 2011).

About thirteen species Moringa tree is known, out of which *Moringa oleifera* is known to grow fast, easily cultivated, self-propagating, adapt easily to the environment of propagation and very versatile (Mayde, 1986). About 50-70 kg of the pod may be harvested per year. The seed of *M. oleifera* contains edible oil, which can be used as a lubricant for fine machineries, such as timepieces, biodiesels, with a high fatty acid composition and, a notable resistance to oxidative degradation (Leone, 2015).

Moringa Seed contains 25.8% to 31.2% oil, the scholars have revealed the proximate composition of extracted oil, and characterizing its quality through their works. The work of Abiodun et al (2012), on health benefits of Moringa Seed oil had the following results. Moisture content 4.70, acid value 7.09, iodine value 55.02, saponification 180.31, S.G 0.91. And the work of Aquila (2013); *shows* a high yield which is 48 mL (96%) and 45 mL (90%) for alkalis catalyzed transesterification, and acid-catalyzed esterification process, using methanol to have the oil ratio of 18:1, and catalyst concentrations, time reaction, agitation speed, with a fixed temperature at 1wt%, 90 minutes, 200 rpm and 70^{o}C, respectively. Given scholar's works, *Moringa oleifera* oil can be alternative oil for domestic and industrial.

The solvent extraction of oil out of many other methods is faster and less expensive compared especially to the common mechanical extraction process. The choice of using Response Surface Methodology (RSM) to optimize the oil yield is because of its accuracy of approximation and cost-effectiveness in constructing the response surface. A detailed description of the design of experiments theory is found in (Box and Draper., 1987). This work is center on sourcing alternative vegetable oil from moringa seed, using a suitable solvent which is cheaply available in the country to maximize the oil extractions in RSM computation.

2. Materials and Methods

Moringa seeds were collected from villages in Ogbomoso, Okeogun, Oyo, and Ibadan towns of Oyo State. The apparatus used for the experiment are Soxhlet Extractor, Heating Mantle, Blenders, Mouslin Bag, Thermal Willey Mill, Retort stand, Weighing Balance, Stop Watch. Hexane. Iodine Chloride, Phenolphthalein, HCl, KOH, NaOH are the chemicals used.

2.1 Pre-treatment Procedure

The *Maringa oleifera* pods collected were exposed to the sun. The seeds were de-husked manually; chaff and other impurities were separated. The seeds are cleaned thoroughly; oven dried, and milled into a paste using a Thermal Willey Mill. The weight was taken and recorded using an electronic weighing balance.

Fig1. Moringa olifera Fruit

Fig 2 .M. olifera Pods

Fig 3. M.olifera Dried Seeds

Fig 4. M. olifera Dehusked Seed

Fig 5. M. olifer Seed Paste

2.2 Oil Extraction Procedure

The kernel was grounded to a fine paste with an electrical food blender. The moringa seed was measured in grams (g) and inserted in a mouslin bag and placed in a soxhlet extractor. A certain amount of hexane was poured into the sample, solvent time and temperature were taken at the required instance, the mouslin bag was taken out of the extractor and the hexane was allowed to recover through (evaporation and condensation). After recovering the hexane the oil obtained was measured. This was done repeatedly.

The oil yield was calculated as $\left(\frac{w}{w}\right) = \frac{weight\ of\ sample}{weight\ of\ oil} \times 100$………. 1

2.3 Experimental Design for the Extraction of Moringa Seed Oil

Optimization of the moringa seed oil extraction was carried out using the Box-Behnken experimental, by running seventeen experiments with three independent variables which were: sample weight X_1, extraction time X_2, and solvent volume X_3.

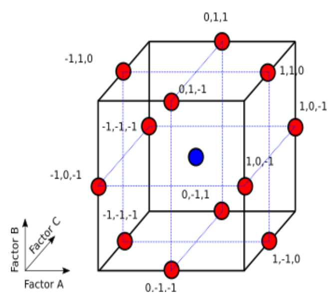

Fig 6: Box-Behnke Extraction Design

3.0 Results and Discussion

3.1 Optimization of *Moringa oliefera* Seed Oil

Box-Behnken experimental design was used in determining the experimental results and values for the optimization of the extracted oil. The experiment was designed in three levels, table 1, also described the three independent variables factors. The response surface is determined by analyzing the data using a polynomial of second-order and applying regression equation as displayed (Oyekunle, 2018; Temitayo, 2017)

$$RF = \mu_o + \mu_1 v_1 + \mu_2 v_2 + \mu_3 v_3 + \mu_1 v_1^2 + \mu_2^2 \gamma_2^2 + \mu_{3_3} \gamma_2^2 + \mu_{1_2} \gamma_1 \gamma_2 + \mu_{1_3} \gamma_1 \gamma_3 + \mu_{2_3} \gamma_2 \gamma_3 \text{ .... } 2$$

Where RF represents the predicted response the intercept term is denoted by the linear coefficients are represented by µ1, µ2, µ3, the interactive coefficients are µ1,2, µ1,3, µ2,3, while the quadratic coefficients are denoted by µ1,1, µ2,2, µ3,3.

Table 1: Factors and their levels for Box-Behnken Design

Factor	Variable	Symbol	Coded factor levels		
			-1	0	+1
A	SW (g)	X_1	20	30	40
B	EXT (min)	X_2	40	45	50
C	SV (ml)	X_3	150	175	200

The experiment had 17 experimental runs and the independent factors were sample weight, extraction time, and solvent volume. The optimum value for yield showed that the oil was economical. The solvent volume, extraction time, and sample weight had an effect on the yield of the oil obtained. Table 2 shows the experimental design for the three independent factors, the percentage oil yield, predicted, and residual values of RSM.

Table 2: Box Benh Experimental Design for Three Independent Factors, Oil Yield, Predicted and Residual Factor for RSM

Run Order	X1	X2	X3	Oil yield	predicted	Residual
1	20	40	175	25.57	25.62	-0.0462
2	40	40	175	30.38	30.31	0.0688
3	20	50	175	26.60	26.60	0.0000
4	40	50	175	37.50	36.88	0.6200
5	20	45	150	37.50	38.07	-0.5737
6	40	45	150	26.60	26.60	0.0000
7	20	45	200	20.73	20.68	0.0463
8	40	45	200	35.47	36.16	-0.6887
9	30	40	150	26.60	26.60	0.0000
10	30	50	150	32.63	32.70	-0.0687
11	30	40	200	30.00	29.43	0.5738
12	30	50	200	35.52	34.83	0.6888
13	30	45	175	26.60	26.60	0.0000
14	30	45	175	40.00	39.36	0.6425
15	30	45	175	35.00	35.64	-0.6425
16	30	45	175	30.00	30.62	-0.6200

17	30	45	175	26.60	26.60	0.0000

The result showed that the predicted value of the RSM was close to the percentage of oil yield gotten. The solvent volume and time had a great effect on the yield of oil obtained. The highest oil yield was 37.5 and the predicted was 38.0. The sample weight was 20, solvent volume 150, and time was 45min.

3.2 Regression Analysis Oil Yield

ANOVA table for RSM shows the analysis of variance of regression. The determination R= 0.9930 and ad R_2 = 0.8877 this indicates that the sample variation was 99.3 for oil extraction can be attributed to the independent variables and 0.07 was not explained by the model

Table 3: Regression Co-efficient and Significance of Response Surface Quadratics

Intercept	26.60	1	0.3031	25.88	27.32	
A-SW (g)	2.49	1	0.2396	1.93	3.06	1.0000
B-EXT (min)	-1.83	1	0.2396	-2.40	-1.26	1.0000
C-SV (ml)	-0.6362	1	0.2396	-1.20	-0.0696	1.0000
AB	0.8725	1	0.3389	0.0712	1.67	1.0000
AC	1.88	1	0.3389	1.07	2.68	1.0000
BC	-4.18	1	0.3389	-4.98	-3.38	1.0000
A^2	8.16	1	0.3303	7.38	8.94	1.01
B^2	-0.1375	1	0.3303	-0.9185	0.6435	1.01
C^2	0.8650	1	0.3303	0.0840	1.65	1.01

Table 4: Analysis of variance (ANOVA) of the regression equation

Source	Sum of Squares	Df	Mean Square	F-value	p-value	
Model	454.69	9	50.52	109.99	< 0.0001	significant
A-SW (g)	49.75	1	49.75	108.31	< 0.0001	
B-EXT min)	26.79	1	26.79	58.33	0.0001	
C-SV (ml)	3.24	1	3.24	7.05	0.0327	
AB	3.05	1	3.05	6.63	0.0368	
AC	14.06	1	14.06	30.62	0.0009	
BC	69.81	1	69.81	151.98	< 0.0001	
A^2	280.36	1	280.36	610.37	< 0.0001	
B^2	0.0796	1	0.0796	0.1733	0.6897	
C^2	3.15	1	3.15	6.86	0.0345	
Residual	3.22	7	0.4593			
Lack of Fit	3.22	3	1.07			
Pure Error	0.0000	4	0.0000			
Cor Total	457.91	16				

The 3D diagrams show the relationship between the independent variables effect of solvent volume, sample weight, and reciprocal interaction on oil yield keeping extraction time at zero the highest oil was observed at the lowest sample weight. This means that the solvent volume is significant in the percentage of oil extracted

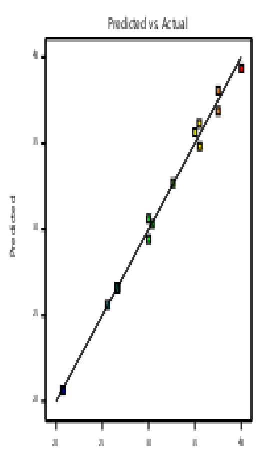

Fig 6. A Graph Showing Predicted and Actual

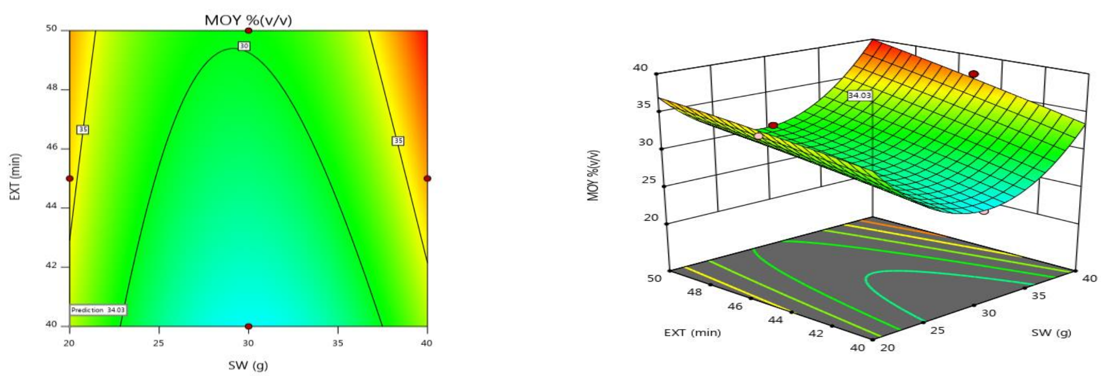

Fig 7: A Graph Showing Predicted and Actual

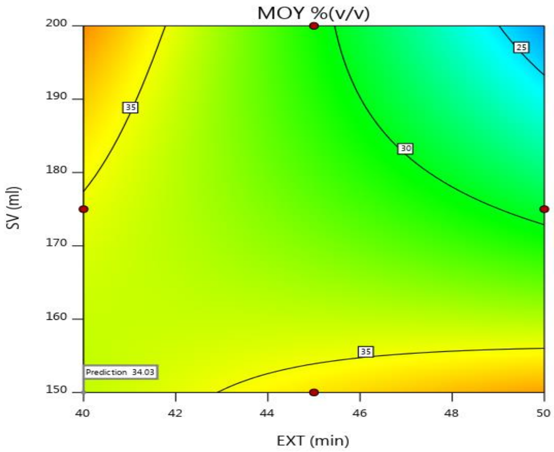

Fig 9: The Graph of Contour and 3D Showing How Extraction Time and Sample Weight Affect the Moringa Oil Yield

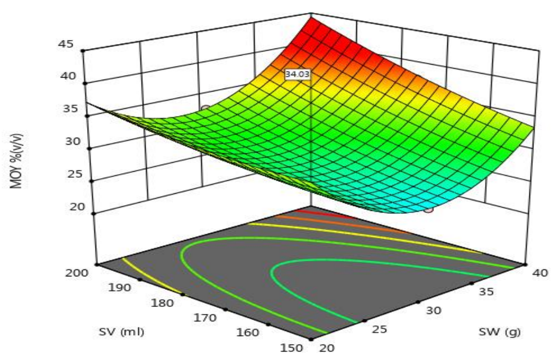

Fig10: A 3D and Contour Graph Showing How Solvent Volume And Extraction Time Affect Moringa Oil Yield.

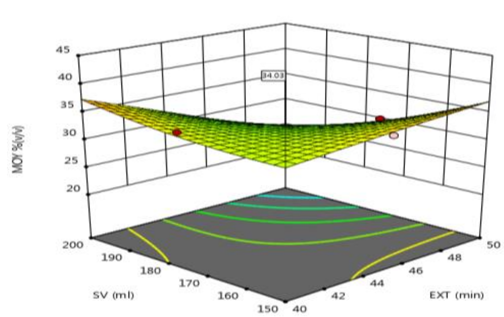

Fig 11: A 3D Graph Showing Solvent Volume and Extraction Time.

4. Conclusion

The extraction of oil from Moringa oleifera seed obtained from Nigeria is carried out. The oil is valuable with a high yield; which remains a good source of rich vegetable oil, which is edible oil, and it is discovered that; solvent volume, sample weight, maintaining the extraction time at zero has reciprocal interaction oil yield; the highest oil was produced at the lowest sample weight. Therefore, *Moringa oleifera* seed oil extracted using solvent and applying RSM is high enough to meet the high demand of domestic and industrial oil utilization in the national growing population, and it can create job opportunities for the unemployed or the underemployed in places where it grows.

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