# Effects of Process Parameters on the Yield of Oil from Melon Seed (*Colocynthis citrullus*).

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## ABSTRACT

The physiochemical properties of melon seed oil were evaluated in this work, using standard analytical techniques. The results showed the percentage (%) moisture, crude lipid, crude protein ash and carbohydrate contents of the melon seed as 11.150, 46.100, 5.650, 15.200, 20.05, respectively. The treatment combinations used (leeching time, leaching temperature and solute: solvent ratio) showed significant differences (P<0.05) in the yield of melon oil seed flour with % oil yield of 41.30-52.99%. Lipid indices of the melon seed oil indicated the acid value (Av) as 1.000mg NaoH/g of oil, free fatty acid (FFA) as 0.500%, saponification valve (sv) as 187.000mg KOH/g of oil, iodine value (IV) as $75.0001_2$/g of oil, peroxide valve as 7.250ml/g of oil, and viscosity as 0.008 cp. A standard statistical package Minitab version 16.0 program was used in the regression analysis and analysis of variance (ANOVA). The statistical software mentioned above was also used to generate various plots such as single effect, interaction plot, contour plot and 3D surface plot. The response or yield of oil extracted from the melon flour was used to develop a mathematical model that correlates the yield of oil. The optimum condition obtained that gave the highest yield of melon oil extracted are leaching time of 2hrs, leaching temperature of $50^0$C or $122^0$F and solute: solvent ratio of 0.05g/ml.

(Keywords: ANOVA, oil extraction, process variables, factorial design, melon seed, proximate analysis.)

## INTRODUCTION

Oils from plant seeds, called vegetable oil are mostly edible and used in food preparations. The nutritive and calorific valves of seeds make them good sources of edible oils and fats diet (Akubugwo et al, 2008, Odoemelam, 2005). Seed oils have extensive demand both for human consumption and for industrial applications (Kyari, 2008) and also have been rated as the second most valuable commodity in the world trade today (Ige et al, 1984).

In oil extraction, many factors influence the yield of oil and these factors include particle size, solute-solvent ratio, leaching time and temperature, agitation of the fluid etc (Coulson, 1991). Melon (*Cococynthis citrullus*, family-Cuclumbitaceae) is a variety of melon seeds grown in India, Africa and part of Asia especially in the drier region. It is a creeping annual plant and an intercropping plant made use in traditional farming practices, thrives well on rich light soil in the hot climate region of Africa (Akpambang et al., 2008). It is popularly called "egusi" in West Africa. It however, has been noted to tolerate low rainfall (Cobley, 1957). In the South-Eastern regions of Nigeria, egusi is best cultivated after the first rains of the year (Ogbonna and Obi, 2000). The first fruits are harvested at about thirteen weeks after planting. The seeds are obtained either in shelled or unshelled forms in West Africa markets and are used greatly in West Africa cookery.

The melon seeds can be milled and used to prepare a popular "egusi" soup where it acts as a food thickener. It can also be fermented to produce "Ogiri" and used as condiments to season or flavor soup (Yusuf et al; 2006; Achinewu, 1987). Melon seeds may also be eaten as snacks, either as whole toasted seeds or as fried cake prepared from milled seeds (Okigbo, 1984; Odunfa, 1981). The seed has a protein content of about 32% and has yield between 110-220kg/ha (Pirie, 1975).

Numerous researchers (Akubugwo et al., 2007; Kyari, 2008; Yusuf et al; 2006; Akpan et al, 1999) among others have carried out a lot of analytical works on seeds primarily because of extensive and increasing demands for them both for human consumption and for numerous industrial applications. The extraction of melon oil from the processed melon flour was done using solid-liquid extraction otherwise known as leaching.

The proximate analysis done on the seed tells its food value and nutritional composition. The raw melon flour (MEF) were subjected to moisture content, crude fat, crude protein, ash content and carbohydrate content as shown in Table 2.

Factorial design was applied to experiment on many factors simultaneously thus providing statistical power to the effect estimates. The objective of this research work is to characterize, extract and study the effects of process variables like (leaching time, leaching temperature and wt. of flour to solvent volume on the yield) Melon oil from its flour. The optimum operating conditions or the extraction of melon oil was also determined and a mathematical model was developed using a standard statistical package Minitab version 16.0 program.

## MATERIALS AND METHODS

### Collection and Processing of Sample

The melon seeds were bought from a shop in Ogbete Main Market in Enugu State. The seeds were taken to the laboratory of Food Science and Technology Department of the Institute of Management and Technology (IMT) Enugu. Standard methods for sample processing, preparation and analytical procedures were used. The melon seeds were hand peeled to remove the husk. Thereafter, the peeled seeds were sundried and milled using machine, wrapped in a polythene bag and kept in a desiccator until needed.

### Proximate and Lipid Indices Analysis

Proximate analysis tells the food value and nutritional composition of the food. Proximate analysis was carried out on the melon seed to determine the percentage moisture, crude fat content, ash, protein lipid and carbohydrate using standard method of analysis. The moisture content of the processed sample was determined by the gravimetric method of AOAC. The crude fat content of the minced sample was extracted by Soxhlet apparatus method as described by (Pearson, 1976, Odo and Ishiwu, 1999). The crude protein was determined by the Kjedahl method, the protein was calculated using the general factor 6.25 (AOAC, 1997). The percentage ash content of the sample was determined gravimetrically by the method of AOAC, while the percentage carbohydrate content was estimated as the nitrogen free extract (NFE) as outlined in AOAC (1997). The results of the proximate analysis are presented in Table 2.

### Physicochemical Analysis of Oil

A standard procedure of the American Oil Chemist Society was used for the lipid indices values. Acid value was determined according to the method outlined in ISO 969.17 and the peroxide value was determined as outlined by AOAC (1997) of the sample. The indicator method was used in determining the saponification value as outlined by (Pearson, 1981). The iodine value was determined by Wij's method as described by (Pearson, 1976, Odo and Ishiwu, 1999). The refractive index of the oil sample was determined using a refractometer according to (Kyari, 2008). The specific gravity of the melon oil sample was described using pycometric method as described (Onwuka, 2005), while the viscosity was determined using a viscometer according to the method outlined by AOAC 1997. The results are shown in Table 1.

## OIL EXTRACTION

The extraction of oil from the processed flour was done using solid-liquid extractor otherwise known as leaching. 2g of the melon flour was dispersed in 40ml of n-hexane and heated for 1hr at $40^0$C to leach out the oil as shown in Table 1 below. The weighed flour sample was dispersed in the given volume of solvent and subjected to the heating temperature and time in a water bath. At the end of the process, the supernatant (oil solvent mixture) was decanted out and centrifuged at 900 rpm for 5 minutes. The clear transparent liquid obtained after centrifuge was then evaporated completely in a hot air oven and the oil was cooled, weighed and the yield calculated. The % oil yield was calculated thus:

$$\% \text{ oil yield} = wt.of\ extracted \frac{oil}{weight of sample} x \frac{100}{1} \quad \textbf{(1)}$$

## EXPERIMENTAL DESIGN

The experiment was designed using Minitab software version 16.0 to determine the influence of leaching time, leaching temperature and solute/solvent ratio as parameters in extraction of oil from the melon seeds. The three parameters were investigated at two levels of (low and high) coded as (-1 and 1). Eight experiments were obtained and the detailed experimental design is presented in Table 4.

**Table 1:** Physicochemical Composition of the Melon Oil Sample.

| Parameters | Melon oil |
|---|---|
| Velocity (V) | 0.008±0.000 |
| AV(mg NaoHg$^{-1}$of oil) | 1.000±0.283 |
| SG | 0.924±0.000 |
| Pv(mlg$^{-1}$of oil) | 7.250±4.243 |
| SV(mg KoHg$^{-1}$of oil) | 187.000±4.243 |
| FFA (%) | 0.500± 0.141 |

Data are means of duplicate determine ±SD
Key: V= viscosity, AV = acid value, SG = specific gravity, PV= peroxide value, SV= saponification value, FFA = free fatty acid.

Table 1 shows the physiochemical composition of the melon oil sample studied. The acid value of the melon oil studied fell within the allowable limits for edible oils (codex Alimentarius Commission, 1982). Therefore the oil is edible and is a good source of raw material for industries. The specific gravity of melon oil obtained is 0.924 and this value compares favorably with 0.920 at 25$^0$C reported by Elert (2000) for specific gravity of plant oil. The Acid value, saponification value, iodine value, specific gravity and viscosity results are compared with ASTM values as shown in table 5 below (Akpan et al., 1999).

**Table 2:** Proximate Composition of Melon Seed Oil.

| Components | Melon (%) |
|---|---|
| Moisture | 11.150±1.630 |
| Fat | 46.100±1.560 |
| Protein | 5.650±0.354 |
| Ash | 15.200±1.131 |
| Carbohydrate | 20.050±1.910 |

Data are means of duplicated determination ± SD

Table 2 above shows the proximate composition of melon seed oil. Results from the present investigation show that the melon seeds are of high nutritional value. The proximate composition being the nutrient composition, show high values of fat, carbohydrate and ash. The ash content exhibiting high value is an indication that the melon seeds are also high in minerals. This is because the minerals are imbedded in the ash and therefore have a positive correlation. Melon seed is a good source of edible oil and fat which when ingested metabolizes to give energy and other fat-soluble vitamins protein content of the seed is 5.650% which is however lower than that obtainable in beans ranged from 7.5% -40% (www.heathaliciousness.com/articles/beans-legomes-highestprotein.php).

## STATISTICAL ANALYSIS OF ACTORS AFFECTING OR YIELD

All extractions and analysis were performed in duplicate. Results were expressed as mean ± standard deviation (SD). The design of experiment selected for this study is two level - three factor factorial design and the response measured is the yield of oil from melon seed flour as outlined by (Mark et al., 2007). The three parameters studies are leaching time, leaching temperature and solute/solvent concentration.

Fishers least significant difference (LSD) was used in identify significant differences among treatment means at P≤0.05 using a statistical package (SPSS version 17.0). Minitab version 16.0 program was used in the regression analysis and analysis of variance (ANOVA). The statistical software mentioned above were also used to generate single effect plots, interaction plots, contour plots and 3D surface plots shown below. The response or yield of oil extracted from the melon flour was used to develop a mathematical model that correlates the yield of oil (i.e., melon to the process variables studies).

$$Y=a+b_1x_1+b_2x_2+b_3x_3+b_{12}+b_{12}+b_{13}x_{13}+b_{23}+x_{23}+b_{123}x_{123} \quad \textbf{(2)}$$

Where Y is the predicted response, a is the value of the fixed response or intercept: $b_1$,$b_2$,$b_3$are the linear coefficients for the input factors $x_1$,$x_2$and $x_3$,$b_{12}$,$b_{13}$,$b_{23}$ and $b_{123}$ are the interaction effect coefficients regression terms, respectively.

## Experimental Design

The experiment was designed using Minitab software version 16.0 to determine the influence of leaching time, leaching temperature and solute/solvent ratio as parameters in extraction of oil from the melon seeds. The three parameters were investigated at two levels of (low and high) coded as (-1 and 1). Eight experiments were obtained and the detailed experimental design is presented in table three below.

**Table 3:** Experimental Design showing the Treatments given to Melon Seed Flour (MEF).

| S/No | Code | $X_1$ | $X_2$ | Solvent (ml) $X_3$ |
|---|---|---|---|---|
| 1 | $MEF_1$ | 1 | 40 | 2:40 |
| 2 | $MEF^2$ | 2 | 50 | 2:40 |
| 3 | $MEF^3$ | 2 | 40 | 2:30 |
| 4 | $MEF^4$ | 2 | 40 | 2:40 |
| 5 | $MEF^5$ | 1 | 50 | 2:30 |
| 6 | $MEF^6$ | 2 | 50 | 2:30 |
| 7 | $MEF^7$ | 1 | 50 | 2:40 |
| 8 | $MEF^8$ | 1 | 40 | 2:30 |

**Table 4:** Yield of Oil from Melon Seeds

| S/No | Sample Treatment | | | % |
|---|---|---|---|---|
| | $X_1$ | $X_2$ | $X_3$ | |
| 1 | 1 | 40 | 40 | 46.03$\pm$0.18 |
| 2 | 1 | 50 | 40 | 47.48$\pm$0.01 |
| 3 | 2 | 40 | 30 | 47.48$\pm$0.11 |
| 4 | 2 | 40 | 40 | 52.43$\pm$0.04 |
| 5 | 1 | 50 | 30 | 46.42$\pm$0.09 |
| 6 | 2 | 50 | 30 | 46.53$\pm$0.04 |
| 7 | 1 | 50 | 40 | 46.48$\pm$0.04 |
| 8 | 1 | 40 | 30 | 41.30$\pm$0.42 |

Data are means of duplicate determination $\pm$ SD

Table 4 shows the result of percentage oil yield from the melon seeds. The melon oil is extracted using different process treatment combinations for the eight samples. For example the oil yield of samples 1 and 2 for melon seed flour differed significantly. The treatments given to samples 2 and 4 for the melon have no significant difference in the oil yield and likewise samples 5 and 6. The percentage of oil yield ranged between 41.30-52.99% as can be observed from table 4 above. Treatments given to samples 2 and 4 exhibited the highest percentage oil yield (42.99 and 52.43%, respectively). The least percentage oil yield of melon flour was observed in sample 8 (41.30%).

## Single Factor Effect

The single effect of treatment combination $x_1$, $x_2$ and $x_3$ on the percentage oil yield is show in Figure 1. The single (one) factor effect shows the interaction of the three process variables studied independently on the yield of oil for melon seeds. It was observed from the plots that there was general increase in the percentage oil yield as the leaching time, leaching temperature and concentration increased, but higher oil yield was observed with leaching time and least with leaching temperature. This could be attributed to the fact that the increment in temperature caused the protein to coagulate at a very fast rate thus reducing the viscosity significantly thereby leading to the release of the oil bond. (www.statease.com).

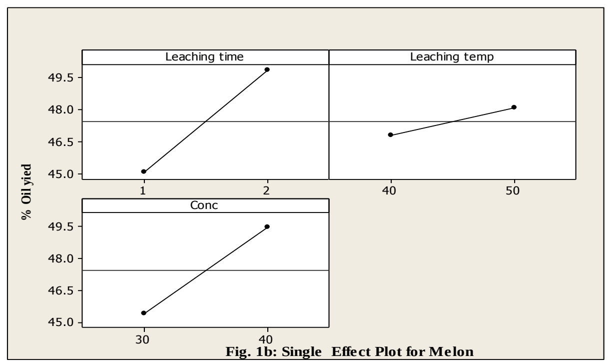


**Figure 1:** Single Effect Plot.

## Effect of Interaction Between Process Variables

The process variables were found to have significant interaction effects. Figure 2 below shows the various interactions of the process variables such as leaching time, leaching temperature and solute/solvent concentrations and their corresponding yields on the melon oil sample. The parameters were operated at two levels of low and high. The black line denotes low (i.e., initial condition), while the red line denotes final condition.

The interaction effect of leaching time versus leaching temperature shows a slight decline in the yield of melon oil at 2 hrs. and at a temperature of 50$^0$C shown by the redline, while the yield of the oil is observed to increase at 1hr and 40$^0$c. The interaction of leaching time against concentration shows that the yield of melon oil at the prevailing condition studied is positive as the parameters are increased from low to high, while the leaching temperature versus concentration as observed from the shows a positive movement which after a period of interaction gave almost the same result or yield of melon oil as can be seen by the convergence of the line plot.

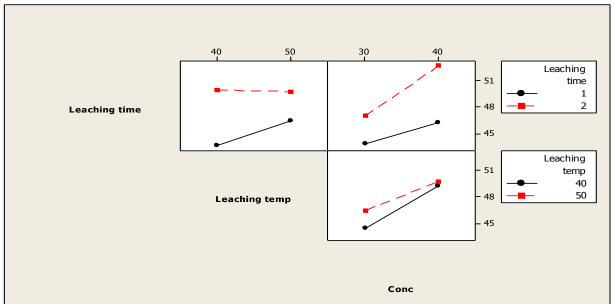


Fig.2b: Interaction Effect of x , x and x on oil yield of Melon seed

**Figure 2:** Interaction Plot.

## Contour Plots of Oil Yield from the Melon Seed

From Figure 3, contour plot of leaching temperature versus concentration for the oil yield of oil from melon seed. It was observed that as concentration increased the yield of oil from the melon seed appreciably increased also. The contour plot of leaching time versus concentration on oil yield from melon seed flour showed a significant increase in the yield of oil from melon seed as the parameters were increased. The contour plot of leaching time versus leaching temperature showed a positive yield of oil from the melon seed as the variable parameters increased from low to high.

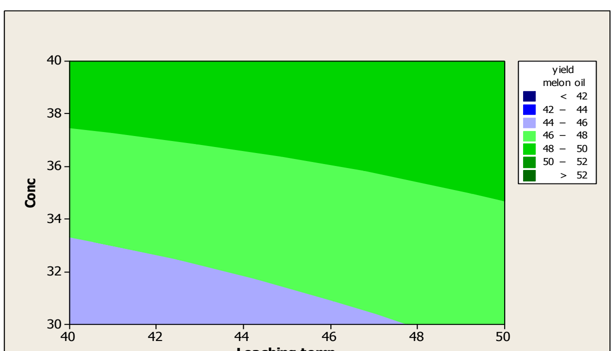


Fig. 4a: Contour plot for oil yield of Melon seed

**Figure 3:** Contour Plot.

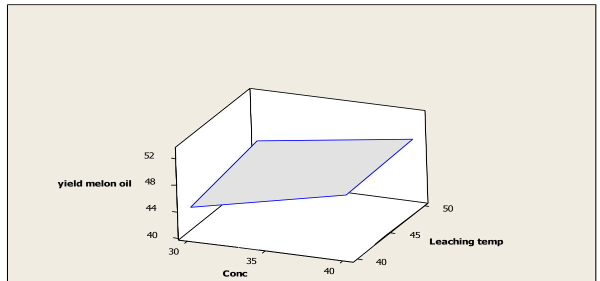


Fig.7a: Surface Plot of oil yield of melon seed

**Figure 4:** Surface Plot Melon Seed.

From Figure 4, surface plots of oil yield from the interactive effects was observed to be the same as that of the contour plot explained above.

## CONCLUSION

The physicochemical properties of the seed, characterization and the effects of the process variables in the melon oil sample were evaluated in this study. The results obtained show the melon seeds to be nutritionally potent with high level of metabolizable energy. Thus, the seed is a good source of food supplement for human nutrition and animal feeds. The seed also show to contain high level of good quality oil whose characteristics compared favorably with most conventional vegetable oils sold in the Nigerian markets. The seed oils had agreeable color and were all liquids at room temperature (25$^0$C).

The study also demonstrated the use of multilevel factorial design using Minitab software version 16.0 in determining the conditions leading to the optimum yield of melon oil extraction. The optimum condition are leaching time of 2hrs, leaching temperature of 50$^0$C and solute: solvent ratio of 2g: 40ml. This methodology could therefore be successfully employed to any process where an analysis of the effects and interaction of many experimental factors are studied.

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