Innovations

# Characterization and Optimization of Soybean Oil from Soybean Seed (Keta and Billo 19) Variety

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***Abstract***

*The objective of this study was extraction, optimization, and physicochemical properties of crude soybean oil (Keta and Billo19)variety and as well as determination of proximate and mineral composition examination of the soybean seed. The soybean seed oil was extracted from (Keta and Billo19)variety using normal hexane by soxhlet device. Concluded the aid of a Design Expert and using the central composite design of the response surface methodology, the experiment was 27 twenty-seven but by composite reduced which has the same value and runs. Using n-hexane as the solvent, each experimental run was accepted out in a 150 ml soxhlet extraction device. The result displayed that the seed keta variety consisted of: (52.35%) and Billo 19 variety consisted 54.23 as the mean value of 53.29 oil yield, the proximate composition value of Keta and Billo19 with the mean value was; moisture (6.342% ), total ash (4.57 %bywt ), crude protein (40.79 %), crude fat (26.175%), crude fiber (4.50 %) and carbohydrate ( 10.63%). Mineral composition analysis of soyabean seed (Keta and Billo19) variety mean value was;- magnesium(432.36mg/100g),sodium (3.4 mg/100g),potassium (24.775 mg/100g),Calcium (429.68ppm),Zink (2.925ppm) and Phosphorus (629.265g/100g). The factors analysis was:- temperature (700C), solvent to solid ratio (10:1), and particle size (0.54mm) obtained from the experiments together with the factors considered during the experiments and the mean value of oil yield was 53.29%. The* *maximum oil yield obtained from the experiment was found to be 53.29 % and the quadratic models developed predicted 58.18%. Then, the request of response surface methodology to optimize oil extraction from soybean seed has been successfully confirmed at optimum parameters: temperature 70, solvent to solid ratio 10, particle size 0.54 was found which is faithfully in convectional with the result attained from the model and the experimental observation and consequently validated the findings of the optimization. Thysicochemical characterization of the soybean oil (Billo19 and Keta)variety was obtained with the mean value was:- acid value (2.914 mg KOH/ g), free fatty acid value (0.2914 %), saponification value (151.01 mg KOH g), iodine value (109.4 g I/100 g), and PH content (4.92%).*

***Keywords:*** *1.Soybean seed oil; 2.Extraction; 3.Physicochemical characterization; 4.Soxhlet extraction; 5.Response surface methodology; 6.oil yield.*

## 1. Introduction

### 1.1 Background of the study

Soybean (Glycine max (L.) Merrill) is a leguminous plant that is most normally grown in the world and it is an important source of protein and fat in the food and animal feed industries and the different literature studied several concepts on soybean seed (R. R. Sharma et al., 2014).Soybean is an important source of proteins (38-42%), lipids (19-22%), minerals (5%), and B vitamins for human nutrition(Bellaloui et al., 2010)**.**In Ethiopia, soybean is being used at industrial level by a very few companies. Defatted soy flour, soybean oil, soymilk, soymilk curd are Annals. Vegetable oil is always at a higher price per ton than the cake, this is because the demand for oil is often higher than the cake. The term oil is used in generic sense to describe all substances that are greasy or oily fluid at room temperature(Audu & Aremu, 2011).

Hexane is extensively used for oil extraction from soybeans and other oilseeds because of its low vaporization temperature, high stability, low a particle size of 2 mm, flake thickness of 0.25 mm, moisture content of 12-13%, temperature of 69°C and the extraction time between 3.5 and 4.5 hrs gave the maximum oil yield. According to Lawson et al., (2011)soybean seed with low oil content are better extracted using the solvent method because the method is characterized by higher oil yield, larger processing capacity and lower refining losses.

Moreover, soybean also contains many other compounds, including minerals, which are beneficial for health and reduce the risk of many diseases (K. Kumar et al., 2014). A study conducted shows that (Lawson et al., 2011) on the parameters affecting the solvent extraction of soybean oil.

Soybean varieties such as Keta and Billo19 are among the varieties developed by Bako Agricultural Research Center, Ethiopia. However, a variety like billo19 is in new variety. In fact, the soybean keta variety can also be reentered to evaluate its performance in terms of its quality. Therefore the present study was carried out with the objective of extraction, optimization and determining the physicochemical properties of the soybean oil.

## 2. Materials and methods

### 2.1 Description of experimental site

The experiment was taken place at Addis Ababa University, (AAU) Food Science and Nutrition Laboratory for oil Extraction and proximate compositions as well as for mineral analysis at JIJE Analytical testing Service Laboratory.

### 2.2 Source of sample

"Keta and Billo19 "varieties of soybean were obtained from Bako Agricultural Research Center Oromia, Ethiopia for the purpose of this study. This research center is located 258 km west of the capital, Addis Ababa, 8 km away from the nearest town, Bako, and 4 km from highway road to Nekemte town, western Ethiopia. The seeds were manually cleaned to remove foreign materials. A factorial experimental design was used in the test of the sample.

### 2.3 Oil extraction using solvent methods by soxhlet apparatus

The solvent extraction was by method as described in (AOAC, 2000b); 920.39)using food grade hexane as solvent. Hexane is extensively used for oil extraction from soybeans and other oilseeds because of its low evaporation temperature, high stability, low corrosiveness and low greasy residual effects (Anil Seth, 2007). In the solvent extraction process, Soxhlet extraction using normal hexane as solvent has been used**.** Extraction using solvent has several advantages. It give higher yield and less turbid oil than mechanical extraction, and relative low operating cost compared with supercritical fluid extraction.

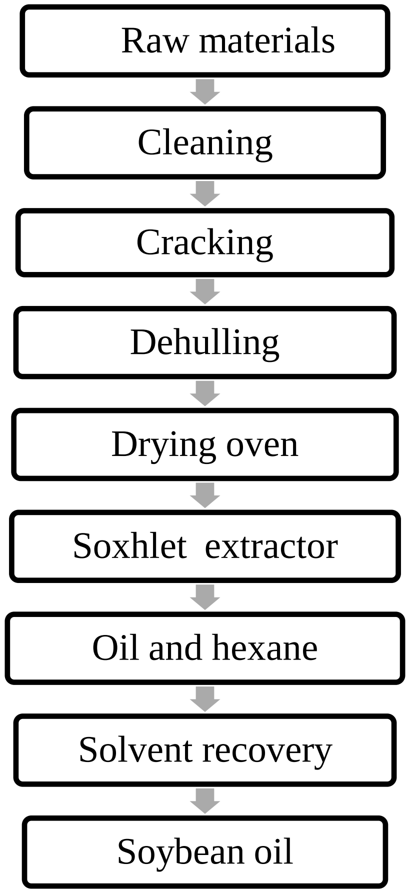


**Figure 1. Processing extraction of soybean oil using solvent extraction methods**

### 2.3.1 Determination the yield of soybean oil extracted

Determination of the yield of soybean oil extracted at the end of each experiment, the yield of the oil was obtained was calculated by the nextfair.

$$percentage\ yeild\ of\ oil = \frac{weight\ of\ oil}{weight\ of\ sample} * 100$$

### 2.4 Optimization of the Process Parameters

The most important parameters affecting the yield and quality of extraction of the seed are: extraction temperature, type of solvent, solvent to solid ratio, particle size of the meal and extraction time. For this thesis work, the effect of three main factors which are temperature, solvent to solid ratio, and particle size were investigated to optimize the extraction operating conditions for achieving maximum oil yield from soybean seed. 50g of grinded powder was extracted with n-hexane. The parameters temperature (65—75$^0$C), solvent to solid ratio (9:1—11:1) and particle size (0.18mm to 0.5mm, 0.9mm on soybean seeds were used for the extraction. At the end of the extraction, the solvent was separated from the oil using rotary evaporator and was collected in the receiving flask. The oil which will be remained in the sample flask has been weighed after the process is completed. The percentage of extracted oil was then calculated by dividing the amount of oil obtained by the amount of the seeds multiplied by 100.

### 2.5 Characterization of physicochemical properties of crude soybean oil

Different physicochemical parameters of edible oil were used to display the compositional quality of oils (Mousavi et al., 2020).

#### 2.5.1 Free Fatty Acid determination

The free fatty acid was determined according to the official methods (AOCS, 2000), Method Number; 920.39). The free fatty acid is the percentage by weight of a specified fatty acid (e.g. % oleic acid) (Zschau, 2000). The percentage of free fatty acid in the oil was calculated as oleic as follows:

$$\text{\% Free fatty acid (\%oleic)} = \frac{V \times N \times 28.2}{Weight\ of\ sample}$$

Where,

V = average volume of NaOH (ml)

N = normality of NaOH (0.1)33

#### 2.5.2Iodine Value determination

Iodine value was determined using method as reported in standard methods (AOAC, 2000)

$$\text{\% Iodine} = \frac{(V2 - V1) \times N \times 12.69}{Weight\ of\ sample}$$

Where,

$V_2$ = Titration of $Na_2S_2O_3$ blank (ml)

$V_1$ = Titration of $Na_2S_2O_3$ sample (ml)

N = Normality of $Na_2S_2O_3$ solution (ml)

#### 2.5.3Peroxide value determination

Peroxide value was evaluated according to (AOCS, 2000).

### 2.5.4 Acid Value determination

The acid value was determined using the procedure recommended by (James, 2013).

$$\text{Acid value} = \frac{A \times B \times (N) \times 56.1}{Weight\ of\ sample}$$

Where:
A = KOH used in titration (ml)
B = KOH used in the blank (ml)
N = normality of KOH

### 2.5.5 Saponification Value determination

The saponification value was determined according to (Akpan et al., 2006)

$$Saponification\ value = \frac{(B-S)\times N\times 65.1}{\text{Weight of sample}}$$

Where;
B = 0.5N HCl required to titrate blank (ml)
S = 0.5N HCl required to titrate sample (ml)
N = normality of HCl solution (ml)

### 2.6. Design of experiments and statistical analysis

In this study, to design the experiments three different factors on soybean oil extraction including temperature, solvent to solid ratio, and particle size was selected as factors. As a response, percentage oil yield was chosen. The Response Surface Methodology (RSM) based on Central Composite Design (CCD) was used to evaluate and optimize the effect of the factors on the response function. The interaction effects, optimal parameters, and the coefficients of the second-order fitting equation were obtained by using Design Expert software. The significance of the independent variables and their relations were tested by means of analysis of variance (ANOVA). The evaluation of relations existing between a collection of controlled experiment factors and measured responses agreeing to one or more selected criteria (Fereidouni et al., 2009)**.**The software design expert (DOE) was working experimental design, data analysis, and analyzing the result of oil extraction phase. The experimental hearings design composed of 18 with3 repetitions. Statistical significance of the typical and model variable was analysis of variance (ANOVA) was used.

**Table 1.Independent variables and their levels used in Central Composite Design (CCD).**

| | Particle size mm | Temperature | Solvent to solid ratio |
|---|---|---|---|
| -1 | 0.18 | 65 | 9 |
| 0 | 0.5 | 70 | 10 |
| +1 | 0.9 | 75 | 11 |

Agree with,(S. Seth et al., 2010)

## 3. Results and discussions

This chapter presents the results and discussions of the oil extraction, optimization, physicochemical analysis of the oil, and the leaching rate of soya bean oil using the solvents, hexane. Comparison of the results with literature is done to point out areas of direct relationship.

### 3.1 Solvent Extraction Using Hexane by soxhlet apparatus from soybean seed

The oil content (dry basis) of the soybean seeds was determined by Soxhlet extraction method. 50 g of the milled seeds, with particle sizes of 0.18-0.9 mm, using standard methods (ASTM E11-13) was covered in filter papers and the oil was extracted using a Soxhlet extractor with n-hexane as the solvent. The solvent to solid ratio was mixed from 9:1-11:1 and the extraction temperature was carried out from 65-75$^0$C. The hexane in the solvent-oil combination was dissolved using a rotary vacuum evaporator and the oil was then collected and weighed.

#### 3.1.1 Percentage of soybean oil yield calculation results

The percentage oil yield (% by weight) was calculated by the following equation and was prepared as follows: calculated using the expression listed below.

$$\%oil\ yield = \frac{mass\ of\ oil}{weight\ of\ sample} * 100$$

% oil yield = 53.29

**Table 2.Factors and oil yield of soybean seed oil extraction results**

| Run | Factor 1 A:temperature ($^0$C) | Factor 2 B:solvent to solid ratio ml/g | Factor 3 C:particle size Mm | Response oil yield Percent % |
|---|---|---|---|---|
| 1 | 65 | 9 | 0.18 | 0 |
| 2 | 70 | 10 | 0.54 | 53.29 |
| 3 | 70 | 11 | 0.54 | 52.35 |
| 4 | 65 | 9 | 0.9 | 0 |
| 5 | 70 | 10 | 0.54 | 53.29 |
| 6 | 70 | 11 | 0.54 | 52.35 |
| 7 | 75 | 9 | 0.9 | 44.03 |
| 8 | 70 | 10 | 0.54 | 53.29 |
| 9 | 75 | 10 | 0.54 | 50.2 |
| 10 | 75 | 11 | 0.18 | 0 |
| 11 | 70 | 9 | 0.54 | 39.4 |
| 12 | 75 | 11 | 0.9 | 50.2 |
| 13 | 75 | 9 | 0.18 | 0 |
| 14 | 65 | 11 | 0.18 | 0 |
| 15 | 70 | 11 | 0.54 | 52.35 |
| 16 | 70 | 10 | 0.18 | 36.4 |
| 17 | 65 | 11 | 0.9 | 0 |
| 18 | 70 | 11 | 0.54 | 50.23 |
| 19 | 65 | 10 | 0.54 | 36.23 |
| 20 | 70 | 10 | 0.9 | 51.2 |

### 3.2 Optimization of solid liquid extraction of soybean seeds

The ability of 'point optimization' was used for all the variables. Table 14 showed the optimum working situations (final goals, high and low limits) of the response (percent oil yield) and factors (temperature, solvent to solid ratio, and particle size) occupied during the optimization analysis. Due to the high cost of manufacture/extraction of oil, extraction of the highest percentage oil yield was maximized while the factors values were set in the range studied. Table 14 presents the optimum situations in uncoded units (temperature, solvent to solid ratio and particle size) which give the highest combination attraction from the Design expert software.

**Table 3.Functioningsituations of response and factors for optimization**

| Variables | Final Goal | Experimental Range | |
|---|---|---|---|
| | | lower limit | higher limit |
| Temperature ($^{0}$C) | In the range | 65 | 75 |
| Solvent to solid ratio (ml/g) | In the range | 9 | 11 |
| Particle size (mm) | In the range | 0.18 | 0.9 |
| % Oil yield | Maximize | 0 | 53.29 |

### 3.3 Effects of individual factors on oil yield

#### 3.3.1 Effect of temperature on oil yield extraction from soybean seed

Temperature is one of the factors that affect the percent yield of soybean oil. The experimental result shows extraction temperature effects greatly the percentage yield of soybean oil using n-hexane as a solvent, shown in Figures 9.Using Soxhlet extraction, the effect of extraction temperature on the amount of extracted oil is significantly at p < o.05(Tesfaye & Tefera, 2017). A range of temperature values from 65$^{0}$C to 75$^{0}$C were used for oil extraction. The maximum oil yield (53.29 % by wt.) was obtained at 70$^{0}$C from Billo19 and Keta soyabean variety. However, the oil yield declines afterwards as most of the solvent had vaporized. By increasing the temperature approaching to the boiling point of the solvent, both the diffusion coefficient and the solubility of the oil in the solvent are enhanced, thus heat treatment improves the extraction soyabean oil (Anastassiades et al., 2003). The higher extraction temperatures the easier to break the molecule inside the seed; as a result, the yield also gets high.

#### 3.3.2 Effect of solvent to solid ratio on oil yield extraction from soybean seed

Increasing solvent to solid ratio up to a specific limit increases the oil yield since the concentration gradient between the solid and the liquid phase becomes greater which favors good mass transfer (Ramanujan& Lao, 2006). Therefore, as the ratio has increased from 9:1 to 11:1, the total amount of extracted oil using hexane. Then based on the results, the solvent to solid ratio of 10:1 was good to extract the maximum amount of oil (53.29 %).

#### 3.3.3 Effect of particle size on oil yield extraction from soybean seed

The extraction was carried out using three different meal sizes namely 0.18mm,0.54mm, 0.9mm. The highest percentage of oil yield was obtained for the particle size of 0.54 mm.

Less oil is extracted from the larger particles > 0.9compared to the smaller size particles. The reason is that larger particles with smaller contact surface areas are more resistant to solvent entrance and oil diffusion. Therefore, less amount of oil will be transferred from inside the larger particles to the surrounding solution in comparison with the smaller ones. Nevertheless, when the particle is too small<0.5, only small amount of oil can be extracted even though the contact surface area for small particle is supposed to be significantly higher than the larger particles. This could have been due to the agglomeration of the fine particles which reduced the effective surface area available for the free flow of solvent to solid,(Vishwanathan et al., 2011).Based on the result, the highest oil yield of Billo19 variety (54.23%) and keta 52.35 was obtained at the mean value of 53.29% and the optimum parameters: particle sizes at 0.54mm,temperature 70$^0$C and solvent to solid ratio10:1 though displays Table 13. This value was agree with previously value(T. Russin et al., 2007).

### 3.4. Statistical data analysis of measureable effects of the factors

### 3.4.1. Effect of temperature and solvent to solid ratio on oil yield from soybean seed

The combined effect of temperature and solvent to solid ratio on percentage oil yield at constant particle size (0.54 mm) is displayed in Figure 2.The percentage of oil yield has been increased as both the temperature and solvent to solid ratio increased. As extraction temperature increased, the diffusivities of the solvent increased, which resulted in higher oil recovery. By increasing the temperature approaching the boiling point of the solvent, both the distribution coefficient and the solubility of the oil in the solvent were possibly improved, thus improved the extraction rate.

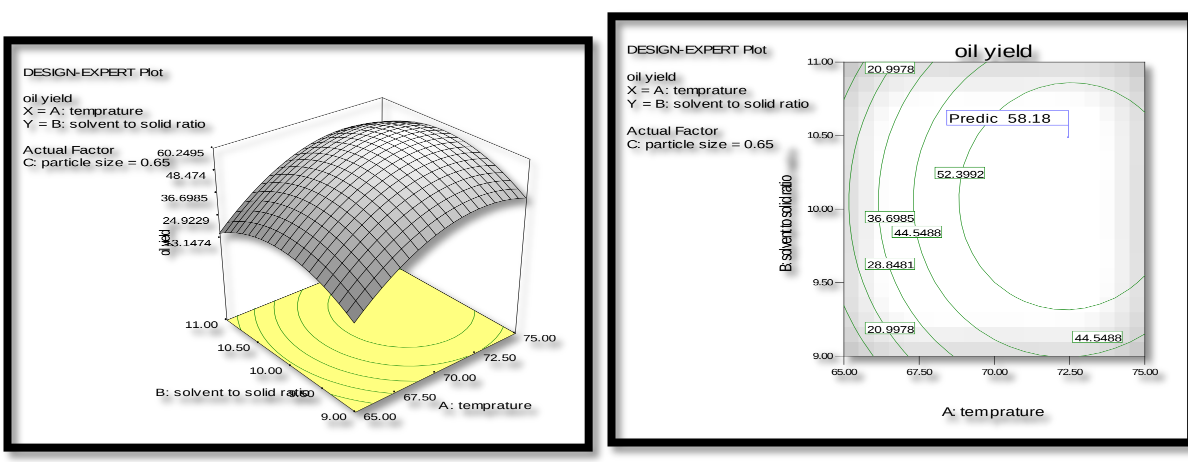


**Figure 2.Response surface plot of temperature and solvent to solid ratio and their interaction effect on the oil yield displaying 3D effect; and Contour plot.**

### 3.4.2 Effect of temperature and particle size on oil yield

The combined consequence of temperature and particle size on the percentage oil yield is presented in Figure 3.As can be seen from the plot (Contour plot), it was observed that, the increase in temperature from 65 to 75$^{0}$C, and an increase of particle size have effect on the extraction oil yield. Then when the temperature increases and the particle size decreases, the oil yield was perceived to increase. But when the temperature increase particle size decrease too small the oil yield was observed decrease.

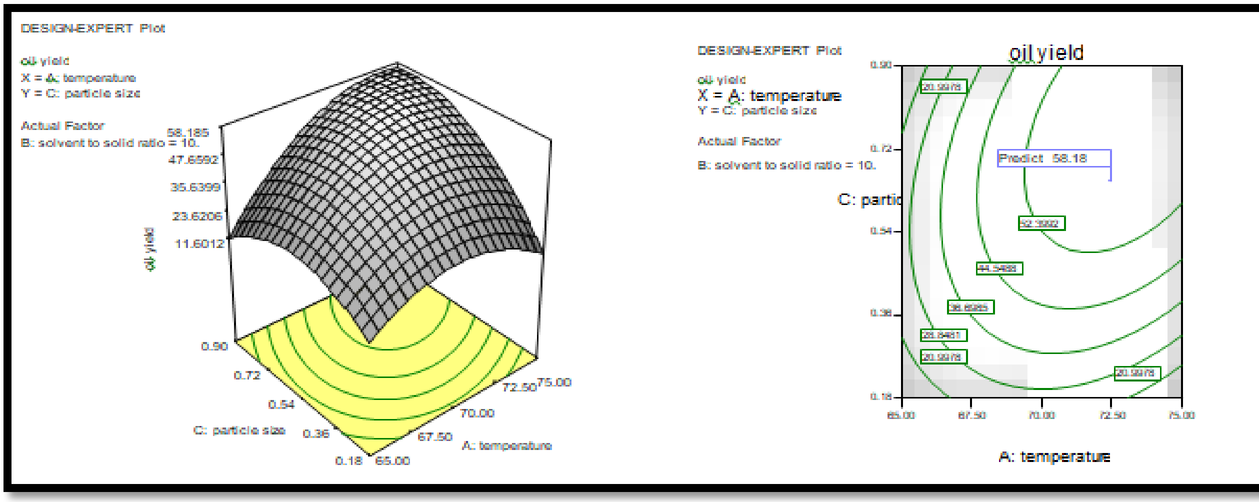


**Figure 3. Response surface plot of temperature and particle size and their interaction effect on the oil yield displaying Left 3D effect; Right Contour plot.**

### 3.4.3 Effect of solvent to solid ratio and particle size on oil yield from soybean seed

The interaction between solvent to solid ratio and particle size on extraction oil was presented in Figure 4. From the plot, it can be seen that as a solvent to solid ratio and particle size increase, the oil yield increases. but, whenever, the amount of solvent to solid ratio and particle size increases much, the oil yield was decreased.

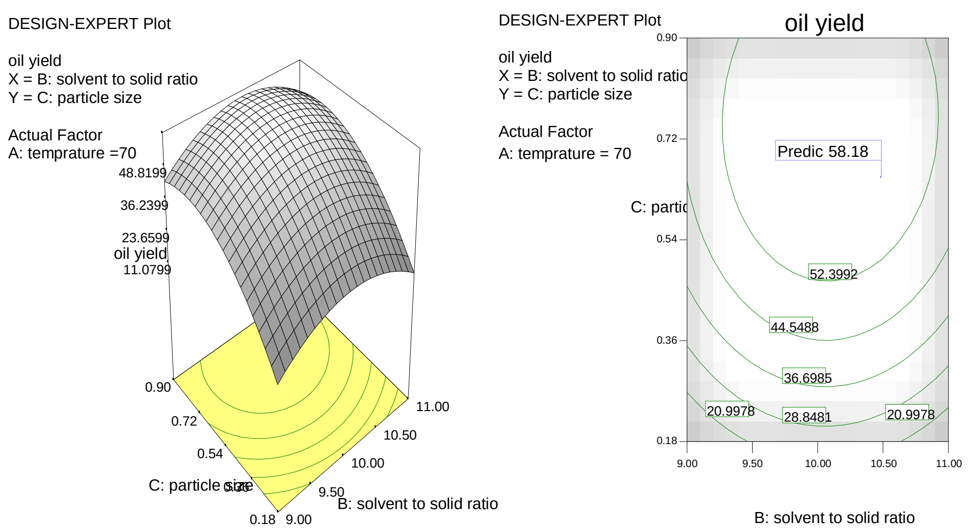


**Figure 4. Response surface plot of solvent to solid ratio and particle size and their interaction effect on the oil yield displaying 3D effect; and Contour plot**

### 3.5 Displaying and model analysis for soybean oil extraction

The design of the experiments carried out in this work was oil yield and its properties are functionally related to the three factors: temperature, solvent to solid ratio, and particle size. The experiments to be carried out were designed with the aid of Design Expert 6.0.8 version using CCD of Response Surface Methodology (RSM). The maximum and the minimum levels used for the factors considered were as given in Table 16. Using the levels of the three factors given in this table, the design of the experiment gave twenty (20) runs to be accepted.

**Table 4.Minimum and maximum levels of the experimental factors**

| Variable | Unit | Minimum | Maximum |
|---|---|---|---|
| Temperature (A) | $^0$C | 65 | 75 |
| Solvent to solid ratio (B) | ml/g | 9 | 11 |
| Particle size (C) | Mm | 0.18 | 0.9 |

The response (% oil yield) was analyzed. According to the CCD of response surface methodology using the three interaction factors which were used for the model generation. The output of different model summary statistics in the table 4 focused on the model maximizing, the Adjusted R- Squared and the Predicted R-Squared values to be large. Therefore, the quadratic model was suggested.

**Table 5.Model Summary Statistics**

| Source | Std.Dev. | R-Squared | Adjusted R-Squared | Predicted R-Squared |
|---|---|---|---|---|
| Linear | 22.06 | 0.2347 | 0.0912 | 0.4804 |
| LFI | 22.65 | 0.3447 | 0.0422 | -4.31 |
| Quadratic | 4.58 | 0.9794 | 0.9609 | 0.8691 |
| Cubic | 4.14 | 0.9899 | 0.968 | -11.4146 |

A second-order quadratic regression was performed to estimate the response function as a second-order polynomial after the examination of the model fit summary revealed that the quadratic model was statistically significant for the response percent oil yield. To perceive the combined effect of the three different independent process parameters on percentage oil yield, 20 experiments were performed. The experimental design was given in Table 5, along with experimental data and predicted responses.

**Table 6.CCD matrixes for the experimental design and predicted responses for % oil yield**

| Run | Factor 1<br>A:temperature<br>℃ | Factor 2<br>B:solvent to solid ratio<br>ml/g | Factor 3<br>C:particlesize<br>Mm | Response<br>oil yield<br>Percent |
|---|---|---|---|---|
| 1 | 65 | 9 | 0.18 | 0 |
| 2 | 70 | 10 | 0.54 | 53.29 |
| 3 | 70 | 11 | 0.54 | 52.35 |
| 4 | 65 | 9 | 0.9 | 0 |
| 5 | 70 | 10 | 0.54 | 53.29 |
| 6 | 70 | 11 | 0.54 | 52.35 |
| 7 | 75 | 9 | 0.9 | 44.03 |
| 8 | 70 | 10 | 0.54 | 53.29 |
| 9 | 75 | 10 | 0.54 | 50.2 |
| 10 | 75 | 11 | 0.18 | 0 |
| 11 | 70 | 9 | 0.54 | 39.4 |
| 12 | 75 | 11 | 0.9 | 50.2 |
| 13 | 75 | 9 | 0.18 | 0 |
| 14 | 65 | 11 | 0.18 | 0 |
| 15 | 70 | 10 | 0.54 | 53.29 |
| 16 | 70 | 10 | 0.18 | 36.4 |
| 17 | 65 | 11 | 0.9 | 0 |
| 18 | 70 | 11 | 0.54 | 50.23 |
| 19 | 65 | 10 | 0.54 | 36.23 |
| 20 | 70 | 10 | 0.9 | 51.2 |

The factors in the model are determined using quadratic regression using ANOVA analysis software. The factors obtained are inserted in the equation. The ANOVA is used to determine the sum of squares, mean square, F-value, p-value, and other relevant parameters. The result obtained from the analysis is presented in Table 6. The Model F-value is 20.20 which implies the model is significant. According to the F-value, there is only a 0.01% chance that a "Model F-value" this great might happen due to noise. Values of "Prob> F" less than 0.0500 indicate model terms are significant. In this case, A, B, C, A2, C2, AB, AC, BC, are significant model terms. According to literature, values greater than 0.1000 decide the model terms are not significant. If there are many insignificant model terms, model reduction may improve your model. The "Lack of Fit F-value" of 0.51 implies the Lack of Fit is not significant relative to the pure error. There is a 78.09% chance that a "Lack of Fit F-value" this large might happen due to noise. Non-significant lack of fit is good we want the model fit.

### 3.6 Physicochemical properties of soybean oil results

The analysis of the physicochemical properties was presented in Table 19. Though, the free fatty acid content value Billo19 and Keta value was 0.32 to 0.31% obtained respectively as the mean value of 0.315% and Standard deviation of 0.0028 which is within the acceptable limits of 0.3-0.7 for crude soyabean oil (Amos-Tautua & Onigbinde, 2013), suggesting the oil's stability and quality. From the results, the iodine value of Billo19 and Keta was 98.2 to 94.56 gI2/100g, obtained respectively as the mean value of 96.38 ml/g and Std. Deviation 1.9798. This value agrees with the expected iodine value range (51-100) for all oils according to AOCS recommended method. A higher iodine value indicates a lower degree of saturation and vice versa. This value could be used to quantify the number of double bonds present in the oil, which signifies the liability of oil to oxidation (Hasan et al., 2016).

The acid value of Billo19 and Keta was 2.912 to 2.916 mg/g and Std. Deviation 0.00283 obtained respectively provides as the mean value 2.9140 revealed Table 19. This value agrees with previously presented (Bellaloui et al., 2010). It was determined the quality of oil information on the quantity, type of glycerides, and mean weights of the acids in a given sample. The acid value is among the characteristics that are necessary for the confirmation of the identity and edibility of the oil. The saponification value of Billo19 and Keta variety was 151.22 to 150.8 mg/g and Std. Deviation 0.296 obtained respectively as the mean value of 151.01 which is agreed in the range previously presented 190.00 mg KOH/g (Oladapo & Awojide, 2015). This value suggests that the sample might be low molecular weight, fatty acid, and triglyceride. The value is close to 197.43 mgKOH/g reported for crude soybean oil by (Ezeokeke & Onuoha, 2016). The larger the saponification number, the better industrial application the soap-making ability of the oil (Martinho& Gomes, 2008). From the analysis showed in table 19. The saponification value gives an indication that the extracted oil sample is not only suitable for the food industry but is also suitable for other industries (e.g. soap manufacture), as it meets the standards of Codex Alimentarius for crude soybean oil.

Unsaponifiable matter value of Billo19 and Keta variety was 8 mg/g to 9mg/g and Std. Deviation obtained respectively at the mean value of 8.5 g/g. This value agrees with the previously estimated range of 8 to 15 mg/g, (Gunstone, 2011). The unsaponifiable matter in this analysis could be linked to the presence of substances like pigments, phosphatides, carbohydrates, gum, and protein contained in the extracted fat without refining. The peroxide value of Billo19 and Keta was 7.61 to 7.56 mg/g and Std. Deviation 0.035 obtained respectively present in Table 19 as the mean value 7.585 (meq/pv/g). The peroxide value indicated that the sample (soybean oil) contains a high level of unsaturated hydrocarbon; however, the peroxide value is in line with the previous study (T. Wang,2011) standard for edible oil. The peroxide value agrees with the previous study of 12.60mg/g (Atinafu & Bedemo, 2011).

The density value of Billo19 and Keta variety was 0.995 to 0.992 to g/ml obtained respectively at the mean value of 0.9935 agree with the previous range of 0.92 to 0.98,(Kyriakidis & Katsiloulis, 2000). The density of seed/vegetable oils is dependent on their fatty acid composition, minor components and temperature (Muhammad et al., 2013). The difference in the density of the reviewed oils may be due to the refined and unrefined characteristics of the oils. The refractive index for the soybean oil was found to be 1.26 to 1.34 at the mean value of 1.30 this value was agree previously presented by 1.46 (Kyriakidis & Katsiloulis, 2000). The values of RI obtained from the soybean oil samples are similar to those of a wide range of vegetable oils. The Refractive index is used mainly to measure the change in unsaturation as the fat or oil is hydrogenated.

**Table 7.Physicochemical properties of soybean oil results for both varieties**

| | Chemical Property | Experimental Value by mg/g | | |
|---|---|---|---|---|
| | | Keta variety | Billo19 | Mean value |
| 1 | Acid value (mg KOH/ g) | 2.912 | 2.916 | 2.9240 |
| 2 | Peroxide value (meq/kg) | 7.56 | 7.61 | 7.585 |
| 3 | Saponification value (mg KOH/ g) | 151.22mgKOH/gmoil | 150.8 | 151.010 |
| 4 | Iodine value (g $I_2$ /100 g) | 98.2 | 94.56 | 96.38 |
| 5 | Unsaponifiable matter | 8 | 9 | 5.075 |
| 6 | PH | 5.40 | 4.45 | 4.925 |
| 7 | Refractive index at $20^0$C | 1.26 | 1.34 | 1.30 |
| 8 | Density (g/ml)at $19.45^0$C | 0.992 | 0.995 | 0.9935 |

## 4. Conclusion and Recommendation

### 4.1 Conclusion

Soybean seed is a good source of oil due to its high percentage of oil yield obtained in the present study. The proximate analysis is a quantitative method used in determining the nutrient content of the soybean seeds.For this analysis, the moisture content, crude protein, crude fat, ash content, crude fiber and carbohydrate were conducted. The moisture content of the soybean seed Keta and Billo variety was (6.342% by wt.)The crude fat content of the seed was found to be relatively high suggesting that the seed is potentially useful as oilseeds .Soybean oil is present in the range of 22.5–27 ml oil/100 g soybean'' and that solvent extraction of soybean seed gave a value of 28 ml oil/100 g soybean. Hexane is a better choice to extract oil from soybean seed due to high purity oil production, easily recover after extraction and high extract capacity. Three main operating parameters affecting the solid liquid extraction of soybean seeds were optimized based on the maximum oil yield extracted from the seeds. The optimum conditions for the lab scale solid liquid extraction were obtained at temperature of 70°C, solid to solvent ratio of 10:1,0.54 mm particle size and hexane as a solvent. Soybean could be considered to be a good source of oil suitable for food formulation as well as pharmaceutical, paint, soap and perfume industries due to its high level of unsaturation in the fatty acid content compared to the other seed oils. Exhausting the indicators collected from solvent oil extraction from soybean with Soxhlet machine, effect of flake moisture content, flake thickness and solvent temperature on oil yield was determined and model equivalence was developed to predict oil yield at a given combination of the process parameters. All the factors under consideration significantly affect oil yield. The interaction between factors did not have a significant effect on oil yield. Highest oil yield was obtained at the highest solvent temperature, lowest particle size and lowest moisture content. The flake thickness has a strong influence on oil yield. The proof results of the developed model displayed that there is good agreement between the predicted and the observed values. It is therefore recommended that the developed model be optimized to establish the optimum values of the evaluated factors. Consequently inexpensive source of macronutrients which can be used in intervention programme aimed at alleviating protein-energy malnutrition. The results of this research represented that the soybeans in Ethiopia, which are not commonly consumed as other legumes, are very nutritious crops, rich in both the studied macro and micro nutrients.

Soybean seeds obtained from BARC are better as the results of proximate composition, mineral composition and physicochemical properties of soybean oil indicated can be used for various food products manufacturing. Soyabean represents an excellent source of high quality protein with a low content in saturated fat, great amount of dietary fibre and minerals. Therefore, the possible use of soyabean in functional food design is very promising, since the consumption of soyabean protein and dietary fibre seems to reduce the risk of cardiovascular diseases and to improve glycemic control. The oil is very rich in unsaturated fatty acids, regulate lipids, cholesterol metabolism and prevent narrowing in the artery/veins (artherosclerosis).

Therefore, the research findings can be used by food companies in recipe development of products. Most studies report that soybean protein can reduce plasma concentrations of total and LDL cholesterol and triglycerides, but does not adversely affect levels of HDL, which has been associated with a decrease in heart disease risk. Other studies hint that soy may have benefits beyond fostering a healthy heart. Data linking soybean oil consumption to a reduced risk of illnesses as diverse as breast cancer, osteoporosis, prostate and colon cancers exists.

### 4.2 Recommendations

Soybean seed make available excessive opportunities for human as an alternative source of energy rising remainders oil. Even though chemical extraction method gives the highest oil yield, the great price of the solvents and the significances of these chemicals to the location make the process less expected to be profitable.

The soybean seed obtainable in BARC was good source of oil and saturated fatty acids the essential fatty acid in soybean seed was Linoleic acid and Linoleic acid. Those Essential fatty acid, recovers heart health. The α-linoleic acid is also an EFA going to ω-3fatty acid family and plays an important role in the regulation of a number of metabolic pathways.

In assessment of the above conclusion the following recommendation are given; Soybean oil improved diet would be refreshed for diabetic individual due to its fibre content. Therefore be engaged for such, the result of physicochemical properties further helping the comfortable of the oil for consumption.

Soyabean could be considered to be a good source of oil suitable for food formulation and industrial application, like medicinal, paint, soap and perfume industries due to its high level of unsaturation in the fatty acid content compared to the other seed oils.

**Conflict of Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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