ETHIOPIAN MANGOES, THE RESOURCEFUL RAW MATERIAL FOR THE MANGO SEED KERNEL OIL PRODUCTION

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ABSTRACT

Oil extracted from the mango seed kernel, one of the byproducts of juice processing industry, have application in the cosmetics industry, due to its antioxidant, skin whitening and anti-wrinkle properties. The main aim of this research is to determine the optimum operating condition for the extraction of oil from the mango seed kernel. A general factorial design was applied to investigate the effect of process variables on the oil yield. The optimum operating conditions for the extraction were a particle size range of 0.25-0.5 mm and extraction time of 6 h. At these conditions, the maximum oil yield with hexane as solvent was 84.81% and the minimum yield was 57.41%. The maximum and minimum yield for the same operating conditions, when petroleum ether was used as solvent was found 83.33% and 61.48%, respectively, while ethanol as solvent results a maximum yield of 57.04% and minimum yield of 23.70%. The physicochemical properties of the mango oil were determined and the results guarantee the use of mango kernel oil for cosmetic application.

Keywords: Extraction, Hexane, Mango seed kernel, Oil, Petroleum Ether, Yield.

INTRODUCTION

Natural oils are used in a wide variety of cosmetic products including personal care as well as makeover products. They consist of ethereal salts of glycerin with a large number of organic acids such as citric acid, oleic acid, and palmitic acid. They are excellent emollients and are derived from a variety of plants [1]. Food and Drug Administration (FDA) defines cosmetics as intended to be applied to the human body for cleansing, beautifying, promoting attractiveness, or altering the appearance without affecting the body's structure or functions [2]. The total value of the cosmetics market in Ethiopia reached $25milion up to June 2012, according to figures from the country's Ministry of Trade and Industry, with the average growth rate over the last three years at 10%. Imported products account for around 90% of the market, with the remaining 10% sourced from domestic manufacturers. Mango seed kernel oil has been used as an ingredient in soaps, shampoos and lotions as it is a good source of phenolic compounds [3]. Presence of high unsaponifiable matter guarantees the use of mango kernel oil in cosmetics industry [4]. It also has a protective effect against the harmful UV radiations [5].

The high content of stearic acid allows its application as a preservative. Hence, it has wide applications, especially in the stearin manufacturing, confectionery and soap industry [6]. To start with the study, the world's top ten mango producers with their main varieties were identified and provided in Table.1. In the context of Ethiopia, mango is produced in the southern and western parts of the country. The total production of mango in Ethiopia is 72,187 tons in 2013/14 [8]. This accounts for 7219 tons of mango seed kernel, annually. The production of mango at Arba Minch and Zuria Woreda is 126,800 qt with total area coverage of 634 hectares. Mango farmsteads in Asossa produce an average of 13,500 mangoes per farmstead [9].

Table 1. World's top ten mango producers, 2015 [7]

No.	Country	Variety	Production (tons/year)
1	India	Alphonso, Badami, Chaunsa, Dasheri, Kesar, Jauhari, Lucknowi, Fazli, Totapuri, Banganapalli, Sindhuri, Kalmi, Neelam, Langra	16,337,400
2	China	Zillate, Mallika, Deshehari,Edward, Saigon, R2E2, Spooner, Bambaroo	4,351,593
3	Thailand	Brahm Kai Meu	2,550,600
4	Pakistan	Anwar Ratol, Langra , Sindhri, Chaunsa, Fajri, Samar Bahist, Dasehri, Saroli	1784,300
5	Mexico	Ataulfo, Haden, Tommy Atkins, Kent, Keitt	1,632,650
6	Indonesia	Arumanis, Gedong	1,313,540
7	Brazil	Espada, Rosa, Bourbon, Uba	1,188,910
8	Bangladesh	Gopalbhog, Himsagar, Khirsapat, Langra, Fasli, Ashwina, Amropali	1,047,850
9	Philippine	Champagne mangoes	823,576
10	Nigeria	Kerosene, Sherri	790,200

The Ethiopian government has a plan to expand mango production by distributing high yielding varieties for small scale farmers, especially, in the Southern region and Oromia region, by grafting mangos of known and high yielding varieties. In Ethiopia, there are many large and small scale mango juices processing industry [10]. During mango processing, peel and kernel constitute about 17-22% of the fruit. The production of oil from the mango seed kernel could be an efficient method of utilizing the waste seed kernels. The operating conditions, including the particle size, extraction time, and solvent type, solid to solvent ratio, temperature and moisture content were proved to have an effect on the oil yield. This research aims to find optimum operating conditions to maximize the oil yield for the production of oil from the mango seed kernel.

MATERIALS AND METHODS

Materials

Asossa mango varieties were purchased from Kenuma and Akea juice processing house, Addis Ababa. Hexane, Petroleum ether, Ethanol, Sodium hydroxide, potassium hydroxide, hydrochloric acid, Folin Ciocalteu reagent, Gallic acid, Sodium carbonate, acetone, and phenolphthalein were procured from Merck, Germany.

Deseeding and processing

The mangoes were peeled and deseeded. The seeds were sun dried for five days. The hard cover of the seed was decorticated manually to obtain the seed kernel. The seed kernel was dried in the oven at 50°C for 18 h. The dried mango seed kernel was milled in centrifugal miller with a sieve size of 4 mm. Then the sample was sieved using a vibrating shaker for 15 min.

Moisture content of the kernel

Seven samples of the kernel were randomly weighed and dried in an oven at 105°C and the weight was measured every 2 h. The procedure was repeated until a constant weight was obtained. The percentage moisture content of the kernel was calculated using the following formula.

$$Moisture\ content\ (\%) = \frac{w1 - w2}{w1} \text{ x } 100 \qquad (1)$$

w1 and w2 are the weight of the sample before drying and after drying respectively.

Mango oil extraction

The experimental work was conducted using soxhlet extractor in triplicate with three different solvents: hexane, petroleum ether and ethanol. 75 g mango seed kernel at three different particle sizes (3-1.5mm, 1.5-0.5mm and 0.5-0.25mm) were extracted using Soxhlet extracter with 300 mL solvents with varying treatment times (2 h, 4 h and 6 h).

The resulting extracts, were purified by simple distillation. The obtained fractions were weighed and physicochemical properties determined. Mango seed kernel had an oil content of 12%. Hence this was used for the calculation of yield. The percentage yield was calculated as follows

$$\%\ Oil\ yield = \frac{(Mass\ of\ oil)x100}{(0.12 \times Mass\ of\ the\ sample)} \quad (2)$$

$$\%\ Extraction\ yield = \frac{(Mass\ of\ oil)x100}{(Mass\ of\ the\ sample)} \quad (3)$$

Physical and chemical characterization

Physical properties including the moisture content, volatile matter, specific gravity, viscosity, pH value, refractive index and chemical properties including the saponification value, un saponifiable matter, iodine value, acid value, peroxide value and total phenolic content were determined.

Moisture and volatile matter of oil

5 g of oil was weighed and dried in an oven at 105 °C for 1 h. The dish was removed from the oven, cooled in a dissector and weighed. The process was repeated until a constant weight was observed. The moisture and volatile matter was calculated using the following formula.

$$Moisture\ and\ volatile\ matter = \frac{W1}{W}x100 \qquad (4)$$

Where w1 and w, are the reduction in the weight of the dried sample and the initial weight of the sample in g.

Specific gravity

The density of oil was determined using a specific gravity bottle. A clean and dry density bottle of 25 mL capacity at 30°C was weighed, filled with water and extracted oil, separately and weighed again. The specific gravity was calculated using the following formula.

$$Specific\ gravity\ at\ 30℃ = \frac{(A - B)}{(C - B)} \qquad (5)$$

Where A, B and C are the weights of the specific gravity bottle with oil, empty specific gravity bottle and empty specific gravity bottle with water at 30°C.

Kinematic viscosity

Kinematic viscosity of the oil was measured using Vibro viscometer. 35 mL oil sample was heated to 30°C and fed to the sample holder. The sensor of the viscometer was immersed into the oil, which measures the dynamic viscosity of oil. The kinematic viscosity is calculated using

$$\nu = \frac{\mu}{\rho} \qquad (6)$$

Where, μ and ρ are the dynamic viscosity and density of oil respectively.

Determination of pH

2 g of the oil sample was added to 25 mL beaker and 13 mL of hot distilled water was added to the sample in the beaker and stirred slowly. It was cooled in a cold water bath to 25°C. The pH electrode was standardized with a buffer solution and immersed into the sample [11].

Saponification value

2 g of sample was added to 250 mL flask. 25 mL of alcoholic potassium hydroxide solution was added and the flask was connected to reflux condenser, kept on the water bath and boiled gently for 1 h. After cooling, the condenser was washed with 10 mL of hot ethyl alcohol. Few drops of phenolphthalein indictor were added and excess potassium hydroxide was titrated with 0.5 N HCl until the disappearance of the pink color [12]. The saponification value, expressed as the number of milligrams of KOH required to saponify 1 g of fat is calculated using

$$Saponification\ value = \frac{56.1(B-S)N}{W} \qquad (7)$$

Where, B, S, N, W are the volume of standard hydrochloric acid required for the blank, volume of standard hydrochloric acid required for the sample in mL, normality of hydrochloric acid and weight of oil taken initially in g respectively.

Unsaponifiable matter

5 g of the sample was added to 250 mL conical flask. 50 mL of alcoholic potassium hydroxide solution was added and the content was boiled under a reflux condenser for 1 h. The condenser was washed with 10 mL of ethyl alcohol. The saponified mixture was transferred to separating funnel and allowed to cool until 25°C.

After the addition of 50 mL of petroleum ether, the separating funnel was shaken vigorously, to allow the layers to separate. The lower soap layer was transferred into another separating funnel and the extraction was repeated three times using 50 mL portion of petroleum ether. To insure the ether extract was free of alkali, the combined ether extract was washed three times with 50 mL aqueous alcohol followed by 25 mL distilled water. The ether solution was transferred to 250 Ml beaker and the ether was evaporated. When all the ether is evaporated, 3 mL of acetone was added, followed by drying at 100°C for 30 min [12]. The residue was dissolved in 50 mL of warm ethanol and titrated with 0.02 N sodium hydroxide. The amount of unsaponifiable matter was determined as follows,

$$Unsaponifiable\ matter = \frac{100(A-B)}{W} \qquad (8)$$

$$where, \qquad B = 0.282VN$$

Where, A, B, N,V, W are the weight of the residue, weight of free fatty acids in the extract as oleic acid in g, normality of standard sodium hydroxide solution, volume of standard sodium hydroxide solution in mL and initial weight of the sample in g.

Acid value

2.510 g of the sample was added to 250 mL conical flask and 50 mL of hot ethyl alcohol was added. A few drops of phenolphthalein was added to the mixture and boiled for 5 min and titrated with 0.5 N sodium hydroxide solutions.

$$Acid\ value = \frac{56.1VN}{W} \qquad (9)$$

Where, V, N, W are the volume of standard sodium hydroxide solution in mL, Normality of sodium hydroxide solution, and initial weight of sample in g. The free fatty acid can be calculated as follows

$$Percent\ free\ fatty\ acid\ = \frac{AV}{1.99} \qquad (10)$$

Total phenolic content

The phenolic compounds concentration in mango seed kernel oil ethanoic, hexanoic, and petroleum ether extracts was determined using Folin Ciocalteu method [13]. 0.4 mL of mango kernel oil were mixed with 2 mL of 10% Folin ciocalteu reagent and 1.6 mL of 7.5% Na_2CO_3 and left in a dark room for 30 min and measured spectrophotometrically at 965 nm. A blank sample consisting of water and reagent was used as a reference. The results were expressed as mg of galic acid equivalents per g the sample (mg GAE/g sample) by reference to galic acid calibration curve. Total phenolic content (TPC) expressed as mg of galic acid equivalent per g of sample is calculated using Equation 11.

$$TPC = \frac{CV}{M} \qquad (11)$$

Where, C, V and M are the concentration of the oil sample in garlic acid equivalent, volume of oil sample and mass of the sample respectively.

Peroxide value, iodine value and refractive index

The Peroxide value, iodine value and refractive index value of the sample was determined at JIJE Analytical testing service laboratory [12].

Experimental design

Regression model were established for the dependent variables to fit the experimental data for the response using Design expert 7.0.0 software.

Table 2. Factors and corresponding ranges and levels

Factors	Levels		
	Low (-1)	Medium (0)	High (+1)
A:Particle size(mm)	0.25-0.5	0.5-1.5	1.5-3.0
B:Time (h)	2	4	6
C: Solvent	Hexane	Ethanol	Petroleum ether

Factorial design is used to test the effect of each factor. (Table 2) In the factorial experiments all the possible combinations of the factor levels were tested [14]. The analysis has performed by Design Expert software using the general factorial design method [15].

RESULTS AND DISCUSSION

Moisture content of the seed kernel

The moisture content of the seed kernel with 11.6, 16.2, 10.5, 10.4, 9.5, 4.9, and 3.5 g was 46.6, 46.9, 49.0, 47.6, 52.6, 51.0 and 51.4 %, respectively. The mean plus the standard deviation of the seven samples gives 49.3% ± 2.47.

Yield of Extraction

The oil extraction was carried out in a Soxhlet apparatus using three different solvents (Fig.1). The oil yield and extraction yield were calculated and summarized in Table 3.

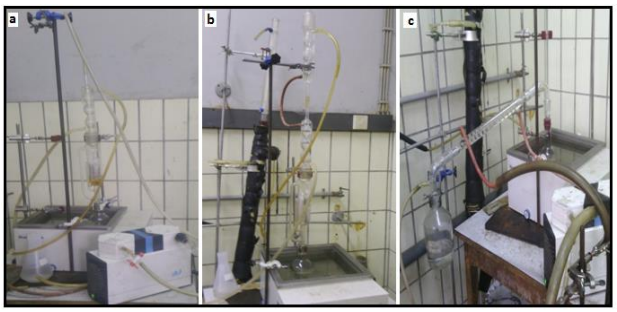

Fig.1. Apparatus for Extraction (a) Hexane and Ethanol (b) Petroleum ether (c) Apparatus for oil separation and purification

Maximum percentage oil yield was 84.81±1.7 (equivalent to 10.18±0.2 percentage extraction yield) for the particle size range of 0.25-0.5 mm, extraction time of 6 h and hexane as the solvent. Minimum percentage oil yield was 18.89±1.11 (equivalent to 2.27±0.13 percentage extraction yield) for the particle size range of 0.5-1.5 mm, extraction time 2 h and ethanol as solvent. Previous reports presented an extraction yield of 8.46±0.1% (equivalent to 70.5±0.83 % oil yield)

[16] with hexane as a solvent for an extraction time of 6 h. Saipraha and Goswami-Giri, 2011 [17] reported an yield of 10.2% (85% oil yield) using hexane as solvent and with extraction time of 5 h.

Effect of process parameters on percentage oil yield

The effect of particle size on oil yield for hexane as a solvent is shown in Fig. 2a. The particle size plays a great role on yield of mango seed kernel oil.The percentage oil yield was inversely related to the particle size i.e smaller particle size gave a high yield while larger particle size resulted in a lower yield. For 2 h, 4 h and 6 h, as a particle size decreases, the oil yield increases from 42.22% to 57.41%, 45.57% to 82.22% and 64.07% to 84.81% for the particle sizes in the range 0.25-0.50, 0.50-1.50, 1.50-3.0 respectively [18]. However, when the particle size is too small or very fine the oil yield decreases even though, the surface area of contact is increased. The reason may be due to agglomeration of fine particle which reduces the contact surface area. Effect of extraction time on percentage oil yield is shown in Fig 2b. The percentage oil yield was directly related to extraction time. The yield increased as extraction time increased. A similar kind of trend was reported earlier [19]. The oil yield increased by 24.81% as the extraction time increased from 2 h to 4 h and it increased by 2.59%, as the time increased from 4 h to 6 h. However, for larger particle size, the yield was lower at the beginning of the extraction and increased gradually as the extraction time increased. The yield increased by 3.35% as the time increased from 2 h to 4 h and by 18.50% as the extraction time increased from 4 h to 6 h. Maximum oil yield is obtained at lower particle size. And the optimum extraction time is 4 h, since 97% of the maximum yield was obtained at this time. The effect of solvent type on percentage oil yield is shown in the Fig. 2c. The maximum oil yield was obtained when hexane is used as a solvent. However, for larger particle size, the yield was lower at the beginning of the extraction and increased gradually as the extraction time increased. The yield increased by 3.35% as the time increased from 2 h to 4 h and by 18.50% as the extraction time increased from 4 h to 6 h. Maximum oil yield is obtained at lower particle size. And the optimum extraction time is 4 h, since 97% of the maximum yield was obtained at this time. The effect of solvent type on percentage oil yield is shown in the Fig. 2c. The maximum oil yield was obtained when hexane is used as a solvent.

The maximum oil yield was 84.81% at extraction time of 6 h and the minimum yield was 57.41% at extraction time. The maximum and minimum yield for the same operating conditions, when petroleum ether was used as solvent was found 83.33% and 61.48%, respectively, while ethanol as solvent resulted in a maximum yield of 57.04% and minimum yield of 23.70%. According to the result obtained in this study the maximum percentage oil yield of petroleum ether (83.33%) was almost equal to that of hexane (84.81%). The boiling point range of petroleum ether (40°C – 60°C) is lower than that of hexane (65°C -69°C) so as to avoid thermal degradation of bioactive components. It is preferable to use petroleum ether than hexane. In comparison to hexane and petroleum ether, the yield obtained from ethanol was the lowest. Hexane and petroleum ether are non-polar organic solvents that have high capacity to dissolve non polar compounds while ethanol can extract non-oil components due to the presence of OH bond (polar). However, currently both hexane and petroleum ether have been identified as air pollutants and can react with other pollutants to produce ozone and photochemical oxidants [20,21].

Table 3. Oil yield and extraction yield of Mango seed kernel oil using full factorial design

Run	Factors			Oil yield (%)				Extraction yield (%)
	A (mm)	B (h)	C (type)	Replicate 1	Replicate 2	Replicate 3	Mean±SD	
1	0.25-0.5	2	Hexane	57.78	60.0	54.44	57.41±2.8	6.89±0.34
2	0.5-1.5	2	Hexane	43.33	45.56	44.44	44.44±1.1	5.33± 0.13
3	1.5-3	2	Hexane	42.22	40.0	44.44	42.22±2.2	5.07±0.27
4	0.25-0.5	4	Hexane	82.22	83.33	81.11	82.22±1.1	9.87±0.13
5	0.5-1.5	4	Hexane	58.89	57.78	58.89	58.52±0.6	7.02±0.08
6	1.5-3	4	Hexane	45.56	43.33	5.73	45.57±2.2	5.47±0.27
7	0.25-0.5	6	Hexane	84.44	86.67	83.33	84.81±1.7	10.18±0.2
8	0.5-1.5	6	Hexane	68.89	70.0	71.11	70.0±1.11	8.4±0.13
9	1.5-3	6	Hexane	64.44	64.44	63.33	64.07±0.6	7.69±0.08
10	0.25-0.5	2	Ethanol	23.33	22.22	25.56	23.70±1.7	2.84±0.20
11	0.5-1.5	2	Ethanol	21.11	20.0	20.0	20.37±0.6	2.44±0.08
12	1.5-3	2	Ethanol	17.78	20.0	18.89	18.89±1.1	2.27±0.13
13	0.25-0.5	4	Ethanol	48.89	47.78	50.0	48.89±1.1	5.87±0.13
14	0.5-1.5	4	Ethanol	40.0	42.22	41.11	41.11±1.1	4.93±0.13
15	1.5-3	4	Ethanol	30.0	30.0	31.11	30.37±0.6	3.64±0.08
16	0.25-0.5	6	Ethanol	56.67	55.57	58.89	57.04±1.6	6.84±0.20
17	0.5-1.5	6	Ethanol	46.67	46.67	47.78	47.04±0.6	5.64±0.08
18	1.5-3	6	Ethanol	43.33	44.44	47.78	45.18±2.3	5.42±0.28
19	0.25-0.5	2	Petroleum ether	62.22	61.11	61.11	61.48±0.6	7.38±0.03
20	0.5-1.5	2	Petroleum ether	38.89	40.0	36.67	38.52±1.7	4.62±0.20
21	1.5-3	2	Petroleum ether	40.0	40.0	40.0	40.0±0	4.8±0
22	0.25-0.5	4	Petroleum ether	73.33	75.56	73.33	74.07±1.2	8.89±0.15
23	0.5-1.5	4	Petroleum ether	56.61	56.67	57.78	57.02±0.6	6.84±0.08
24	1.5-3	4	Petroleum ether	44.44	42.22	45.57	44.08±1.7	5.29±0.20
25	0.25-0.5	6	Petroleum ether	83.33	82.22	84.44	83.33±1.1	10.0±0.13
26	0.5-1.5	6	Petroleum ether	68.89	71.11	67.78	69.26±1.7	8.31±0.20
27	1.5-3	6	Petroleum ether	61.11	60.0	63.33	61.48±1.7	7.38±0.20

Therefore, even if the yield obtained from ethanol was the lowest, from the health and environmental point of view, it is suggested for this extraction process. Table 4 shows the analysis of variance (ANOVA) result. The model F- value of 35.57 implies the model is significant. Value of probe>F less than 0.05 indicates the terms are significant. In this case, A-particle size, B-extraction time, C-solvent type and A^2-square of particle size are significant model terms. Values greater than 0.1000 indicates the model terms are not significant. Hence AB-interaction between particle size and time, AC-interaction between particle size and solvent type, BC-interaction between time and solvent type and B^2-the square of time are not significant model terms [22]. The model terms A, B, C and A^2 were significant model terms, whereas interaction model terms AB, AC, BC and B^2 are not significant model terms. Often we think about removing non-significant model terms or factors from a model, but in this case removing AB, AC and BC will result in a model that is not hierarchical. The hierarchy principle indicates that if a model contains a higher-order term, it should contain all the lower-order terms that compose it. Hierarchy promotes a type of internal consistency in a model, and many statistical model builders rigorously follow the principle [23, 24]. The regression equations in terms of actual factors are given below,

Solvent type: Hexane

$$Yield\ (\%) = +52.750 - 35.369A + 10.813B - 0.623AB + 9.552A^2 \quad (12)$$

Solvent type: Ethanol

$$Yield\ (\%) = +17.619 - 29.396A + 11.77B - 0.623AB + 9.552A^2 \quad (13)$$

Solvent type: Petroleum ether

$$Yield\ (\%) = +50.822 - 35.409A + 10.751B - 0.623AB + 9.552A^2 \quad (14)$$

Fig. 3 shows the relation between the actual value of the experiment and value predicted by the model equation developed by the design expert software 7.0.0

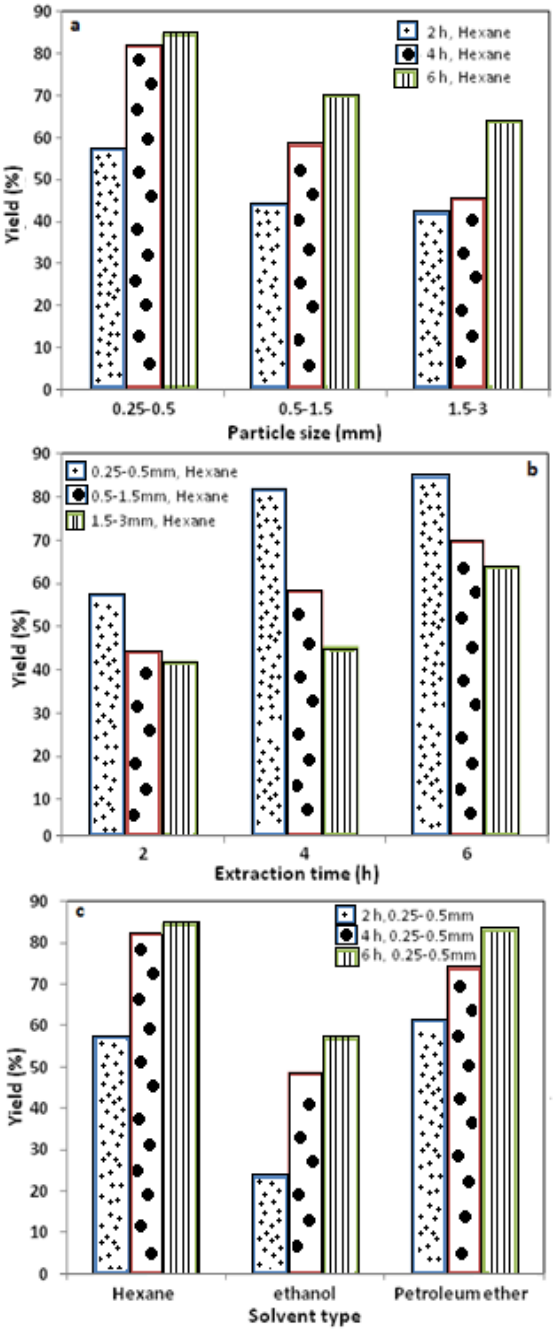

Fig.2. Effect of (a) Particle size, (b) Extraction time, (c) Solvent type on the Mango seed kernel oil yield (%)

Table 4. Analysis of variance (ANOVA)

Source	Sum of squares	Degree of freedom	Mean square	F value	P value Prob > F
Model	8362.2	11	760.2	35.6	< 0.0001
A	16022.1	1	1602.1	77.1	< 0.0001
B	3072.9	1	3072.9	147.8	< 0.0001
C	3185.4	2	1592.6	76.6	< 0.0001
AB	16.91	1	16.91	0.81	0.38
AC	130.4	2	65.19	3.14	0.0728
BC	15.68	2	7.84	0.38	0.6921
A^2	316.9	1	316.85	15.24	0.0014
B^2	21.9	1	21.94	1.06	0.3205
Residual	311.8	15	20.94		
Cor Total	8673.9	26			

Parameter optimization

Using optimization function in design expert software 7.0.0, it was predicted that at the following operating conditions of 0.39 mm particle size, 5.67 h extraction time and hexane as solvent, a maximum oil yield of 85.01% could be obtained, which agreed well with the experimental value 84.81%. A minimum yield of 16.99 % was predicated at particle size of 1.4 mm, 2.22 h and ethanol as solvent. This was also in agreement with the experimental value (Fig. 3).

Mango seed kernel oil characterization

Fig.4 shows the production of mango seed kernel oil. Using the process parameters that gave a maximum oil yield, the particle size range 0.25-0.5mm, extraction time of 6h and hexane as solvent, the oil was extracted and characterized. The phenolic content was determined by using all the solvents. The moisture and volatile matter of oil constituted about 2.2%. Specific gravity was found to be 0.905. The kinematic viscosity of oil was $5.4\times10^{-5}m^2/s$. The pH value of oil was found to be 5.9±0.36. pH was in the range of 5.6 to 6.5, which is slightly neutral. In preparation of skin and hair care materials, the preferable pHvalue is in the range of 3.5- 6.5, suggesting its application in the cosmetic industry. Refracto meter was used to determine the refractive index of the kernel oil and AOAC official method 921.08 was implemented. A refractive index of 1.456 at a temperature of 40°C was obtained. Refractive index indicates the purity of oil. The lower the refractive index is the higher the quality of oil. Saponification value of mango seed kernel oil was 184.66 mg KOH/g of oil. High saponification value implies greater a proportion of fatty acids of low molecular weight. The values obtained for saponification value of mango seed kernel oil was favorably comparable with the saponification value of olive oil (185 - 196) which is a well-known vegetable oil in cosmetics industry. High saponification value of the mango kernel oil suggests the use of the oil in the production of liquid soap, shampoos and lather shaving creams. The oil has 3.85% of unsaponifiable matter. The result obtained was in agreement to the reported values: 3.45% and 2.78% respectively [17,25].

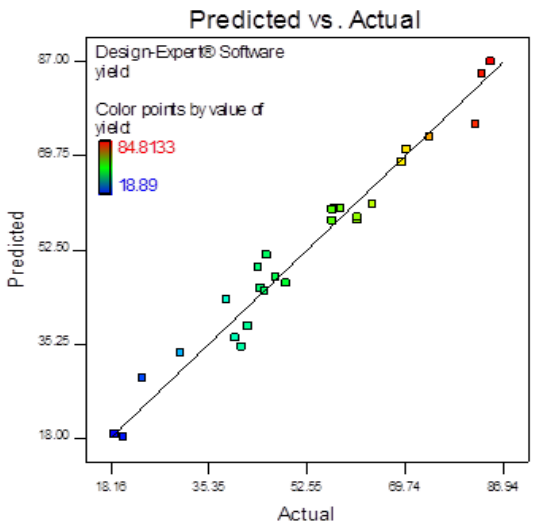

Fig. 3. Actual versus predicted values of Mango seed kernel oil.

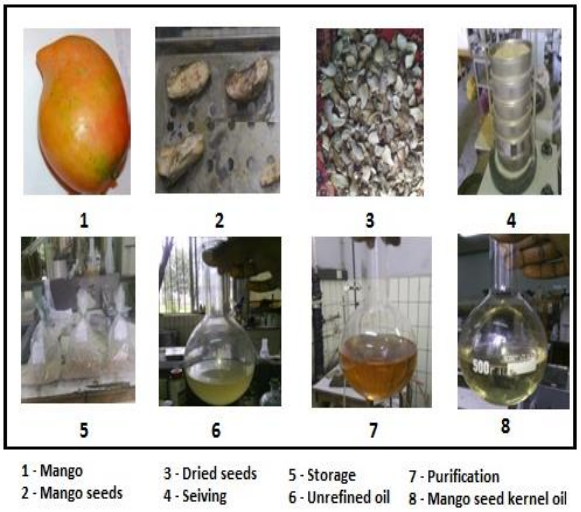

Fig. 4. Production of mango seed kernel oil from mango seeds

Unsaponifiable matters are substances soluble in oil which fails to form soap when blended with sodium hydroxide. The presence of high unsaponifiable matter, 3.85 guarantees the use of mango seed kernel oil in cosmetics industry.

The average acid value of mango seed kernel oil is 2.38±0.33 which is relatively smaller. The low acidity of oil is an indication of oil which is free from hydrolytic rancidity and enables the direct use of such oil without further neutralization [4].

The low free fatty acid content, 1.18 was indicative of low enzymatic hydrolysis. This could be an advantageous that mango seed kernel oil cannot develop flavor during storage. Iodine value of mango seed kernel fat was 40.44g/100g of oil. The result indicated as mango kernel oil, low iodine value so it has high resistance to oxidation and longer shelf life. The oil could be classified as a non-drying oil since its iodine value is lower than 100. Certainly, the oil can also be used extensively as lubricants and hydraulic brake fluids. Peroxide value is one of the most widely used test for oxidative rancidity in oils. It is a measure of the concentration of peroxides and hydroperoxides formed in the initial stages of lipid oxidation. Generally, the peroxide value should be less than 10 mg/g oil in the fresh oils. Peroxide value of mango seed kernel fat was 2.92 meq peroxide oxygen/kg. Oils with high peroxide values are unstable and easily become rancid [26]. Peroxide values were good indices for the stability of the oil. So mango seed oil had a high quality due to the low level of peroxide value. Total phenolic content was found to be 83.2 mg/g, 115.8 mg/g and 79.6 mg/g for hexane, ethanol and petroleum ether extracts respectively. A total phenolic content of 98.7mg/g has been reported earlier [16]. A total phenolic content of 118.1mg/g has been reported earlier [27]. The oil extracted with ethanol resulted in high phenolic content followed by hexane and petroleum ether. The potential use of phenolic compounds for the development of new skin care cosmetics has been emphasized. Phenolic compounds can be used as skin whitening, sunscreen and anti-wrinkle agents [28]. In addition, phenolic compounds are the main component responsible for antioxidant activity [29]. This is mainly due to their redox property which can play an important role in absorbing and neutralizing free radicals. So the presence of high phenolic content in mango seed kernel implies that high free radical scavenging activity. Higher un saponifiable matter gives the Ethiopian mango (Assosa variety) higher opportunity to be used in cosmetics industry.

CONCLUSIONS

Mango seed kernel oil was extracted from mango seed kernel using soxhlet extractor. A maximum oil yield of 84.81% was obtained for the seed kernel particle size range of 0.25-0.5mm with hexane as solvent for the extraction time of 6 h. A minimum oil yield of 18.87% was obtained for a particle size range of 0.5-1.5mm, with ethanol as solvent for the extraction time of 2 h. Due to the presence of a high percentage of unsaponifiable matter and phenolic content, the oil extracted from mango seed kernel guarantees, its application in the cosmetics industry.

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