EFFECT OF MOISTURE CONTENT ON THE YIELD AND CHARACTERISTICS OF OIL FROM *MORINGA OLEIFERA* SEEDS

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ABSTRACT

The effect of moisture content variation on the yield and characteristics of oil from Moringa Oleifera seeds were investigated. The oil was extracted using the soxhlet method at 7.28%, 10%, 15% and 20% moisture content for sample A, B, C and D respectively. The extracted oil was characterized using standard methods. The results show a percentage oil yield of 38.01%, 38.48%, 32.56% and 27.53% for samples A, B, C and D respectively. The extracted oil had viscosity (kg/m^3) of 43.50, 43.69, 44.00 and 44.30 with specific gravity of 0.90, 0.93, 0.94 and 0.97 for samples A, B, C and D respectively. The results also shows saponification (mg/KOH/mol) and iodine (g/100g) values of 117.12, 93.97, 96.77, 91.16 and 68.58, 68.50, 68.41, 68.42 for sample A, B, C and D respectively. The acid values (mg/KOH/mol) are 3.23, 3.16, 2.81 and 2.81 for sample A, B, C and D respectively. The peroxide value (mg/KOH/mol) and free fatty acid (mg/KOH/mol) ranged between 0.95-1.15 and 5.61-6.45 for the extracted oil at moisture content of 7.28-20%. It can be concluded that oil yield decreases with increase in moisture content, with the highest oil yield obtained at 10% moisture content. Moisture content has no effect on the refractive index of moringa seed oil; the high free fatty acid value indicates its edibility while the iodine value is a measure of the unsaturation of the oil. Therefore, an initial seed moisture content of 10% (w.b) is recommended for the extraction of oil to obtain maximum oil yield while the oil can be use as lubricant, cooking as substitute for other vegetable oil but it is not suitable for soap making.

Keywords: Moringa Oleifera seeds, oil yield, characteristics, moisture content

INTRODUCTION

Moringa Oleifera is the most widely cultivated species of a *monogeneric* family, the *Moringaceae,* which is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan (Jed and Fahey, 2008). *Moringa* tree is the fastest of all the trees as it reaches 3m (9ft) in just ten months after the tree is planted (Sutherland *et al.,* 1994). The popular name of *Moringa* in Nigeria is "*Zogale*" in the north, "*Ewe Igbale*" and "*Idagba Manoye* in the southern part and "*Odudu Oyinbo*" in the eastern part of Nigeria. The leaves are eaten as greens in salads, in vegetable curries, as pickles and for seasoning. Leaves and young branches are relished by livestock. The bark of the trees can be used for tanning and also yields a coarse fiber (Anwar *et al.,* 2007). The flowers which must be cooked are eaten mixed with other foods and have been shown to be rich in potassium and calcium (Patty, 2007). The pods are extremely nutritious, containing all the essential amino acids along with many vitamins and other nutrients. The immature pod can be eaten raw or prepared like green peas or green beans (Rajangam, 2001) while the mature pods are usually fried and possess a peanut-like flavor (Fuglie, 1999).

The seeds of *Moringa* yield 38-40% edible oil known as Ben Oil (Sengupta and Gupta 1997). This oil is relatively easy to extract using simple household technology, solvent method and

ISSN-L: 2223-9553, ISSN: 2223-9944
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screw press oil expeller method (Abdulkarim *et al.,* 2005). It is one of the most stable oil in nature and has a shelf life of up to five years. Therefore, extracting oil from seeds has a lot of commercial potentials for communities in developing countries. There is already an existing demand for *Moringa* oil in the west, which is recognized as luxury aromatherapy oil (Christopher, 2010). The oil has a huge variety of uses, this include:

Cooking

Ben oil is used for household cooking, because it is colourless, odourless and resist rancidity, this property of the oil enhance the improvement and retention of taste and natural flavor. This oil also contains fatty acids, vitamin A and C, which is needed in the human body (Fuglie, 1999).

In Cosmetics

The *Moringa* seed extract is used in cosmetics as the oil penetrates deeply into the skin; carrying essential nutrients and helping the skin refresh and rejuvenate it. Beauty companies around the world now uses *Moringa* oil in perfumes, massages, aromatherapy, because the oil has a property which is nourishing to the skin.

Lubricating

Moringa oil due to its light weight is used for lubricating machinery parts, which do not require heavy oil for effective movement of such parts.

Soap Making

The oil is used in making soaps because of the constituent of the oil which is essential.

The oil resembles olive oil and rich in fatty acids and oleic acid, which makes it suitable for edible purposes. If *Moringa* seeds are to be used for oil production, the seeds are harvested and immediately processed. The traditionally the fresh soft *Moringa* seeds are broken into pieces and heated with water and then they are pressed for oil.

Moringa oil possesses exceptional oxidative stability which may explain why the Egyptians placed vases of *Moringa* oil in their tombs. *Moringa* oil has a potent antioxidant considered to be the factor behind its remarkable stability. *Moringa* oil is non-drying flavored oil with a pale yellow consistency (Anwar and Bhanger, 2003). The healing properties of *Moringa* oil were documented by ancient cultures. Due to the increasing awareness of the use of *Moringa Oleifera* seed oil; there is the need to know the appropriate sets of parameters necessary for the optimum extraction of this oil. The aim of this work is to evaluate the effect of moisture content on the oil yield of *Moringa Oleifera* seeds and to characterize the quality of the oil produced.

MATERIALS AND METHOD

Sample preparation

Moringa Oleifera seed pods were obtained from a local farm in Bacita area of Kwara State, Nigeria. The manual method of hand shelling was done to remove the shell and other foreign materials from the seeds.

Determination of Moisture Content

The initial moisture content of the sample was determined on dry basis using oven drying method at 105^0C as described by AOAC, 1990 standard methods. Moisture content was calculated using equation 1:

$$M_i = \frac{Msi - Msf}{Msf} \quad (1)$$

Where:

M_i = M.C in % dry basis

M_{si} = is the initial mass before oven drying.

M_{sf} = is the final mass after oven drying.

Variation of Moisture Content

The initial moisture content of the *Moringa Oleifera* seed was calculated to be 7.28 %. The sample were then divided into four groups; sample A, B, C and D. Calculated amount of distill water were added to samples B, C and D and refrigerated for seven days to achieve the desired moisture content of 10 %, 15 % and 20 % respectively while sample A was retained at the initial moisture content of 7.28 %. The quantity of water added was calculated from the following relation as given by Sacilik *et al*., 2003:

$$Q = \frac{Wi(Mf - Mi)}{(100 - Mf)} \quad (2)$$

Where:

Q = is the quantity of water (g).

M_f = is the final moisture content of the sample in % dry basis.

M_i = is the initial moisture content of the sample in % dry basis.

W_i = initial mass of the sample in grams.

Oil Extraction Using Soxhlet Method

The Soxhlet method is the most commonly used semi-continuous process for the extraction of lipids from foods (Obikili, 2010). According to Soxhlet procedure, oil and fat from solid material are extracted by repeated washing (percolation) with an organic solvent, usually hexane or petroleum ether. The n-hexane was used for the purpose of this work. The grounded *moringa* seed samples were placed in a porous cellulose thimble. The thimble is then placed in an extraction chamber which is being suspended above a flask containing the solvent and below a condenser. Heat is being applied to the flask and the solvent evaporates and moves to the condenser where it is converted into liquid that trickles into the extraction chamber containing the sample (Obikili, 2010). The extraction chamber is made in such a way that when the solvent surrounding the sample exceeds a certain level it overflows and trickles back down into the boiling flask. The flask containing solvent and lipid is removed at the end of the extraction process. The solvent in the flask is evaporated in an oven and the mass of the lipid remaining is measured. The percentage of the lipid in the initial sample is then calculated. This procedure was carried out for samples A, B, C and D respectively at three replicates.

Determination of Percentage Oil Yield

The extraction of oil using soxhlet extractor was repeated on each of the sample and the oil was recovered by solvent evaporation. It was heated at a temperature higher than that of the solvent until the solvent finally evaporates leaving behind the extracted oil. The procedure was carried out for all samples. The average oil yield on each sample was obtained.

The percentage oil yield was calculated as follow;

$$\% \text{ oil yield} = \frac{Weight\ before\ extraction - Weight\ of\ sample\ after\ extraction}{Weight\ of\ sample\ before\ extraction} \times 100$$

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Determination of Specific Gravity and Density

Hundred millilitres (100ml) of specific gravity bottle was cleaned and dried in a dry-air oven. Then it was cooled in a desiccator. The weight of the specific gravity bottle was obtained as W_1, then the specific gravity bottle was filled with clean water, and the weight of the bottle plus water obtained as W_2. The water was poured out and the bottle allowed to, dry (Ibrahim and Onwualu, 2005). The specific gravity bottle was again filled with oil and the weight of the specific gravity bottle oil obtained as W_3. The specific gravity and relative density of the oil is calculated using the formula below;

$$\text{Density} = \frac{\text{Weight of oil}}{\text{Volume of oil}} \quad \text{i.e} \quad \frac{W_3 - W_1}{100}$$

$$\text{Specific gravity, } = \frac{\text{Weight of oil}}{\text{Weight of equal Volume of H20}}$$

Determination of Saponification Value

Two grams (2g) of sample weighed into a 250 cc. conical flask and added 25cc of approximately normal alcoholic potash (prepared by dissolving 56g KOH in 1 litre of alcohol) and a few glass beads. The mixture was then boiled gently under reflux on a water bath for 1hr. while the process is on (refluxing), titrate 25ml of the alcohol potash against 0.5M HCl, using phenolphthalein as indicator. After boiling, the mixture was titrated with 0.5M HCl, immediately. The end point will be a faint pink (Obikili, 2010).

$$\text{Saponification Value} = \frac{(B-A) \times 28.05}{Weight\ of\ oil\ sample} \text{ mg. KOH/gm.}$$

Where; B=Blank titre, A= sample titre

Determination of Free Fatty Acid

Acid value is expressed as % free fatty acid calculated as oleic acid. The dish was accurately weighed containing about 5g of the oil sample, poured into a conical flask and re-weighed, thus obtaining the actual weight of the oil taken. Fifty milliliters (50ml) of hot neutral alcohol was added with a few drops of phenolphthalein and shaken vigorously. The solution was titrated with 0.5 M sodium hydroxide (NaOH) solution with constant shaking until the pink colour remains constant. From the quantity of 0.5M alkali used, the percentage of acid present was calculated, stating the result in terms of oleic acid (Farooq *et al.* 2006).

Determination of Peroxide Value

One gram (1g) of oil sample was added with 1g of potassium iodide and 20ml glacial acetic acid chloroform 2:1. It was then boiled for 1 min. The hot solution was transferred into a flask containing 20ml of 5% potassium iodide solution. And few drops of starch solution was added and titrated with 0.025 N $Na_2S_2O_3$ to a faint yellow colour. One millilitre (1ml) of starch indicator was added and the titration continued until the blue colour disappears. Determine using AOAC 1990 method (Eromosele, *et al.* 1994).

$$\text{Peroxide Value} = \frac{\text{Molar equivalent}}{\text{Weight of oil Sample}} = \frac{\text{S X N X 100}}{\text{Weight of oil Sample}}$$

Where; S = Weight of $N_2S_2O_3$ used, N = Normality of $N_2S_2O_3$

Determination of Iodine Value

Five milliliter (5ml) of chloroform solution was taken and 5ml of Dan's reagent (acetic acid + $CHCl_3$) was added, the solution was kept in fume cupboard for 10min. Five milliliter (5ml) of

10% potassium iodite was added with 20ml of distilled H_2O, stirred several times to mix solution and Titrate to a colorless end point with 0.025N $N_2S_2O_3$ (Eromosele, *et al.* 1994).

$$\% \text{ Iodine Number} = \frac{(B-A)\ 0.00317 \times 0.001269 \times 100}{Weight\ of\ sample}$$

Where; B = Blank Titre, A= Sample Titre, 1ml 0.025 $N_2S_2O_3$ = 0.0 0317g

Statistical Analysis

The data obtained were analysed statistically using the software package SPSS 15.0 (Statistical package for social science).

RESULTS AND DISCUSSION

The Effects of Moisture Content on the Oil Yield of *Moringa* Seeds

The results of the percentage oil yield of *moringa* seed at various moisture contents are as presented in Figure 1. Sample A have an oil yield of 38.01%, sample B 38.48%, sample C 32.56% and sample D 27.533 %. Samples A and B have a yield similar to the value of 38 – 40% as reported by Sengupta and Gupta (1997). The sample C and D with 15 and 20 %moisture content respectively produces a lower oil yield below the reported value of 38-40%. This shows that the oil yield of *moringa* seeds will decrease with increase in seed moisture content above 10% (Figure 1). This result indicates that the higher the moisture content, the lower the oil yield of *moringa* seed which is similar to other oil bearing seeds.

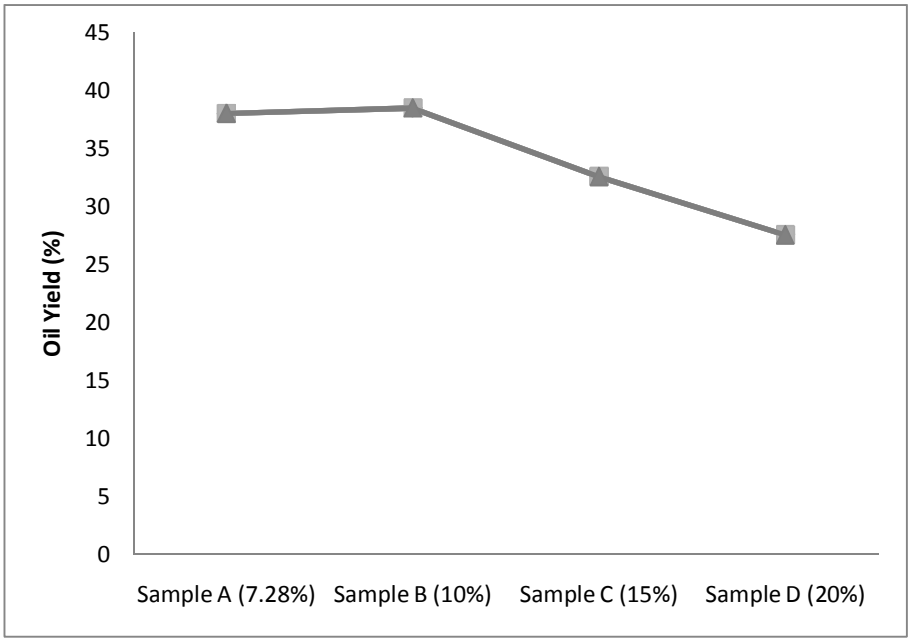

Figure 1. The Effect of Moisture Content on the Oil Yield of *Moringa* Seed

The Effects of Moisture Content on some Physical Characteristics of *Moringa* Seed Oil

The physical properties of the extracted *moringa oleifera* seed oil were compared to FAO/WHO (2009) international standard for edible oil as stated by Chopra and Kanwar (1992) and Uzama *et al* (2011). The effect of moisture content on the physical properties of *moringa oleifera* seed oil are as presented in Table 1.

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Table 1. Physical properties of *moringa* seed oil

Properties	*Sample A*	*Sample B*	*Sample C*	*Sample D*	**Standard for edible*
Viscosity 40^0c (kg/m^3)	43.50	43.69	44.00	44.30	60
Specific gravity @ 30^0	0.90	0.93	0.94	0.97	1.16
Refractive index @ 40^0c	1.46	1.46	1.457	1.46	1.46±0.05
Smoke point	245	248	230	230	250

* F.A.O/W.H.O (2009)

Viscosity

The viscosity of *moringa* seed oil determined at 40^0C for sample A, B, C, D are 43.50, 43.69, 44.00 and 44.30 respectively. These values are lower than the recommended viscosity for edible oil as reported by Chopra and Kanwar (1992). Based on the oil fluidity, sample A has the highest viscosity this shows that, the viscosity will decrease with increase in moisture content. This property makes *moringa* oil suitable for lubrication because it is light. The viscosity increases in a non-uniform linear manner up to 20% moisture content (Table. 1).

Specific Gravity

The specific gravity of *moringa* seed oil determined at 30^0C for sample A, B, C, D are 0.9, 0.93, 0.94, and 0.97 respectively, which shows little deviation from international standard for edible oil presented by Chopra and Kanwar (1992). Specific gravity which is the density of substance to that of water increases with increase in moisture content. Therefore, sample D with the highest moisture content has the greatest specific gravity. The specific gravity increases in a non-uniform linear manner as the moisture content increases (Figure 2).

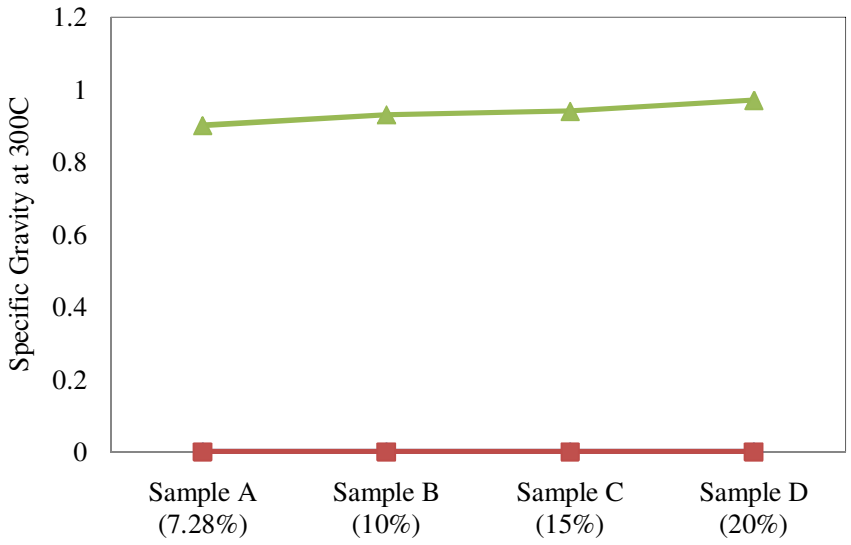

Figure 2. Effect of Moisture Content on Specific Gravity of Moringa Seed Oil

Refractive Index

The refractive index of *moringa* seed oil determined at 40^0C for sample A, B, C, and D are 1.457, 1.461, 1.457, and 1.455 respectively which shows little or no differences from the

international standard for edible oil presented by Chopra and Kanwar (1992) which is 1.460 - 1.465. The refractive index increases in a uniform linear manner from moisture content below 10% and begins to decrease above 10% moisture content in a non-uniform linear manner. Sample B has the highest refractive index at 40^0C which is an indication for checking the purity of the oil. Therefore, sample B with 10% seed moisture content has the highest purity.

Smoke Point

The smoke point of *moringa* seed oil determined for sample A and B are 245^0C and 248^0C respectively while that of sample C and D are 230^0C which shows little variation from that stated by Uzama *et al* (2011) which is 250^0C. The smoke point increases in a non-uniform linear manner up to 15% moisture content and shows no changes above 15% moisture content (Figure 3). Smoke point which is the temperature, at which the smoke is first detected, tends to be higher for oil extracted at lower seed moisture content.

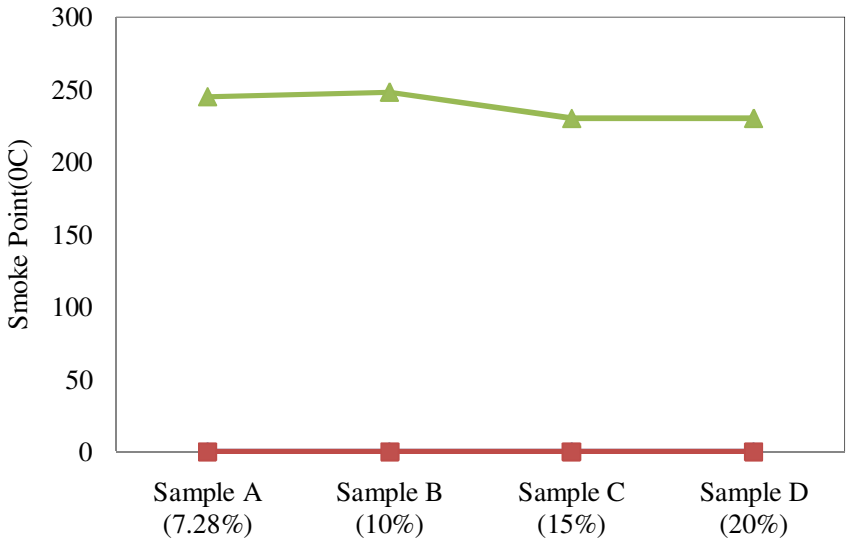

Figure 3. Effect of Moisture Content on Smoke Point of *Moringa* Seed Oil

The Chemical Characteristics of *Moringa* Seed Oil Produced at Various Moisture Content

The chemical properties were compared to FAO/WHO (2009) international standard for edible oil as stated by Chopra and Kanwar (1992) and Uzama *et al* (2011). The effect of moisture content on the chemical properties of *moringa oleifera* seed oil are as presented in Table 2.

Saponification Value

The saponification value of *moringa* seed oil determined for sample A, B, C and D are 117.109mg/KOH/g, 93.968 mg/KOH/g, 96.773 mg/KOH/g, and 91.163 mg/KOH/g respectively (Fig. 4). The values for all the samples are lower than the recommended international standard for edible oil as reported by Chopra and Kanwar (1992). The saponification values gives information concerning the character of the fatty acid present in the oil and the solubility of the soap derived from it in water. A high saponification value indicates that the oil contains low portion of fatty acids. This is an indication that *moringa* seed oil will not be suitable for soap making.

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Table 2. Chemical Properties of *Moringa* seed Oil

Properties	*Sample A*	*Sample B*	*Sample C*	*Sample D*	**Standard for edible*
Saponification value(Mg/kOH/g)	117.11	93.97	96.77	91.16	181.4±2.60
Iodine value (Mg/100g)	68.58	68.50	68.41	68.42	80-106
Acid value(Mg/kOH/g)	3.23	3.16	2.81	2.81	4
Peroxide value(M/Mol/kg)	1.15	1.15	0.95	0.95	10
Free fatty acid (Mg/KOH/g)	6.45	6.31	5.61	5.61	5.78-7.28

* F.A.O/W.H.O (2009)

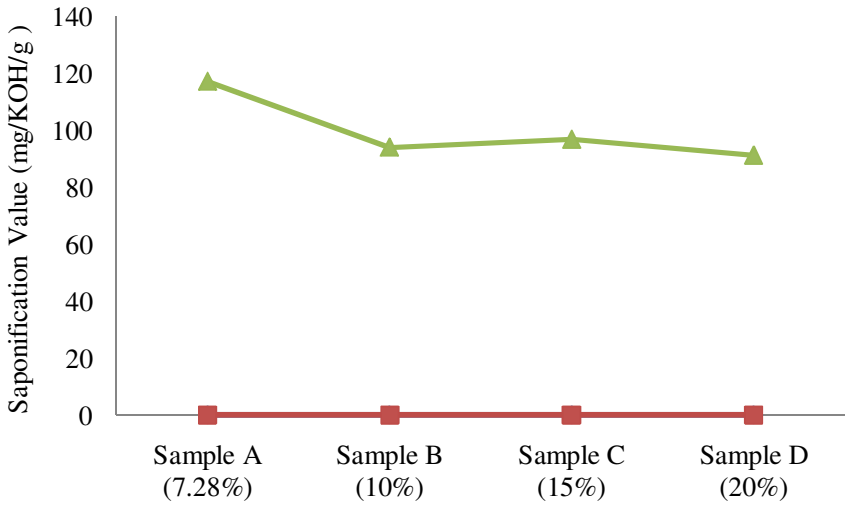

Figure 4. Effect of Moisture Content on saponification Value of *Moringa* Seed Oil

Iodine Value

The iodine value of *moringa* seed oil determined for sample A, B, C, and D are 68.58/100g, 68.50 100g, 68.41/100g and 68.42/100g respectively. The standard specified by FAO/WHO (2009) for edible oil is between 80 – 106 /100g. Sample A has the highest value, although they all fall below the standard for edible oil as stated by Chopra and Kanwar (1992). The iodine value decreases in a uniform manner between 7.28 - 15% seed moisture content and tends to increase above 15% seed moisture content (Table 2). The iodine value of the oil is a measure of the unsaturated acid present; this also indicates the non-drying qualities of oil. The greater the iodine value, the greater the unsaturation and thus the greater the liquidity. The lower value indicates lower degree of unsaturation. Thus sample D with the highest moisture content has the lowest iodine value, indicating that the higher the moisture content the lower the iodine value.

Acid Value:

The acid value of *moringa* seed oil determined for sample A and B are 3.23 and 3.16 while that of sample C and D are both 2.81 which shows little deviation from the standard specified by FAO/WHO (2009) for edible oil as stated by Chopra and Kanwar (1992) which is 2.8 9 ± 0.01. The acid value decreases in a non-uniform linear manner between 7.28 and 15% seed moisture content and remained constant at seed moisture content above 15 % (Fig. 5). Hence,

the lower the moisture content, the lower the acidity value, indicating the extent of edibility of *moringa* oil which conforms to the reports of Sengupta and Gupta (1997).

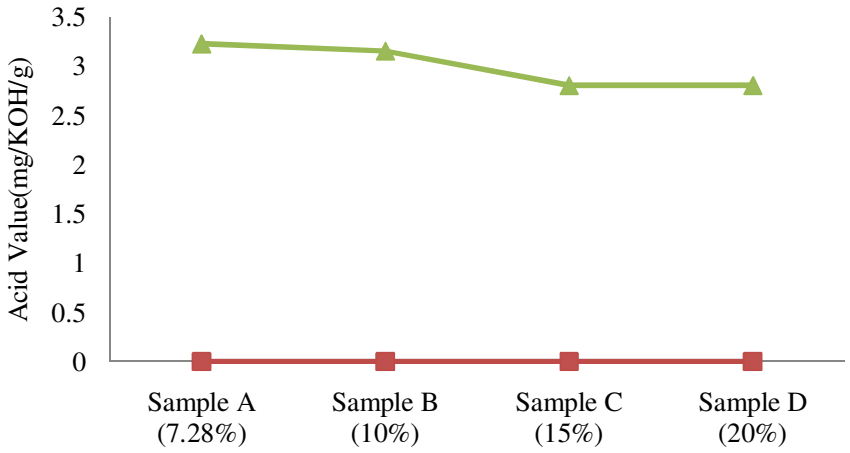

Figure 5. Effect of Moisture Content on the Acid Value of *Moringa* Seed Oil

Peroxide Value

The peroxide value of *moringa* seed oil determined for sample A and B is 1.15mEq/kg while that of sample C and D is 0.95mEq/kg which is very low compared to the standard specified by FAO/WHO (2009) for fresh edible oil which is 10mEq/kg. The peroxide values of the oil increased between 7.28 and 10% seed moisture content and decreased between 10 and 20% (Fig. 6). Peroxide value is a measure of its oxygen content, which is used to monitor the development of rancidity through the evaluation of the quantity of peroxide generated in the product. Hence, the peroxide value tends to decreases with increases in moisture content. The lower peroxide value of moringa seed oil indicates that it will not easily go rancid which is related to its longer shelf life and its stability which conforms to the reports of Anwar and Bhanger (2003) that *moringa* seed oil has a shelf life of up to 5 years.

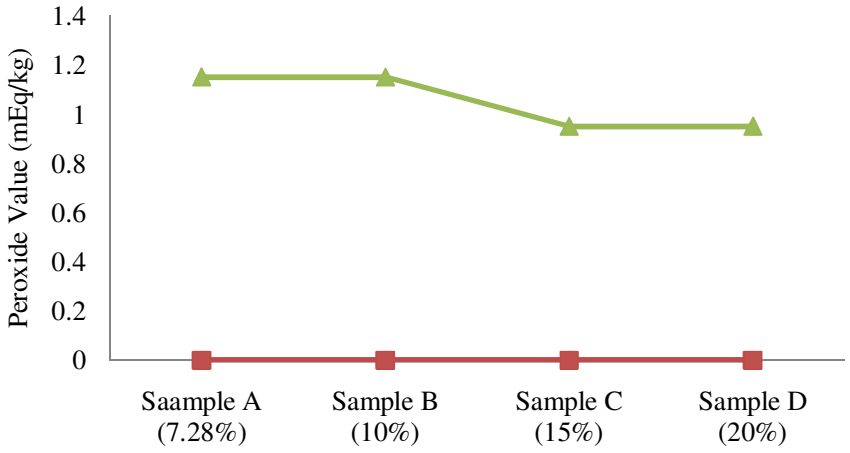

Figure 6. Effect of Moisture Content on the Peroxide value of *Moringa* Seed Oil

Free Fatty Acid

The free fatty acid (mg/KOH/g) of *moringa* seed oil determined for sample A is 6.453 mg/KOH/g, sample B is 6.311 mg/KOH/g while that of sample C and D is 5.610 mg/KOH/g respectively (Fig. 7). The values obtained for the free fatty acid shows very little deviation

ISSN-L: 2223-9553, ISSN: 2223-9944
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from the standard specified by FAO/WHO (2009) for edible oil which is 5.78 - 7.28 mg/KOH/g. The free fatty acid value measures the extent to which the glycerides in the oil have been decomposed by lipase action. This decomposition is usually accelerated by light and heat; hence, as rancidity is normally accompanied by free fatty acid formation, the determination is often used as general indication of the condition and edibility of the oil. The free fatty acid value of the oil decreases in a non-uniform linear manner up to 15% seed moisture content and remains unchanged between 15-20% moisture content.

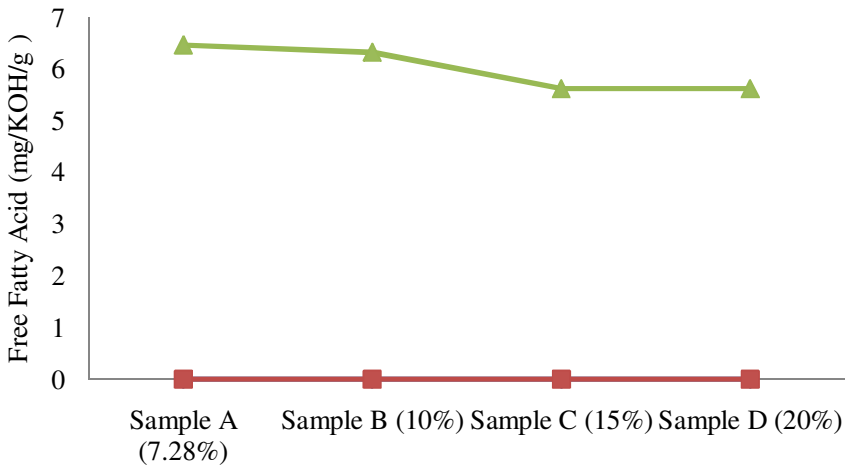

Figure 7. Effect of Moisture Content on the Free Fatty Acid Value of *Moringa* Seed Oil

CONCLUSIONS

It can be concluded that *moringa* seed oil yield decreases with increase in moisture content with the highest oil yield of 38.48 % was obtained at 10% seed moisture content. Moisture content has no effect on the refractive index of *moringa* seed oil. The high free fatty acid indicates its edibility and suitable for lubrication due to its high viscosity. *Moringa* seed oil will have a longer shelf life due to its low peroxide level. An initial seed moisture content of 10% (d.b) is therefore recommended for the extraction of oil to obtain maximum oil yield. *Moringa* seed oil can be used in cooking as substitute for other vegetable oil and also as lubricants. It may however not be suitable for soap making.

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Moringa oleifera Lam. belongs to the family Moringaceae, and is predominantly found in India and tropical and arid countries, including Namibia. The different plant parts of the tree have been subject to extensive research for many years due to the beneficial properties and applications in the medicinal, food, and fuel industries.Â Good thermal and oxidative stability is imparted on the oil by the high oleic acid concentration and tocopherols, which makes the oil a suitable candidate for frying and cooking. The additional presence of high concentrations of campesterol, â–¡-sitosterol, stigmasterol, and Î”5-avenasterol make the oil a suitable raw material for the nutraceutical industry. The moringa seeds yield 38â€“40% edible oil. The refined oil is clear, odorless, and resists rancidity at least as well as any other botanical oil. The seed cake remaining after oil extraction may be used as a fertilizer or as a flocculent that forms the particles into a solid to purify water. The bark, sap, roots, leaves, seeds, oil, and flowers are used in traditional medicine in several countries.Â A large number of reports on the nutritional qualities of Moringa now exist in both the scientific and the popular literature. It is commonly said that Moringa leaves contain more Vitamin A than carrots, more calcium than milk, more iron than spinach, more Vitamin C than oranges, and more potassium than bananas,â€ and that the protein quality of Moringa leaves rivals that of milk and eggs. Essential oil extracted from Moringa oleifera L. seeds was assayed for the evaluation of antimicrobial activity against oral pathogens. Oral pathogens used for the evaluation were Streptococcus mutans KPSK2, Lactobacillus casei ATCC 6363, Candida albicans ATCC 10231, Porphyromonas gingivalis W50, Actinomyces israelii ATCC 10048 and Actinomyces viscosus (clinical isolate). The microbial growth inhibitory potential of the oil was initially determined using agar disk diffusion method. Then the minimum inhibitory concentration (MiC) values were also evaluated by agar dilution method. Essential oil extracted from. M. oleifera seeds has antimicrobial activity against C. albicans, P. gingivalis, A. israelii and A. viscosus with the zones of inhibition ranging from 10 to 13 mm. The effect of moisture content variation on the yield and characteristics of oil from Moringa Oleifera seeds were investigated. The oil was extracted using the soxhlet method at 7.28%, 10%, 15% and 20% moisture content for sample A, B, C and D respectively. The extracted oil was characterized using standard methods. The results show a percentage oil yield of 38.01%, 38.48%, 32.56% and 27.53% for samples A, B, C and D respectively. The extracted oil had viscosity (kg/m 3) of 43.50, 43.69, 44.00â€¦ Expand. savap.org.pk.