Characterization of Marula (*Sclerocarya caffra*) Kernel Oil and Assessment of its potential use in Zimbabwe

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Abstract

To investigate the potential use of marula (*Sclerocarya caffra*) oil, dried marula seeds were crushed to release the kernels and oil was extracted using Soxhlet apparatus and the characteristics of oil determined. The average oil content was found to be 55.9 %. The saponification value of the oil was in the range 180- 189mgKOH/ g oil whilst the iodine value was in the range 66- 70 and the average acid value was 3.6 %. The fatty acid profile of the marula oil was determined using Gas Liquid Chromatography. Oleic acid was found to be the predominant fatty acid. The oil was also low in saturates. It is apparent from the determined characteristics that marula oil has potential use in salad and cooking oils.

Introduction

The Marula (*Sclerocarya caffra*) tree, a member of the Anacardiaceae, is widely utilised in Africa (Shone, 1979 and Wehmeyer, 1969). It is widely distributed in South Africa, Swaziland, Botswana, Namibia, Zimbabwe as well as northward in tropical Africa (Palmer, 1972). The tree grows in warm and dry areas of the middle and lowveld sandy soils. Marula fruits are oval and pale yellow when ripe. They consist of a hard woody seed covered by pulp and juice which make the fleshy part of the fruit (Tredgold, 1986). The fleshy part is used to make products such as jam, juice, liquer and beer. The remaining hard seed contains two or three oil rich nuts(the kernel) which can be eaten as a snack. The kernel has been observed to contain some oil which is currently being used to make some cosmetic ointments and for meat preservation (Coates, 1990). There is now a world wide trend to explore wild plants for oil, to augment the already existing sources of oil (Ikechukwu, 1998). In Nigeria (Ikechukwu, 1998), a study was undertaken to establish the composition of fifteen lesser-known wild tropical seeds. It was found that some of these less familiar seeds could be used as sources of edible oils.

The fact that the marula tree grows in drier parts, where common oilseeds cannot thrive, has stirred interest in it as a potentially valuable source of oil. This has led to the evaluation of marula kernel oil as a potential source of vegetable oil, in some countries such as Sudan and South Africa (Salama, 1973 and Burger, 1987). In evaluating the potential of oil for use, the fatty acid profile plays an important role. An oil with a high content of oleic acid, makes an ideal frying oil (Haumann, 1996) because of the stability offered by the acid. Oils that are high in polyunsaturated and monounsaturated fatty acids, modify the plasma lipoprotein profile of the body and thus reduce the risk of heart diseases (Kinsella et al. 1990).

Results from both South Africa and Sudan show that there are differences in the oil contents of trees grown in different regions. In Zimbabwe, there has been little documentation of the characteristics of marula kernel oil. With the prevalence of oilseeds such as sunflower, groundnuts and soyabeans, marula potential as a source of edible oil has remained unclear. The purpose of this work was to characterise marula oils obtained from trees growing in different parts of Zimbabwe and to compare these characteristics with those obtained from South Africa. The potential uses of marula oil as edible oil, in comparison to other conventional oils, is assessed.

Materials and Methods

Samples

Three samples of dried marula seeds were collected in the Kariba , Bulawayo and Plumtree areas of Zimbabwe, where the marula tree predominantly grows. The seeds were carefully crushed to expose the kernels. The kernels were kept at 5°C during the period of analysis. The analyses were done in triplicate.

Determination of moisture content.

About 1 g of the kernel sample was dried for 3 hours in an oven at 105°C.

Oil Content Determination

The marula kernels were ground to a powder from which oil was extracted for eight hours using hexane (boiling point 30 - 60°C) in Soxhlet apparatus. Oil was also extracted from ground whole marula seeds. The solvent was removed by a rotary evaporator under reduced pressure and residue solvent was flushed out with nitrogen. The oil content was determined by the weight difference method. Nitrogen was then bubbled into the oil where 0.05 %2, 6 - ditert-butyl-4-methyphenol (BHT) was added. The oil was then stored at - 40° C (Kates, 1986).

Saponification Value (SV)

The saponification value of the extracted oil was determined according to the International Union of Pure and Applied Chemists (IUPAC) methods (IUPAC, 1987). Two grams of the oil were refluxed in 25ml alcoholic potassium hydroxide for one hour. The excess alkali was titrated with 0.5M hydrochloric acid in the presence of a phenolphtalein indicator. The blank test was carried out simultaneously, under the same conditions but without the oil. The saponification value was calculated as

$$SV = 56.1 \times M \times (B \times S)/m$$

where B is the blank titre (ml), S the sample titre (ml). M is the molarity of the standardized hydrochloric acid solution used, m is the mass in grammes, of the test portion of sample.

Iodine Value (IV)

The iodine value was determined using modified Wijs method (AOCS, 1989). To a flask containing 0.1 grams of oil, 20 ml carbon tetrachloride was added and the flask gently warmed to mix. When the solution was cool, 25ml Wijs solution added. The flask was stoppered and placed in a dark cupboard for one hour after which 20 ml of potassium iodide solution and 50ml of water were added. The contents were titrated with standardised 0.1M sodium thiosulphate. Starch solution was used as an indicator to mark the end point. The blank test was carried out simultaneously, under the same conditions but without the oil. The iodine value was calculated as:

$$IV = (B - S) \times M \times 12.69/m$$

Where B is the blank titre (ml), S the sample titre (ml), M the actual molarity of sodium thiosulphate and m the mass of sample (grams).

Acid Value (AV)

Two grams of the oil to be analysed was put in a 50 ml 1:1 mixture of ethanol and diethyl ether, followed by titration of the free fatty acids present with an ethanolic solution of potassium hydroxide. The resulting acid value was calculated as:

$$AV = 56.1 \times M \times S/m$$

where S is the number of ml of the standardized potassium solution used, M is the exact molarity of the standardized potassium hydroxide solution and m is the mass in g. of the test portion of the sample (AOAC, 1990).

Gas Liquid Chromatography of FAME

The fatty acid methyl esters (FAMEs) were prepared by refluxing 5 grams of oil in 25ml of sodium methoxide followed by acidification of the solution with 2 ml acetic acid. The solution was then transferred to a separating funnel using 40ml diethyl ether. The ether layer was washed with 100ml water and then by another two washes of 50ml water. The ether layer was then filtered and dried over anhydrous sodium sulphate and the ether evaporated off leaving the FAMEs. The FAMEs were analysed on a gas chromatography equipped with a flame ionisation detector. The initial column temperature was 120°C and the final column temperature being 220°C. The injector temperature was 230°C and the detector temperature was 25°C. The carrier gas, nitrogen, had a flow rate of 30ml per minute and soya bean FAMEs were injected as a standard (IUPAC, 1987).

Results

There were variations in the oil yields of the marula kernels obtained from the three areas of Zimbabwe as shown in **Table 1**. The range was 50 % - 65 %. The average oil content of the crushed whole seed was 5.2%. Oleic acid made up more than 70 % of the total lipids in the oil (**Table 2a** and **2b**). There were no statistically significant differences in the fatty acid profiles of the oils obtained from the crushed whole seed and that obtained from the kernel of the same fruit. The average values for the SV, IV and AV for the oils were 184.5, 67.7 and 3.6 respectively (**Table 3**).

Table 1 Oil and Moisture Contents of Marula Kernels (g/ 100g sample)

	Kariba	Bulawayo	Plumtree	Mean	S.D
Moisture content	5.2	5.0	5.4	5.2	0.2
whole seed oil	5.3	4.9	5.5	5.2	0.3
Kernel oil	52.0	50.8	64.9	55.9	7.8

Table 2a. Fatty Acid profile of Marula whole seed oil

	Whole seed oil g/100g				
Fatty acid	Kariba	Bulawayo	Plumtree	Mean	S.D
Lauric acid C12: 0	0.0	0.1	0.1	0.0	0.01
Palmitic acid C16: 0	10.8	11.0	10.0	10.6	0.53
Stearic acid C18: 0	7.2	7.0	7.1	7.1	0.08
Oleic acid C18: 1	72.3	72.0	72.1	72.1	0.16
Linoleic acidC18: 2	8.4	8.7	8.5	8.5	0.17
Linolenic acid C18: 3	1.1	0.8	0.8	0.9	0.16
Gadoleic acid C20: 1	0.1	0.3	1.3	0.6	0.65
Behemic acid C22: 0	0.2	0.1	0.1	0.1	0.06
Erucic acid C22: 1	0.1	0.0	Trace	0.1	-
Total Saturated	18.4	18.1	17.3	17.9	0.57
Total monounsaturated	72.5	72.3	73.4	72.8	0.58
Total Polyunsaturated	9.5	9.5	9.0	9.3	0.28

Table 2b. Fatty Acid profile of Marula kernel seed oil

	Kernel oil g/100g oil				
Fatty acid	Kariba	Bulawayo	Plumtree	Mean	S.D
Lauric acid C12: 0	0.0	0.1	0.1	0.0	0.01
Palmitic acid C16: 0	10.8	11.3	10.1	10.7	0.61
Stearic acid C18: 0	7.1	6.3	7.2	6.9	0.52
Oleic acid C18: 1	72.4	71.8	71.9	72.0	0.32
Linoleic acidC18: 2	8.4	9.5	8.5	8.8	0.61
Linolenic acid C18: 3	0.4	0.6	0.8	0.6	0.20
Gadoleic acid C20: 1	0.6	0.3	1.3	0.7	0.54
Behemic acid C22: 0	0.1	0.1	0.1	0.1	0.03
Erucic acid C22: 1	Trace	0.0	Trace	0.0	-
Total Saturated	18.1	7.7	17.4	17.7	0.32
Total monounsaturated	73.0	72.1	73.3	72.8	0.59
Total Polyunsaturated	8.8	10.1	9.3	9.4	0.66
- not calculated					

Table 3. Some characteristics of Marula kernel oil

	Kariba	Bulawayo	Plumtree	Mean	S.D
Saponification Value (mgKOH/goil)	185.0	180.1	188.2	184.5	4.09
Iodine Value(WIJIS)	69.0	67.3	66.8	67.7	1.17
Acid Value(%)	3.7	3.5	3.6	3.6	0.10

Table 4. A comparison of the Major Fatty Acids in Marula Oil and Olive Oil

	Marula oil	Olive oil*
C16:0	10.73	7.5- 20
C18:0	6.85	0.5- 3.5
C18:1	72.05	53- 86
C18:2	8.81	3.5- 20
C18:3	0.60	0.0- 1.5

*(Salunkhe, 1991)

Discussion

The values for the oil yields show that the oil content depends on the source of the seed. These results are in line with those obtained in South Africa (Burger, 1987). It was found that the oil content of Marula seeds from different trees was in the range of 33.5- 54.1. The seeds from the Zimbabwean varieties gave higher oil yields than those from South African varieties. This could be due to the influence, in the soil that affects lipid development. The average oil content of 5.2 % is too low to make extraction of oil from the whole Marula seed viable. Oil has therefore to be extracted directly from the kernel where the oil yield is quite high. This will thus necessitate the development of an easy method to crack the seed.

Like oils from South African kernels, the fatty acid composition of marula oils from Zimbabwean kernels, is similar to that of olive oil (Table 4), an oil that is believed to be responsible for the positive effects of so called "Mediterranean diets." This could mean that the use of marula oil in foods could produce similar diets in southern and eastern Africa, where the marula is mostly grown. The high oleic acid present suggests that the oil might be stable. However the oil seems to have a low content of the essential fatty acids (EFA). In this regard, marula oil could be blended with other oils high in polyunsaturated fatty acids (PUFAs), where it would help stabilise the oils and at the same time these oils would provide the EFAs. Marula oil could also be a natural alternative to the genetically modified high-oleic-acid sunflower oil.

There is need for research to establish the position of the oleic acid on the glycerol molecule. Should the oleic acid be on the second position, marula oil could prove to be a valuable starter material for the production of cocoa butter substitutes to be used in the chocolate industry.

Conclusion

From its composition of low saturates and high oleic acid content, it can be concluded that Marula kernel oil has potential use in salad and cooking oils.

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