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Effect of Stripping Methods on the Oxidative Stability of Three Unconventional Oils

Abdalbasit Mariod · Bertrand Matthäus · Ismail H. Hussein

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Abstract Stripped and non-stripped oils from *Sclerocarya birrea* [marula oil (SCO)], *Aspongopus viduatus* [melon bug oil (MBO)] and *Agonoscelis pubescens* [sorghum bug oil (SBO)], traditionally used for nutritional applications in Sudan, were investigated for their fatty acid and tocopherol composition, and their oxidative stability. Three stripping methods were used, phenolic compounds extraction, silicic acid column, and aluminum oxide column. The stripping methods did not affect the fatty acid composition. Non-stripped SCO, MBO and SBO contained oleic, palmitic, stearic and linoleic acids, which were not significantly ($P < 0.05$) different than stripped SCO, MBO and SBO. The stripping methods' effect on the tocopherol composition of the studied oils, the total amount of tocopherol in non-stripped oils decreased by extraction of phenolic compounds, mean that part of the tocopherols was extracted with the phenolic compounds. No traces of tocopherols were found in oils stripped using silicic and aluminum columns and the tocopherols were eliminated during the stripping processes. The stability of SCO, MBO and SBO oils was 43, 38 and 5.1 h, respectively, this stability decreased by 22.0, 37.6 and 23.5%, respectively after extraction of phenolic compounds. This stability decreased by 96.9, 98.2 and 90.2% respectively, when stripped using the aluminium column and decreased by 92.6, 96.1 and 86.3% when stripped by the silicic column. It is possible to assume that the tocopherols and phenolic compounds play a more active role in the oxidative stability of the oils than the fatty acid composition and phytosterols.

Keywords *Agonoscelis pubescens* · *Aspongopus viduatus* · Aluminum oxide column · Oxidative stability · Stripping · Silicic column · *Sclerocarya birrea*

Introduction

Sclerocarya birrea subsp. *caffera* is a Savannah tree, belonging to the family Anacardiaceae. The common English name is Marula, the tree is commonly known in Sudan as Homeid, where it is widely distributed in western and southern areas [1]. We found that the kernels contained 53.0, 28.0 and 8.0% of oil, protein and carbohydrate respectively [2]. The oil contained 67.2, 5.9 and 14.1% of oleic, linoleic and palmitic acid, respectively; and 13.7 mg/100 g of tocopherols [3]. Recent studies on the oil from *Sclerocarya birrea* kernels showed high oxidative stability even during deep frying depending on its fatty acid and tocopherol composition [4], but the level of total tocopherols decreased during processing by 38.7%, while no change in fatty acid composition was observed [5]. *Aspongopus viduatus* (melon bug) is a bug 20 mm long, of the order Hemiptera, melon bugs are widely distributed in the Kordofan and Darfor states of Sudan where it is considered as the main pest of watermelon. The bug is known

A. Mariod (✉)
Food Science and Technology Department,
College of Agricultural Studies,
Sudan University of Science and Technology,
P.O. Box 71, Khartoum North, Sudan
e-mail: basitmariod@yahoo.com

B. Matthäus
Federal Research Center for Nutrition and Food,
Institute for Lipid Research, Piusallee 68/76,
48147 Münster, Germany

I. H. Hussein
National Oilseed Processing Research Institute,
University of Gezira, P.O. Box 20, Wad Madani, Sudan

locally as Um-buga and used in nutrition by collecting the oil from it after hot water extraction [3].

Agonoscelis pubescens (sorghum bug) of the family Pentatomidae, commonly known in Sudan as Dura andat. In Western Sudan, sorghum bug adults are collected and eaten after frying, while in some areas of Sudan, oil was extracted from the collected bugs and this was used for cooking and some medicinal uses. The sorghum bug oil content was 60% with 40.9, 34.5 and 12.1% of oleic, linoleic and palmetic acids respectively, the oil contains 34.0 mg/100 g tocopherols [3]. Insect oils extracted from *Aspongopus viduatus* and *Agonoscelis pubescens* are used as famine food in Western parts of Sudan and have traditional medicinal uses [3]. Mustafa et al. [6] determined the antibacterial activities of melon bug crude oil, silicic acid column purified oil and phenolic compounds-free oil by agar diffusion assay against seven bacterial isolates, and they reported that the crude oil and the phenolic compounds-free oil showed high antibacterial activities against some test species while the silicic acid column purified oil showed no antibacterial activity.

Oxidative stability is an important parameter evaluating the quality of oils and fats, as it gives a good estimation of their susceptibility to oxidative degeneration, the main cause of their alteration. The greater or lesser stability of an oil, means the conservation or not of the so-called dynamic parameters during the useful life of the product. Baldioli et al. [7] studied the importance of tocopherol content in oxidative stability of virgin olive oil; they reported a low correlation between the oxidative stability and α-tocopherol concentration. Gutierrez et al. [8] studied the role of fatty acid composition in the stability of olive cultivars.

In most seed oils, tocopherols are the main antioxidants, whereas in virgin olive oils, a fair correlation has been found between total phenols and oxidative stability. A statistical study showed that the contribution of olive phenolic compounds to Rancimat stability was 51%, that of the fatty acid composition 24%, and that of α-tocopherol 11% [9]. Recent studies suggest that the phenolic compounds naturally contained in virgin olive oil improve its resistance to oxidative deterioration. Phenolic compounds improve the oxidative stability of virgin olive oil and extend its shelf life. The higher oxidative stability of virgin olive oil, compared to that of other vegetable oils, is due to both the high oleic acid (monounsaturated) and low polyunsaturated fatty acid content of the triacylglycerols, and also to the level of natural phenolic components with antioxidant activity [10]. The oils differ in the degree of unsaturation, of the fatty acids constituting their triacylglycerols, as well as in the quantity and quality of the compounds in their non-saponifiable constituents. Differences in composition are translated into differences in the stability, sensory and technical qualities of the oils [11].

Minor components in edible oils affect both their autooxidative and photooxidative stabilities. Thus, stripping of minor components may influence the stability of oils being studied. Peroxide values (PV) of non-stripped borage and evening primrose oils were significantly higher ($P < 0.05$) than corresponding values for stripped oils [12]. Each stripping process or treatment has a specific function and removes certain components, which can act as prooxidants or antioxidants.

From the literature it was clear that fatty acid composition and minor constituents that are naturally present in oils (phenolic compounds, tocopherol and phytosterols) are the main components responsible for the oils oxidative stability. The high oxidative stability of the SCO and MBO oils [3] could be explained by these components.

The aim of this work was to examine the impact of fatty acids and minor components, including phenolic compounds, and tocopherols in three unconventional Sudanese oils (SCO, MBO and SBO) on their oxidative stability. Fatty acids, oxidative stability, peroxide value and residual tocopherols were determined. This research also sought to investigate which component/components responsible for the high oxidative stability of the three unconventional oils.

Materials and Methods

Materials

Dried seeds of *Sclerocarya birrea* were collected manually from Ghibaish locality of western Sudan. Seeds were dehulled (decorticated) using Vice model 2XFRONT equipment (Heuer, Germany), crushed and ground with a grinding mill (Petra Electric, Burgau, Germany). The oil was extracted from the ground material by extraction with *n*-hexane (b.p. 50–60 °C) in a Soxhlet apparatus for 6 h following the AOCS method Aa 4-38 [13]. The oil was kept in a plastic container at 4 °C until further use.

Aspongopus viduatus insects were collected from the Ghibaish locality of Western Sudan, and the oil was obtained following Mariod et al. [3]. In brief, the collected bugs were killed by a sudden hot water shock and crushed using a local wooden mortar. The oil was extracted by using boiling water, and the top oily layer was collected. Then the oil was heated again to remove water drops and afterwards kept in a plastic container at 4 °C until further use *A. pubescens* was collected from the Rahad Agricultural area central Sudan. The bugs were stored in a tight polyethylene bag, killed by treatment with hot water for few minutes and then sun dried [3]. After crushing using a laboratory mortar, the oil was extracted using diethyl ether following AOCS method Aa 4-38 [13]. The oil obtained by the extraction was stored at 4 °C until used for frying.

Reagents and Standards

All solvents used were of analytical grade: *n*-hexane, *n*-heptane, diethyl ether, ethanol and methanol (Merck, Darmstadt, Germany).

Oil Stripping Using Silicic Acid, Charcoal, Celite and Sugar Columns

Stripping was carried out following Baldioli et al. [7] in brief the oils were purified by passing 300 g of oil through a chromatographic column (60 × 3 cm), packed with a series of 20 g activated silicic acid (100 mesh; Merck, Darmstadt, Germany), 10 g activated charcoal and Celite 2:1 (Serva, Feinbiochemica, Heidelberg, Germany), 40 g powdered sugar (Münster, Germany, local supermarket) and Celite 2:1, and 20 g of activated silicic acid. The silicic acid was activated as follows: 300 g of silicic acid was suspended in distilled water and agitated. After 20–30 min. of settling all the suspended silicic acid was decanted, and the process was repeated three times. A 500-mL amount of methanol was then added with agitation, and the slurry was allowed to settle for 30 min. Supernatant methanol was then decanted, and the silicic acid was dried in three stages: first on a water bath at 100 °C, then at 100 °C in an oven for 12 h, followed by activation at 200 °C for 12 h.

The solvent in the eluant was evaporated using a rotary evaporator at 40 °C, and the solvent traces were removed by flushing with nitrogen. Samples of purified and crude oils were kept at –18 °C for analysis. All determinations were carried out in triplicate.

Oil Stripping Using an Aluminum Oxide Column

Samples of SCO, MBO, and SBO were purified from antioxidants and from trace metals and other prooxidants via adsorption chromatography using a glass column (40 × 2.5 cm ID) packed with 250 g of activated alumina (100 °C for 8 h and then at 200 °C for 12 h) suspended in petroleum ether. Following Lampi et al. [14], the oil (100 g) was dissolved in an equal volume of petroleum ether and passed through the column, which was then washed then with 200 mL of *n*-hexane. The chromatographic column was wrapped with aluminum foil to prevent light-induced oxidations during the purification process, and triacylglycerols were collected in an aluminum foil-wrapped flask. The solvent in the eluant was evaporated using a rotary evaporator at 40 °C, and the solvent traces were removed by flushing with nitrogen. Samples of purified and crude oils were kept at –18 °C for analysis. All determinations were carried out in triplicate.

Stripping by Extraction of Phenolic Compounds

The phenolic compounds were extracted following the method of Tsimidou et al. [15]. In brief, 50 g oil was dissolved in 50 mL petroleum ether, then extracted three times with 30 mL of a mixture consisting of methanol:water (60:40, v/v). The three extracts were combined and treated once with 50 mL petroleum ether. The solvent was evaporated to dryness in a rotary evaporator (Büchi, Switzerland) at 40 °C. All determinations were carried out in triplicate.

Fatty Acid Analysis

The fatty acid composition of SBO, SCO and MBO was determined following the ISO [16] method. In brief, one drop of the oil was dissolved in 1 mL of *n*-heptane, 50 μL 2 M sodium methanolate in methanol was added, and the closed tube was agitated vigorously for 1 min. after addition of 100 μL of water, the tube was centrifuged at 4,500*g* for 10 min. and the lower aqueous phase was removed. After adding 50 μL 1 M HCl to the heptane phase, the two phases were briefly mixed and the lower aqueous phase was rejected. About 20 mg of sodium hydrogen sulfate (monohydrate, extra pure, Merck, Darmstadt, Germany) was added, and after centrifugation at 4,500*g* for 10 min. the top *n*-heptane phase was transferred to a vial and injected into a Varian 5890 gas chromatograph equipped with a capillary column, CP-Sil 88 (100 m long, 0.25 mm ID, film thickness 0.2 μm). The temperature program was: from 155 °C heated to 220 °C (1.5 °C/min.), 10 min isothermal; injector 250 °C, detector 250 °C; carrier gas 1.07 mL/min hydrogen; split ratio 1:50; detector gas 30 mL/min hydrogen; 300 mL/min air and 30 mL/min nitrogen; manual injection volume less than 1 μL. The peak areas were computed by integration software and the percentages of fatty acid methyl esters (FAME) were obtained as a weight percent by direct internal normalization.

Tocopherols

For determination of tocopherols, a solution of 250 mg oil in 25 mL *n*-heptane was directly used for the HPLC. The HPLC analysis was conducted using a Merck-Hitachi low-pressure gradient system, fitted with a L-6000 pump, a Merck-Hitachi F-1000 Fluorescence Spectrophotometer (detector wavelengths for excitation 295 nm, for emission 330 nm) and a D-2500 integration system. 20 μL of the samples were injected by a Merck 655-A40 Autosampler onto a Diol phase HPLC column 25 cm × 4.6 mm ID (Merck, Darmstadt, Germany) using a flow rate of 1.3 mL/min. The mobile phase used was *n*-heptane/*tert*-butyl

methyl ether (99:1, v/v) [17]. All determinations were carried out in triplicate.

Oxidative Stability (Rancimat Method)

The oxidative stability of the oils was determined by the Rancimat method [18]. All experiments were carried out with a 743 Rancimat (Methrom AG, Herisau, Switzerland). In brief, 3.6 g oil was weighed into the reaction vessel, which was placed into the heating block kept at 120 °C. The air flow was set at 20 L/h for all determinations. Volatile compounds released during the degradation process were collected in a receiving flask filled with 60 mL distilled water. The conductivity of this solution was measured and recorded. The software of the Rancimat evaluated the resulting curves automatically. All determinations were carried out in duplicate.

Statistical Analysis

Each value is a mean of three replications. Values of different parameters were expressed as means ± standard deviations (mean ± SD). The discussion is based on the one-way analysis of variance (ANOVA; $P < 0.05$). All statistical analyses were performed using the SPSS of the windows statistical package (Release 8.0).

Results and Discussion

Fatty Acid Composition of Stripped and Non-Stripped Oils

The fatty acid composition of stripped and non-stripped SCO, MBO and SBO are given in Table 1, 2 and 3, respectively. The results in these tables indicate that non-stripped SCO, MBO and SBO contained oleic, palmitic, stearic and linoleic acids, respectively, which were not significantly ($P < 0.05$) different than stripped SCO, MBO and SBO. The results of fatty acid of this work are similar to those of Mariod et al. [3] who found that the predominant fatty acids in *Sclerocarya birrea*, melon bug and sorghum bug oils were oleic, palmitic, stearic and linoleic acids, respectively.

Vegetable oils have different susceptibilities to oxidative degradation due to differences in their fatty acid composition and their contents of known and unknown antioxidant/prooxidant components. As a general assumption from Tables 1, 2, and 3, the stripping methods does not affect the fatty acid composition. Previous studies [12] showed no change in fatty acid composition of non-stripped and stripped borage and evening primrose oils. Baldioli et al. [7], Psomiadou et al. [19] and Khan and Shahidi [12] indicated the possibility of using a silicic acid column for the chromatographic techniques to provide an effective

Table 1 Fatty acids (%), tocopherols composition (mg/100 g) and peroxide value (mequiv/kg) of non-stripped and stripped *Sclerocarya birrea* oil (SCO)

	Fatty acids (FA)					Oleic/linoleic ratio	Tocopherols (TOC)			Total TOC	Peroxide value (PV)
	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Other[A] FA		α-T	γ-T	δ-T		
Non-stripped	14.2 ± 0.5	8.8 ± 0.3	68.0 ± 1.1	5.9 ± 0.2	3.1 ± 0.1	11.5 ± 0.3	0.357 ± 0.1	13.047 ± 0.3	0.320 ± 0.1	13.72 ± 0.3	0.5 ± 0.1[a]
Stripped by PC extraction	14.2 ± 0.5	8.2 ± 0.3	68.5 ± 1.2	5.6 ± 0.2	3.5 ± 0.1	12.2 ± 0.3	0.00 ± 0.0	9.546 ± 0.4	0.194 ± 0.1	9.74 ± 0.3	1.5 ± o.4[b]
Stripped by Aluminum column	14.4 ± 0.5	8.5 ± 0.3	68.5 ± 1.2	5.1 ± 0.2	3.5 ± 0.1	13.4 ± 0.2	0.00	0.00	0.00	0.00	5.3 ± 0.5[c]
Stripped by silicic column	13.9 ± 0.4	8.8 ± 0.3	68.3 ± 1.4	5.6 ± 0.2	3.4 ± 0.1	12.2 ± 0.3	0.00	0.00	0.00	0.00	4.2 ± 0.3[d]

Values are means of three determinations ± SD. Values followed by different letters in each row are significantly different ($P < 0.05$) from one another

PC phenolic compounds

[A] Other minor fatty acids include: 14:0, 16:1, 20:0, 20:1, 22:0, 22:1, 24:0, and 24:1

Table 2 Fatty acids (%), tocopherols composition (mg/100 g) and peroxide value (mequiv/kg) of non-stripped and stripped melon bug oil (MBO)

	Fatty acids (FA)						Oleic/ linoleic ratio	Tocopherols (TOC)			Total TOC	Peroxide value (PV)
	Palmitic acid	Palmitoleic	Stearic acid	Oleic acid	Linoleic acid	Other[A] FA		α-T	γ-T	δ-T		
Non-stripped	30.9 ± 0.1	10.7 ± 0.2	3.5 ± 0.3	47.1 ± 0.3	3.9 ± 0.3	3.9 ± 0.3	12.0 ± 0.4	0.168 ± 0.1	0.135 ± 0.1	0.00 ± 0.0	0.303 ± 0.1	1.2 ± 0.3[a]
Stripped by PC extraction	30.9 ± 0.1	10.6 ± 0.2	3.5 ± 0.3	47.4 ± 0.3	3.6 ± 0.3	4.0 ± 0.3	13.2 ± 0.4	0.00 ± 0.0	0.048 ± 0.1	0.124 ± 0.1	0.17 ± 0.1	2.3 ± 0.5[a]
Stripped by Aluminum column	30.7 ± 0.1	10.9 ± 0.2	3.6 ± 0.3	47.4 ± 0.3	3.8 ± 0.3	3.6 ± 0.3	12.5 ± 0.4	0.00	0.00	0.00	0.00	6.4 ± 0.7[b]
Stripped by silicic column	30.8 ± 0.1	10.4 ± 0.2	4.1 ± 0.3	47.5 ± 0.3	3.7 ± 0.3	3.6 ± 0.3	12.8 ± 0.4	0.00	0.00	0.00	0.00	6.0 ± 0.5[b]

Values are means of three determinations ± SD. Values followed by different letters in each row are significantly different ($P < 0.05$) from one another

PC phenolic compounds

[A] Other minor fatty acids include: 14:0, 16:1, 20:0, 20:1, 22:0, 22:1, 24:0, and 24:1

Table 3 Fatty acids (%), tocopherols composition (mg/100 g) and peroxide value (mequiv/kg) of non-stripped and stripped sorghum bug oil (SBO)

	Fatty acids (FA)							Oleic/ linoleic ratio	Tocopherols (TOC)			Total TOC	Peroxide value (PV)
	Palmitic acid	Palmitoleic	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid	Other[A] FA		α-T	γ-T	δ-T		
Non-stripped	12.2 ± 0.4	1.0 ± 0.4	7.3 ± 2	40.9 ± 0.5	34.5 ± 0.5	1.1 ± 0.2	3.0 ± 0.2	1.2 ± 0.0	0.88 ± 0.2	32.16 ± 0.5	0.78 ± 0.3	34.03 ± 0.6	3.1 ± 0.5[a]
Stripped by PC extraction	13.0 ± 0.4	1.8 ± 0.4	7.0 ± 2	40.1 ± 0.5	33.8 ± 0.5	0.8 ± 0.2	3.3 ± 0.2	1.2 ± 0.0	0.75 ± 0.3	16.24 ± 0.5	0.18 ± 0.2	17.33 ± 0.6	6.5 ± 0.6[b]
Stripped by Aluminum column	13.0 ± 0.4	1.8 ± 0.4	7.0 ± 2	40.8 ± 0.5	33.2 ± 0.5	0.9 ± 0.2	3.3 ± 0.2	1.2 ± 0.0	0.00	0.00	0.00	0.00	8.2 ± 0.8[c]
Stripped by silicic column	12.6 ± 0.4	1.0 ± 0.4	7.3 ± 2	41.4 ± 0.5	33.8 ± 0.5	1.1 ± 0.2	2.8 ± 0.2	1.2 ± 0.0	0.00	0.00	0.00	0.00	7.8 ± 0.6[d]

Values are means of three determinations ± SD. Values followed by different letters in each row are significantly different ($P < 0.05$) from one another

PC phenolic compounds

[A] Other minor fatty acids include: 14:0, 16:1, 20:0, 20:1, 22:0, 22:1, 24:0, and 24:1

Table 4 Oxidative stability [h] (Rancimat 120 °C) of non-stripped and stripped *Sclerocarya birrea* oil (SCO), melon bug oil (MBO) and sorghum bug oil (SBO)

Oil	Non-stripped	Stripped by PC extraction		Stripped by aluminum column		Stripped by silicic column	
	(h)	(h)	(% decrease)	(h)	(% decrease)	(h)	(% decrease)
SCO	43.0 ± 2.1^{a}	33.5 ± 1.3^{b}	22.0 ± 0.2	1.3 ± 0.4^{c}	96.9 ± 1.6	3.2 ± 0.7^{d}	92.6 ± 1.1
MBO	38.0 ± 1.5^{a}	23.7 ± 1.0^{b}	37.6 ± 0.5	0.7 ± 0.1^{c}	98.2 ± 2.2	1.5 ± 0.5^{c}	96.1 ± 1.5
SBO	5.1 ± 0.4^{a}	3.9 ± 0.3^{a}	23.5 ± 0.3	0.5 ± 0.1^{b}	90.2 ± 0.6	0.7 ± 0.2^{b}	86.3 ± 0.7

Values are means of three determinations ± SD. Values followed by different letters in each row are significantly different ($P < 0.05$) from one another

PC phenolic compounds

means of purifying and stripping vegetable oils of their minor components.

Tocopherol Composition of Stripped and Non-Stripped Oils

Vegetable oils contain tocopherols and tocotrienols, especially α- and γ-tocopherols, as their main antioxidants. The antioxidant behavior of tocopherols represents a complex phenomenon as they are efficient antioxidants at low concentrations but they gradually lose their efficacy as their concentrations in the vegetable oils increase [11].

The effect of the stripping method on tocopherol composition of SCO, MBO and SBO is given in Tables 1, 2 and 3, respectively. From these tables it is clear that the stripping methods affect the tocopherol composition of the studied oils, the total amount of tocopherol in non-stripped oils decreased by extraction of phenolic compounds, which means that part of the tocopherol content was extracted with the phenolic compounds. No traces of tocopherols were found in oils stripped using silicic and aluminum columns meaning that tocopherols were eliminated during the stripping processes. Khan and Shahidi [12] reported that no tocopherols were detected in borage and evening primrose oils purified using a silicic acid column.

Oxidative Stability of Stripped and Non-Stripped Oils (Peroxide Value Test)

The peroxide values of stripped and non-stripped SCO, MBO and SBO are presented in Tables 1, 2 and 3. Since the oils were obtained from three different sources, the initial qualities, as reflected by their peroxide value were somewhat different. The peroxide values of stripped SCO, MBO and SBO were higher ($P < 0.05$) than those of their corresponding non-stripped counterparts. Oils stripped by using an aluminium column method showed a higher peroxide value in comparison with the other two stripping methods.

Oxidative Stability of Stripped and Non-Stripped Oils (Rancimat Test)

Table 4 shows the effect of the stripping methods on the oxidative stability of SCO, MBO and SBO. Total phenolic compounds level of SCO, MBO and SBO were 3.3, 20.7 and 0.95 mg/100 g oil, respectively [3]. Although the oxidative stability of the SCO was considerably higher than that of MBO, the oxidative stability of the three oils does not correlate directly with the amount of phenolics. It has been mentioned that oil stability is correlated not only with the total amount of phenolics, but also with the presence of selected phenols [20]. Stripping by extraction of phenolic compounds has a significant affect on the oils' stability measured by induction period (IP). The induction periods of non-stripped SCO, MBO, and SBO oils were 43.0, 38.0 and 5.1 h, respectively, these induction periods decreased by 22, 37, and 23.5% respectively in stripped oils. This means that, theoretically, the phenolic compounds share in stability by 22, 37, and 23.5%. In oils after removal of phenolic compound, the difference in stability between non-stripped MBO and stripped MBO was much greater than the difference in stability between non-stripped SCO and stripped SCO and that between non-stripped SBO and stripped SBO and that is in agreement with their total phenolic compounds order which is MBO > SCO > SBO.

The stability (as induction period IP) of SCO, MBO and SBO oils stripped using silicic column decreased by 96.9, 98.2 and 90.2%, respectively (Table 4). Which theoretically means that these oils do not contained tocopherols, phenolic compounds, and sterols which are the responsible components for oxidative stability of oils. The decrease in stability between non-stripped MBO and stripped MBO (98.2%), was much greater than the difference in stability between non-stripped SCO and stripped SCO (96.9%), and that between non-stripped SBO and stripped SBO (90.2%) in spite of the total tocopherol content of the three oils were in the order of SBO > SCO > MBO [3].

Previous studies [21, 22] used a column packed with alumina to purify oils from antioxidants and from trace

metals. Fuster et al. [22] reported that the analysis of sunflower, high oleic sunflower, and rapeseed oils purified using a glass column packed with alumina showed that they were composed mainly of triacylglycerols together with minor amount of sterol esters.

In oils stripped using a silicic acid column, the difference in stability between MBO and purified MBO was much greater than the difference in stability between SCO and purified SCO and that between SBO and purified SBO in spite of the total sterols were in the order SBO > SCO > MBO (449.9, 286.6 and 17.5 mg/100 g, respectively) [3]. From these results it is quite clear that stripping methods have a great affect on the oils' oxidative stability, stripping using silicic and aluminum columns has a greater affect and the decrease in the induction period was much higher than stripping using the phenolic compound extraction method.

The non-stripped oils contain the main four components that are assumed to be responsible for the stability. They are fatty acids as triacylglycerols, tocopherols, sterols and phenolic compounds. Oils stripped by phenolic compound extraction are assumed to contain triacylglycerols, tocopherols, sterols, while oils stripped using alumina column contain triacylglycerols and sterols, oils purified using a silicic acid column contained only the triacylglycerols. From these results it is possible to assume that the stability of the three oils is due to the combined effect of fatty acids, tocopherols, sterols and phenolic compounds, and that tocopherols and phenolic compounds play an active role in the oxidative stability of the three unconventional oils more than the fatty acid composition and phytosterols under the Rancimat oxidation conditions.

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