Available online at www.elixirpublishers.com (Elixir International Journal)

Agriculture

Elixir Agriculture 67 (2014) 21554-21556

ISSN: 2229-712X

The effects of dewaxing on the physico-chemical properties of some vegetable oils

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ARTICLE INFO

Article history:
Received: 26 September 2012;
Received in revised form:
24 January 2014;
Accepted: 7 February 2014;

Keywords
Vegetable oil,
Solidification,
Turbidity,
Wax,
Dewaxing.

ABSTRACT

The effects of dewaxing on the physico-chemical properties of some brands of vegetable oil have been investigated. Five (5) brands of crude vegetable oil including soybean oil (SO), beniseed oil (BO),cottonseed oil (CSO) and palm kernel oil (PKO) were used for these investigations. The physico-chemical properties and the wax contents were determined before and after the dewaxing operation. The wax contents (ppm), saponification numbers, % free fatty acid contents, slip melting points (^{0}C) of the oil samples were reduced while the iodine values of the oil samples increased after the dewaxing operation. The dewaxed oil samples showed good abilities to withstand refrigerator temperature.

Introduction

Vegetable oil is oil from vegetable sources such as palm fruit, palm kernel, peanut, corn, cottonseed, soybean etc. It is composed of triglycerides of stearic, palmitic, lauric or any other fatty acid and very small amount of non-glyceride materials, such as lecithins, cephalins (especially those from oil seeds), sterols, hydrocarbons, wax and some free fatty alcohols. β – carotenes, chlorophyll and tocopherol (Vit. E) are also present in fats and oils [1,2].

The fatty acids differ in chemical composition. Some are saturated e.g. arachidic, Butyric, Palmitic, Stearic, Myristic, Capric, Caprilic etc, while some are unsaturated e.g. Oleic, Linoleic, Elaidic, Palmitoleic, Arachidonic acids etc.

Generally speaking, the saturated fatty acids are called fats and are usually solids at atmospheric temperature while the unsaturated fatty acids are called oils and are usually liquids at atmospheric temperature [3].

Presently in Nigeria, the principal edible oils sold in the markets are refined palm/palm kernel oils, soybean oil, cottonseed oil and corn oil. There are also the unrefined peanut and palm oils sold in the markets. Beniseed (*Sesame indicum*) oil is also found in Nigeria's markets.

Palm oil consists mainly of a balanced mixture of saturated fatty acids, which constitute the yellow/orange solid fraction and unsaturated fatty acid (oleic lineoleic) that constitute the reddish liquid fraction [4,5]. The fatty acids of palm oil are essentially 45% palmitic acid and 55% mixed 18 carbon acids [4]. Palm oil is constituted of about 52.1% saturated fatty acids. Palm kernel oil has a high content of lauric and myristic acids and is constituted of about 84.2% saturated fatty acids. Peanut oil has high oleic and linoleic acids content and is constituted of about 18.9% of unsaturated fatty acids. Soybean oil contains small quantities of wax and other non-glycerides consisting mainly of lecithins and cephalins. It consists of mainly linoleic acid. It is constituted of about 86% of unsaturated fatty acids. Cottonseed oil contains small quantities of phosphatides and other non-glyceride substances. It is constituted of about 70.5% unsaturated fatty acid. Corn oil contains higher percentage of oleic and linoleic acids than cottonseed oil and other non-glyceride materials. However, it contains little quantity of wax. It is constituted of about 86.1% unsaturated fatty acids. [6]. The fatty acid composition of a typical beniseed (*Sesame indicum*) oil sample has been reported as 7-11 % of palmitic acid, 39-56 % linoleic acid, 2-6 % of stearic acid and 32-54 % of oleic acid [7]. Antioxidants and several steroids have also been found in beniseed oil.

It is common with some of these oils (especially those of palm origin) to form cloud (or crystallize) at ordinary temperature while some (especially those from oil seeds) remain clearly liquid at ordinary temperature, or even when chilled.

The cloudiness in oils in attributed to the presence of wax and or some saturated glycerides with high molecular weight, and of limited solubility in the liquid fraction of the oil. Also the presence of short chain fatty acids at level of about 50% makes the oil solid at slightly below room temperature.

Wax is not harmful but the formation of cloudy precipitates in the oil at ordinary temperature makes it unacceptable in oils especially to the commercial producer of mayonnaise who needs oils that would not solidify on chilling. Wax or solid fats are not acceptable in salad oils.

Waxes are esters of higher fatty acids with very long chain. The ester is formed within this long chain fatty acids and monohydric fatty alcohols or with steroids. They are usually water-insoluble. The most common of the alcohols used in this ester formation is myricil alcohol. This reacts with palmitic acid to form the ester called myricil palmitate. Cetyl alcohol also forms an ester, cetyl palmitate with palmitic acid.

Besides these esters, waxes also contain higher molecular weight un-branched hydrocarbons. These result from the decarboxylation of fatty acids. They also contain esters of steroids (steroid alcohols), free fatty acids as well as hydroxyl fatty acid [8].

This paper presents the effect of dewaxing on the physico-chemical properties of some common brands of vegetable oil.

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Materials And Methods

The crude oil samples used for these tests were obtained from the Raw Materials Research and Development Council (RMRDC) Lagos. The oil samples are soybean oil, beniseed oil cottonseed oil, palm kernel oil. The tests carried out on the samples include (i) cold stand (ii) cloud point (iii) slip melting point (iv) wax content (v) saponification number (vi) iodine value (viii) free fatty acid. The cold stand, cloud point and slip melting point were determined according to the methods described by Ogbuagu, (1995) [9]. The saponification number (S.N) and iodine value (1.V) were determined according to the various methods described by James (1995) [10]. The free fatty acid (FFA) was determined by the method described by Pearson (1976) [11]. The wax content was determined using the turbidimetric (spectrophotometric) method described by Morrison and Russell (1982) [12]. The tests were carried out on the oil samples before and after the dewaxing operation. The dewaxing operation was carried out according to the method described by Sullivan (1976b) [13].

Results And Discussion

The result of the cold stand analysis is presented in table 1 while the results of the wax content and some of the physico-chemical properties of the crude and dewaxed oil samples are presented in Tables 2a and 2b.There are marked effects on the physical properties of the oil samples after the dewaxing operation.

The results of the analyses show that amongst the oil samples used for the study, soybean oil has the highest wax content (4.10ppm) while palm kernel oil has the lowest wax content (2.50ppm). The wax contents of the oil samples were reduced after the dewaxing operation and also with soybean having the highest wax content (3.70ppm) and palm kernel oil with the lowest wax content (2.30ppm).

The cloud points and the melting points decreased after the dewaxing operation. The undewaxed and the dewaxed soybean oil samples have the lowest cloud and melting points while the palm kernel oil samples have the highest values.

The results of the melting point and the cloud point are also reflective of the result of the cold stand as the dewaxed oil samples showed improved ability to withstand refrigerator temperature (Table 1). The ability of palm kernel oil to remain liquid was also improved after the dewaxing operation as the solidified mass, under the refrigerator temperature, melted within 20 minutes on being brought out of the refrigerator as against the undewaxed sample which solidified and remained so for a very long time (≤ 1 hour).

The chemical properties were also affected as a result of the dewaxing operation. The free fatty acid composition of the oil samples were reduced after the dewaxing operation with soybean oil; 0.32- 0.27%., beniseed oil; 0.34-0.29%., cottonseed oil; 0.30-0.26% and palm kernel oil; 0.38-0.32%.

There were decreases in the saponification numbers of the oil samples after the dewaxing operation; soybean oil , 193.30-189.62., beniseed oil, 195.79-191.86., cottonseed oil, 197.47-193.00., palm kernel oil, 217.00-199.72 and increases in the iodine numbers of the oil samples after the dewaxing operation; soybean oil, 73.60-121.82., beniseed oil, 63.45-111.67., cottonseed oil, 53.30-106.60., palm kernel oil, 40.68-73.68.

Saponification number of fats and oils relates inversely to the average molecular weight fatty acid composition of the fat or oil. Thus, a small saponification number indicates that the fat or oil is composed of long-chain or high molecular weight fatty acids. Again, the more saturated a fat or oil is, the higher the saponification number and/or the lower the iodine number. In other words, the more unsaturated a fat or oil is, the less the saponification number.

Table 1: Cold Stand Of The Un-Dewaxed and Dewaxed oil samples.

	Oil samples	Undewaxed	Dewaxed
1.	Soyabean Oil (SO)	Did not solidify	Did not solidify
2.	Benniseed Oil (BO)	Did not solidify	Did no solidify
3.	Cottonseed Oil (CSO)	Solidified slightly	Did no solidify
4.	Palm kernel Oil (PKO)	Solidified and remained so for a very long time (≤ 1 hour).	Solidified but melted after 20 minutes it was removed from the refrigerator.

Table 2a: Wax content and the physico-chemical properties of the un-Dewaxed oil samples.

	Oil samples	Wax content (ppm)	Cloud Pt. (^{0}C)	M.Pt. (^{0}C)	I.V	S.N	%FFA
1	Soyabean Oil (SO)	4.10	0-1	1-2	73.60	193.30	0.32
2	Benniseed Oil (BO)	4.00	2-3	3-4	63.45	195.79	0.34
3	Cottonseed Oil (CSO)	3.70	6-7	7-8	53.30	197.47	0.30
4	Palm Kernel Oil (PKO)	2.50	24-25	25-26	40.68	217.00	0.38

Table 2b: Wax contents and the physico-chemical properties of the Dewaxed oil samples

	Oil samples	Wax content (ppm)	Cloud Pt. (^{0}C)	M. Pt. (^{0}C)	I.V.	S.N.	%FFA
1	Soyabean Oil (SO)	3.70	-2 to – 3	-1 to -2	121.82	189.62	0.27
2	Benniseed Oil (BO)	3.50	0.6 to 0.7	0 to 1	111.67	191.86	0.29
3	Cottonseed Oil (CSO)	3.20	0.70 to 0.80	0.60 to 0.70	106.60	193.00	0.26
4	Palm Kernel Oil (PKO)	2.30	11.20 to 11.50	10.50 to 11.50	73.68	199.72	0.32

Table 3: Thermal stabilities of the Un-Dewaxed and Dewaxed oil samples

	Oil Samples	Undewaxed			Dewaxed		
		Smoke Pt. (^{0}C)	Flash Pt. (^{o}C)	Fire Pt. (^{o}C)	Smoke Pt. (^{0}C)	Flash Pt. (^{o}C)	Fire Pt. (^{o}C)
1	Soyabean Oil (SO)	185	278	310	197	286	335
2	Benniseed Oil (BO)	165	265	290	179	280	320
3	Cottonseed Oil (CSO)	155	250	275	168	276	300
4	Palm Kernel Oil (PKO)	142	230	268	162	260	290

Waxes are esters of higher fatty acids with very long chain. The ester is formed within this long chain fatty acids and monohydric fatty alcohols or with steroids. They are usually water-insoluble. The most common of the alcohols used in the ester formation is myricil alcohol. This reacts with palmitic acid to form the ester called myricil palmitate. Cetyl alcohol also forms an ester, cetyl palmitate with palmitic acid. Besides these esters, waxes also contain higher molecular weight un-branched hydrocarbons. These result from the decarboxylation of fatty acids. They also contain esters of steroids (steroid alcohols), free fatty acids as well as hydroxyl fatty acid [8]. These molecules differ from triglycerides by the linear structure and the greater number of carbon atoms [14].

Palmitic acid is a saturated fatty acid. Thus, removal of wax from vegetable oils implies the removal of some saturated fatty acid(s) thereby making the dewaxed oil to be less saturated.

Therefore, the reduction in the saponification numbers of the dewaxed oil samples could have resulted from the reduction in the wax content. In the same vein, the increase in the iodine numbers of the oil samples could have resulted from the relative increase in the unsaturation of the dewaxed oils as a result of the removal of some of the saturates/wax from the oil samples.

The results of the thermal stabilities of the un-dewaxed and dewaxed oil samples are presented in table 3.The thermal stabilities of the oil samples were also increased after the dewaxing operation.

The increase in the thermal stabilities (smoke, flash and fire points) of the dewaxed oil samples resulted from the decrease in the free fatty acid (FFA) content of the dewaxed oil samples. A study on the relationship between smoke point and quality of olive oil also reported that extra virgin olive oils (with low free fatty acids) have a high smoke point [15]. Free fatty acid (FFA) content of a fat or oil affects its thermal stability as an increase in FFA content decreases the thermal stability and vice versa.

Conclusion

Dewaxing of vegetable oils reduces the solidification (crystallization) of the vegetables oils at ordinary temperature. It reduces the melting point, free fatty acid, saponification number but increases the iodine value of vegetables oils. The reduction in the free fatty acid content enhances the quality of the oil.

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