effects of phosphoric acid on physico- chemical parameters of soyabean oil

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Citation

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Abstract

The soybean seeds used for this work were obtained from Gboko in Benue State of Nigeria. The beans were prepared for use by shaker screening, cracking, bin conditioning and flaking. By solvent extraction using hexane, a dark coloured crude oil was obtained.The oil was further treated with 2-3% water and 0.05% phosphoric acid to obtain the degummed oil. Both oil samples were investigated for their physico-chemical parameters such as , melting point, specific gravity, refractive index, colour, flash, smoke, fire, soft and turbidity points the values were; -14.00±1.2C, 0.918±0.006, 1.472±0.010, 35.00±0.00, 342.00±2.12C 228.00±1.95C, 344.00±1.65C, 40.00±1.30Cand 10.00±0.55JTU respectively. Others include, free fatty acid 1.36±0.08%, saponification value 199.63±1.81mg KOH/goil , acid value 2.72±0.17 mg KOH/goil, peroxide value 21.38±1.61meq/peroxide/kg, iodine value 119.21±0.40WIJ and yield 21.00±0.20% for crude soy bean oil. While degummed oil sample were determined, the parameters and values includes; melting point -16.00±1.00C specific gravity 0.917±1.00, Refractive index 1.473±0.003, colour 26.00±0.00units, Free fatty acid 1.08± 1.10%, Saponification value 198.40 ± 1.99 (mg KOH/g oil), Peroxide value 18.14± 2.28 (meq/peroxide/kg), Iodine value 122.04± 4.15 (WIJS) Acid value 2.10 ± 0.20%. The qualitative determination of the fatty acid composition was carried out by methylation and application of gas chromatography. The fatty acid detected includes myristic, palmitic, palmitoleic, stearic, oleic, linoleic, linolenic and traces of arachidic and eicosienic acids, the values were 0.016%, 7.269%,0.014%,2.635%, 21.166%, 39.900%, 6.767%, 0.010%, 0.0000988% respectively for crud soybean oil. Myristic acid 0.018%, palmitic 9.161%, palmitoleic 0.014%, stearic 3.034%, oleic 22.952%, linoleic 47.981%, linolenic 6.284%, arachidic 0.061% and eicosienic 0.0001% for degummed soybean oil. . The result indicated among others, the oil contain high degree

INTRODUCTION

Soybeans (Glycine max) are native to Northeasthern Asia and were first introduced into state in 1765 (Soybeans Reearch Advisary institude,1984). Today, the united state stands the largest producer of soybeans oil with 56% of the world production.

Nigeria set an excellent example of potential for soybeans production and utilization in West and Central African countries. It was first introduced to Nigeria in 1908 and it is widely grown at the middle belt of Nigeria (Root et, al, 1987).

Soybeans was primarily utilized as a sources of oil, However, there are other outlet of soybean products such as meal or cake which are used for animal feed and gum which serves as good source of lecithin.(Liu,2000).

Soybean contains about 18%-23% total lipid. This lipid contains 88.1% neutral lipid, 9.8% phospholipids and 16% glycolipid. Neutral lipid, primarily consists of triglyceride, accompanied by smaller proportion of free fatty acids, sterols and sterol ester. The main components in neutral lipids, phospholipids and glycolipids are palmitic, oleic, linoleic and linolenic acids. (Salunke et al,1992). Soybean oil is characterized by a relatively high content of unsaturated fatty acid and remain a liquid form at ordinary temperature.(Morris and Jacob ,1999).

Practically, all soybean oil is produced by solvent extraction. After this extraction and desolventization , the crude soybean oil contains both oil-insoluble and oil- soluble impurities that must be removed. The oil- insoluble materials may be removed through filteration, however, the soluble materials must be removed by several methods which lead to manufacture of edible soybean oil product(Erickson et al,1980).

The soybean crude oil contains 2% phosphatide as one of the soluble material in which 1.8% are hydratable which can be removed with 2-3% hot water. The remaining 0.2% phosphatide are non-hydratable, and thus, the addition of

phosphoric acid to the oil will remove this type of phosphatide.(Lucas, 2002).

The removal of gum either hydrable or non-hydratable is referred to as degumming. The process is carried out to; produce lecithin, degummed oil that can stand for a long term storage or transportation and prepare oil suitable for physical refining (Erickson, et al, 1980).

However soybean oil is the dominant vegetable oil used domestically in edible oil products such as salad, cooking oils, shortenings, margarines and also find it uses in industrial applications.

This paper is however aimed at extracting, degumming as well as characterizing of both crude and degumming soybean oil with the purpose of considering the effect of phosphoric acid (a degumming agent) on physic chemical parameters on the oil samples (crude soy bean oil and degummed soybean oil)

MATERIALS AND METHOD

The soybeans used for this work were obtained from Gboko in Benue State of Nigeria. They were prepared for use by shaker screening, cracking, bin conditioning and flaking. A soxhlet extractor was used for solvent extraction of the oil. The crude oil collected was further degummed with 2-3% of hot water and 0.05% of 75% phosphoric acid the mixture was agitated and allow to settle for 45 minutes after which the phosphotide (gum) drained from the reaction vessle. The crude and degummed oils obtained were used for physic-chemical and fatty acid composition determination.

The moisture contents, melting point and specific gravity were determined according to official standard method.(AOAC,1984). The refractive index was determined by Abbe Refractometer while the colour was determined using Lovibond tintometer in one inch cell. The colour which was in unit was calculated based on (5R+Y-B) where R is Red pigment Y is Yellow and B is Blue pigment.(Carson, 1995).

The smoke point, flash point, fire point and soft point were measured by American society of testing materials (ASTM,2005). The Turbidity was determined using Palm Test Turbidity Tube (ASTM,2005).

The chemical properties of the oil samples free fatty acid, saponification, peroxide value iodine value and acid value were determined by official standard method (AOAC,2005). Analytical test method for fatty acid methyl esters was done using Agilent 6890 series Gas chromatography filled with a flame ionization detector and enhanced integrator. Helium gas was used as carrier gas. The column initial temperature was 250^{O}C rising at 10 ^{O}C /mm to a final temperature of 300 ^{O}C while the injection and dectetor were maintained at 250 ^{O}C and 300 ^{O}C respectively.

A polar capillary column (30m X 0.25mm) was used to separate the esters. The peaks were identified by comparism with standard fatty acid methylesters obtained from Johnson wax Nigeria Ltd, Lagos.

RESULTS AND DISCUSSION

Figure 1

Tables1: Shows the physico-chemical parameters of crude and degummed soybean oil.

Parameters	Crude oil sample	degummed oil sample
Melting point ^{O}C	-14.00±1.20	-16.00±1.00
Specific gravity	0.918±0.06	0.917±0.003
Refractive index at 2^{O}C	1.472±0.010	1.473 ± 0.003
Flash point (^{O}C)	342.00 ± 2.12	335.00 ± 1.78
Fire point (^{O}C)	344.00 ± 1.65	343.00 ± 1.05
Smoke point (^{O}C)	228.00 ± 1.95	232.00 ± 1.23
Turbidity point (^{O}C)	10.00 ± 0.55	5.00 ± 0.23
Soft point (^{O}C)	40.00 ± 1.30	38.00 ± 1.10
Moisture content (%)	Nil	Nil
Colour (units)	35.00 ± 0.00	26.00 ± 0.00
Free fatty acid (%)	1.36 ± 0.08	1.08 ± 1.10
Saponification value (mg/KOH/goil)	199.63 ± 1.81	198.40 ± 1.99
Peroxide value (meq/peroxide/kg)	21.38 ± 1.61	18.14 ± 2.28
Iodine value (WIJS)	119.21 ± 0.4	122.04 ± 4.15
Acid value (%)	2.72 ± 0.17	2.10 ± 0.20
Yield(%)	21.00 ± 2.00	

Mean ± standard deviation of triplicate determination.

Figure 2

Table 2:The fatty acid composition of crude and degummed soybean oils

Fatty Acid Methyl ester	fatty acid	carbon Number	Crude soy beans oil (%)	Degummed soy bean oil (%)
Methyl Myristate	myristic	14:0	0.016	0.18
Methylpalmitate	palmitic	16:0	7.269	9.161
Methylpalmitoleate	palmitoleic	16:1	0.014	0.014
Methylstearate	Stearic	18:0	2.635	3.034
Methyloleate	oleic	18:1	21.166	22.952
Methyllinoleate	linoleic	18:2	39.900	47.981
Methyllinoleneate	linolenic	18:3	6.760	6.284
MethylArachideate	Arachidic	20:0	0:010	0.061
MethylEicosenoate	Eicosenic	20:1	0.0000988	0.0001

Figure 3

Table 3: Summary of Result of fatty acid composition of soybean oils.

Oil	Saturated Fatty Acids (%)	Monosaturated fatty acids (%)	Poly unsaturated fatty (%/)	Total
Crude	9.930	21.180	46.660	77.770
Degummed	12.274	22.966	54.265	89.505

DISCUSSION

Table 1 presents the result of the physico- chemical parameters of the crude and degummed soybean oils. The moisture content of both the oil samples was not detected. This was as a result of the efficiency of distillation unit used for obtaining the crude oil from oil-solvent mixture and centrifuge machine used for the separation of both the gum (phosphatide), the water and neutral oil.

The colour of the crude was 35 Lovibond units in 1 inch cell and this was reduced to 26. Lovibond units after degumming the crude oil. This might be as a result of phosphoric acid used for degumming which might have removed some red colour pigments from the crude oil thereby making the oil becoming more yellowish.(Reward ,1997). The melting point of the crude soybean oil which was -14.00 ±1.20 decreases to -16.00±0.006 after degumming. This is an indication that the oil sample is a liquid at room temperature and that the degummed oil is more pure than the crude oil because of the presence of impurities lower the melting point of the substance. (Wiedermann,1985). There was no remarkable difference in the specific gravity and refractive index of the oil samples. The specific gravity was within the range value of 0.924 to 0.926 reported by (Lillian,1978), while the refractive index was within the range value of 1.472 to 1.476 as reported by (Samah and Allan,2001).

The result of the smoke point, flash point, fire point and soft point for crude soybean oil were 228.00±0 ,1.95 ^{O}C , 342.00±2.12 ^{O}C , 344.00±1.65 ^{O}C , and 40.00±1.30 ^{O}C respectively.while that of degummed oil were, smoke point, 232.00±1.23 ^{O}C, flash point, 335.00±1.78 ^{O}C, fire point, 343.00±1.05 ^{O}C, and soft point, 38.00±1.10 ^{O}C. There was decrease in those values from crude to degummed oil samples except for smoke point, this is owing to the fact that the phosphatide and other suspended impurities have been removed in the process of degumming. The turbidity point for crude and degummed soybean oil samples were 10.00±0.55 ^{O}C and 5.00±0.23 ^{O}C respectively. This showed that impurities present in the crude oil sample make clearity difficult. The free fatty acid content of the crude and degummed oil samples were 1.36±0.08% and 1.08±1.10% respectively. Though, the phosphoric acid used for degumming does not have direct reaction with free fatty acid, yet, some of the free fatty acid was lost to water used for degumming process.

The saponification value of soybean oil decreases from crude to degummed oils. The values were determined to be 199.63±1.81 mgKOH/goil and 198.40±1.99 mgKOH/goil respectively. The values obtained were in conformity with the value range of 197mg/KOH to 199.00 mg KOH/goil reported by (Erickson,et al,1980). The peroxide value of oil as reported by (Gunstone and Norris, 1983) was a measure of oxidative rancidity of oil. The peroxide value for crude and degummed soybean oils were 21.38 meg/peroxide kg and 18.14 Meq /peroxide / kg respectively. These high peroxide values were an indication that the oil sample was prone to oxidative rancidity. According to Howard, (1997), the iodine value of oil is the degree of unsaturation and indicated a range value of 120 to 143WIJS for soybean oil. The values obtained for crude and degummed oils were 119.21WIJS and 122.04 WIJS respectively. This was an indication that the degree of unsaturated was high in degummed than crude oil samples. This was owing to impurities present in the crude oil sample which lower the iodine value.

Table 2 depicts the result of fatty acid composition of crude and degummed soybean oil. The saturated fatty acids detected were myristic, palmitic, stearic and arachidic acids.

The values obtained for crude oil sample were 0.016, 7.269, 2.635 and 0.010 % /100g of oil respectively. This was an indication that the addition of phosphoric acid to degume crude oil allows more fatty acids to be detected.

The monounsaturated fatty acids detected in all the oil samples include Palmitoleic, Oleic and Eicosenic acids. The values obtained for crude oil were 0.014, 21.116 and 0.0000988 % /100g respectively. While that of degummed oil samples were 0.014, 22.952, and 0.0001 % /100g of oil respectively. The value of degummed oil sample was higher than that of crude oil sample. However, there was no remarkable difference in the value of palmitoleic acid content. Oleic acid was the major monounsaturated fatty acid in the oil samples. The values obtained for crude and degummed oil samples were 21.116 and 22.952 % / 100g of oil respectively. The value of degummed oil was higher than that of crude oil sample .However, this value were in line with the range values reported by Guy, (2000). Eicosenic acid was detected but it was infinitesimally low in value.

The polyunsaturated fatty acids detected were linoleic and linolenic acids. The linoleic acids values for crude degummed oil samples were 39.900 and 47.981% / 100g of oil respectively. The values of linolenic acids for crude and degummed oil samples were 5.760 and 6.284% / 100g of oil respectively.

It was linoleic acids that had the highest value among all the different fatty acid detected. This acid is responsible for high level of unsaturation of soybean oil. However, the value was within the range value reported by (Guy, 2000).

Table 3 present the summary of result of fatty acid composition of crude and degummed oil samples. The percentage saturated, monosaturated and polyunsaturated fatty acids for crude oil sample were 9.930 % /100g, 21.130 % /100g and 45.660 % /100g of oil respectively giving a total of 76.720 % /100g. The values of saturated, monounsaturated and polyunsaturated fatty acids for degummed oil sample were 12.229 % /100g, 22.9661 % /100g and 54.265 % /100g respectively. This amount to a total value of 89.4601. An indication that more fatty acids were detected after degumming process.

CONCLUSION

The results of the investigation carried out on crude and degummed soybean oil samples revealed that the quality of oil improved after phosphoric acid treatment. However, the physico-chemical parameter and fatty acid composition of both samples were an indication that the oil samples was more of unsaturated triglyceride than saturated triglyceride. Nevertheless, the degummed oil sample was not suitable enough for consumption.

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