
FATTY ACID PROFILE, PHYSICO-CHEMICAL AND FUNCTIONAL PROPERTIES OF OIL AND PROTEIN ISOLATE SIMULTANEOUSLY EXTRACTED FROM SESAME (*Sesamum indicum*) SEED

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Abstract

This work evaluated the fatty acid profile, physico-chemical characteristics of oil, physico-chemical and functional properties of protein isolate produced from sesame seeds by the application of simultaneous recovery technique through aqueous process under optimal conditions. The fatty acid profile of the extracted oil indicated high level of unsaturated fatty acids (82.95%), which consists of 43.89% monounsaturated and 39.06% polyunsaturated fatty acids. The major fatty acids are oleic acid (43.59%) and linoleic acid (38.53%). Physico-chemical properties of the oil showed specific gravity, 0.91; viscosity, 39.10 cP; refractive index, 1.471; flash point, 248 °C; smoke point, 227 °C; acid value, 4.488 mgKOH/g oil; iodine value, 112.21 g/100g; peroxide value, 6.0 meq O₂/kg oil; saponification value, 192.24 mgKOH/g oil and free fatty acids, 2.24% oleic acid. Physico-chemical properties of the sesame protein isolate (SPI) showed that it has bulk density and pH of 0.173 g/ml and 6.16, respectively. Functional properties of SPI showed water absorption capacity, 296.55%, oil absorption capacity, 131%; emulsifying activity index, 13.76 m²/g; emulsion stability index, 44.13%; foam capacity, 64.63%; foam stability, 11.24 % and least gelation capacity, 5%. The results showed that sesame oil and protein could be recovered simultaneously under optimal conditions without corresponding adverse effects on the fatty acid profile, physicochemical and functional properties and could find possible use as foods and food ingredients.

Keywords: Sesame oil, sesame protein isolate, fatty acid profile, physico-chemical properties, functional properties, simultaneous recovery technique

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1. INTRODUCTION

Sesame (*Sesamum indicum* L.), otherwise known as sesamum or benniseed, member of the family *Pedaliaceae*, is one of the most ancient oilseed crops known to mankind. Sesame is grown primarily for its oil-rich seeds. The seed is rich in protein and the protein has amino acid profile with good nutritional value (NAERLS, 2010). The chemical composition of sesame shows that the seed is an important source of oil (44-58%), protein (18-25%), carbohydrate (~13.5%) and ash (~5%) (Borchani *et al.*, 2010). Sesame seed is primarily grown for its oil in Nigeria and the oil is a primary source of cooking oil in Eastern Nigeria. Its oil is odourless and close in quality to olive oil (Tunde-Akintunde and Akintunde, 2007). Sesame oil is straw-like in colour and has an excellent taste. Sesame seed oil is a natural salad oil, requiring little or no winterization, is one of the few vegetable oils

that can be used directly without refining and is used widely as cooking oil. Because of the excellent quality of the edible oil it produces, sesame is often called queen of the oil seed crops (NAERLS, 2010; Tunde-Akintunde *et al.*, 2012).

Sesame protein is rich in methionine, cysteine and tryptophan. Since these amino acids are missing from a number of other sources of vegetable protein, such as soya, sesame protein isolate can be added to recipes to give a better nutritional balance. There is high level of protein deficiency in many developing countries especially in many parts of Africa continent. Sesame protein isolate, a cheap vegetable protein source, can be used for food enrichment of infant weaning foods. The conventional processes to extract edible oil from oilseeds or fruit pulps involve mechanical expression and/or solvent extraction. While n-hexane is broadly accepted as the most efficient solvent for oil extraction, its flammability,

explosiveness, and mild toxicity, and environmental impacts are an ongoing concern for the food industry. The extraction process leaves low levels of solvent residues in the extracted oil and the meal, which are safe, yet undesirable. Recently, a great deal of research has focused on the development of alternatives to hexane as the extraction solvent. The least expensive solvent is water. Aqueous processing of oil-bearing materials eliminates the potential hazards of explosion and fire, eliminates the negative environmental impacts due to emissions of organic solvents, and does not leave toxic or undesirable solvent residues in the resulting food products. Simultaneous recovery of oil and protein from oil seed has ability to minimize production costs, reduce extraction time, eliminate risk of using organic solvent and prevent food poison by chemicals. Previous works on simultaneous recovery using aqueous method involved use of enzymes, which are expensive and may affect the final cost of the product. The authors had previously shown that simultaneous recovery of sesame oil and protein was affected by solid-to-solvent ratio and pH. The optimized conditions were established to be solid-to-solvent ratio, 1:3; pH, 11; extraction temperature, 47 °C; and surfactant concentration, 0.1 M NaCl. The aim of this study was therefore to employ the optimized extraction conditions and investigate its influence on the physicochemical and functional properties of sesame protein isolate and some physical and chemical properties of sesame oil.

2. MATERIAL AND METHODS

Materials

Sesame seeds were obtained from Oja-oba market in Akure, Ondo State Nigeria. The seeds were sorted and chaffs and other extraneous materials were separated from the seeds. The seeds were washed, dried in a cabinet dryer at 50 °C and milled to powder using a hammer mill. The flour was then passed through a 630 micron sieve to obtain flour samples with homogenous particle size.

All chemicals and reagents used for this research were of analytical grades and were obtained from either Fisher Scientific (Oakville, ON, Canada) and Sigma Chemicals (St. Louis, MO, USA).

Simultaneous recovery of oil and protein isolate

Preliminary study was carried out to identify the optimal conditions for the independent variables used in this research. The methods of Agbenla *et al.* (1993); Latif and Anwar (2011); Bih-King and Levente (2003) were employed with some modifications. Fifty grams of ground sample was weighed and dispersed in 150 ml of 0.1 M NaCl at 47 °C and stirred for 30 min using a thermostat water bath (Julabo, model SW22, Germany). The pH of the slurry was adjusted to 11 using 0.1 N NaOH solution. The sample was then stirred again for 30 min and centrifuged at 3664 x g using a centrifuge (0502-1 Hospibrand, USA) for 20 min at room temperature to separate the product into oil, aqueous fraction and solid fraction as shown in Fig. 1. The oil and emulsion phase was centrifuged to separate out clear oil. The pH of the aqueous fraction was adjusted to 4.5 to precipitate out the soluble protein. The product obtained was stirred on a magnetic stirrer for 1 h and then centrifuged at 3664 x g using a centrifuge (0502-1 Hospibrand, USA) at room temperature for 15 min. The whey was discarded. The solid fraction was dissolved in distilled water for washing and the pH of the suspension was adjusted to 7. The mixture was stirred on a magnetic stirrer for 30 min and centrifuged at 3664 x g for 15 min at room temperature to separate the protein isolate from the whey. The protein isolate was then lyophilized. The oil and protein isolate were packaged for further use.

Physicochemical and Functional Properties of Sesame Protein Isolate

The pH was measured by making a 10 % (w/v) suspension of the sample in distilled water. The suspension was mixed thoroughly and the pH was measured with a Hanna checker pH meter (Model HI1270). Bulk density was determined

by the method of Okezie and Bello (1988). Least gelling concentration was determined using the method of Sathe and Salunkhe (1981). Oil absorption was determined by the centrifugal method elicited by Beuchat (1977). Water absorption capacity was determined at room temperature and at temperatures ranging between 60 to 90 °C using a combination of the AACC (1995) method and those of Sosulski (1962) and Rutkowski and Kozłowska (1981).

Physical and Chemical Properties of Sesame Oil

Iodine value was determined by the Hanus method as described by AOAC (1990). Peroxide value was determined by Anwar *et al.* (2007). Acid value was determined by Pearson (1976). Saponification value was determined by AOAC (2000) method. Smoke and flash points were determined by the method of Badifu (1988). Specific gravity and refractive index were determined as described in AOAC (1990). Viscosity measurement was carried out using a digital viscometer (NDJ-85, Shangai Nirun Intelligent Technology Co Ltd) according to the manufacturer's instructions. A 200 ml of the extracted oil was put into the viscometer cup and run at 750 rpm at 30 °C. The viscosity value of the sample was recorded and the measurement was repeated in triplicate.

Fatty Acid Profile

A 50 mg of the extracted oil was saponified (esterified) for 5 min at 95 °C with 3.4 ml of 0.5 M KOH in dry methanol. The mixture was neutralized by using 0.7 M HCl. A 3 ml 14% boron trifluoride in methanol was added. The mixture was heated for 5 min at the temperature of 90 °C to achieve complete methylation process. The fatty acid methyl esters were thrice extracted from the mixture with redistilled n-hexane. The content was concentrated to 1 ml for gas chromatographic analysis and 1 µl was injected into the injection port of gas chromatography (HP 6890 powered with HP ChemStation Rev. A 09.01, 1206, software) at inlet temperature of 250 °C, GC column dimension of 30 m x 0.25 mm x 0.25 µm, detector temperature of 320 °C, hydrogen

pressure of 22 psi, compressed air of 35 psi, split ratio 20:1. The initial temperature of the oven programme was 60 °C. The first ramping was done at 12 °C/min for 20 min while the second ramping was done at 15 °C/min for 30 min. The gas carrier was nitrogen and the column type was HP INNOWax.

Table 1 Physico-chemical Characteristics of Sesame Oil

Parameters	Mean Values
<i>Physical Properties</i>	
Physical state at 4 °C	Liquid/light yellow colour
Refractive index at 25 °C	1.471±0.03
Specific gravity	0.910±0.02
Viscosity (cP)	39.10±0.67
Flash point (°C)	248.0±0.49
Smoke point (°C)	227.0±0.68
<i>Chemical Properties</i>	
Acid value (mg KOH/g oil)	4.488±0.06
Iodine value (g I ₂ /100 g oil)	112.21±0.38
Peroxide value (meq O ₂ /kg oil)	6.0±0.25
Saponification value(mg KOH/g oil)	192.24±0.92
Free fatty acids (as % oleic acid)	2.24±0.07

3. RESULTS AND DISCUSSION

Quality Characterization of Sesame Oil Physical properties

The results of the physical properties of the sesame oil are shown in Table 1. At 4 °C, the oil was liquid/light yellow which was in line with the observation of Tunde-Akintunde (2012). The refractive index was 1.471. Observations on the refractive index of the oil agreed with previously published report of Betiku *et al* (2012) who reported 1.470. Elleuch *et al* (2007) observed the same value of refractive index for the sesame oil. Gulla and Waghray (2011) reported 1.465. The viscosity, which is a measure of the resistance of oil to shear, was 39.10 cP. Betiku *et al* (2012) reported 35.08 cP. Although Besbes *et al* (2005) reported mean value of 50-100 cP for most vegetable oils, Elleuch *et al* (2007) reported a lower value (12.93 cP) for sesame oil. Nzikou *et al* (2009) reported 40.60 and 29.10 cP. The specific gravity of the oil was 0.910.

This value was in consistent with the report of Betiku *et al* (2012) who reported 0.88 and

Gulla and Waghray (2011) who reported 0.922. The physical properties obtained in this study further corroborated previous studies on physical properties of sesame oil and would assist in ensuring purity and checking adulteration. It further shows that oil obtained by simultaneous extraction exhibited similar physical properties as the oil obtained by conventional methods of solvent extraction and expression by screw or hydraulic press. Smoke point is the temperature at which the oil begins to break down to glycerol and free fatty acids, and produce bluish smoke. The glycerol is then further broken down to acrolein which is a component of the smoke. The smoke point also marks the beginning of both flavour and nutritional degradation (Wolke, 2007). The smoke point of the oil was 227 °C. Wolke (2007) reported 232 °C. The flash point was 248 °C. The high smoke and flash points make the oil suitable for deep frying.

Chemical properties

The chemical properties are among the most important properties that determines the present condition of oil (Nzikou *et al.*, 2009). Table 1 showed the results obtained for the chemical properties of the optimized sesame oil. The acid value was 4.488 mgKOH/g oil. According to Tunde-Akintunde *et al.* (2012), the acid value for local sesame seed varied from 3.1-6.6 mgKOH/g oil. Iodine value is an index of the unsaturation, which is the most important analytical characteristic of an oil (Gulla and Waghray, 2011).

The iodine value of 112.21 g/100 g was obtained. This was in agreement with Tunde-Akintunde *et al.* (2012) and Elkheir *et al.* (2008) who reported a range of values from 101.52 to 114.85 g/100g for the local sesame seed cultivars. Betiku *et al.* (2012) reported 108 g/100 g, Gulla and Waghray (2011) reported 106.9 g/100g, Nzikou (2009) reported 112.4 and 117.2 g/100g while Borchani *et al.* (2010) reported 113.35 g/100g. The high iodine value obtained signified that the oil contained a substantial level of unsaturation. This observation is supported by the high level of

unsaturated fatty acids present in the oil (Elleuch *et al.*, 2007).

The peroxide value measures the content of hydroperoxides in the oil and its low value indicates the efficiency of the extraction method applied in this work to limit oxidation of polyunsaturated fatty acids and possibly due to the presence of some natural antioxidants. According to Gulla and Waghray (2011), fresh oils usually have peroxide values below 10 meqO₂/kg oil and a rancid taste often begins to be noticeable when the peroxide value is above 20 meq O₂/kg oil. The peroxide value obtained was 6.0 meq O₂/kg oil, which is within the limit stipulated for vegetable oils (Betiku *et al.*, 2012). Betiku *et al.* (2012) reported 7.80 meq O₂/kg oil. According to Tunde-Akintunde *et al.* (2012), the peroxide value for local sesame oil ranged from 2.22 – 15.07 meq O₂/kg oil while that of improved ranged from 2.24-10 meq O₂/kg oil.

Saponification value of 192.24 mg KOH/g oil was obtained for the sesame oil in this study. A high saponification value suggests a high concentration of high molecular weight triglycerides. This value was closed to 190 mg KOH/g oil, which was reported by Betiku *et al.* (2012). Borchani *et al.* (2010) reported 186.60 mg KOH/g oil; Nzikou *et al.* (2009) reported 192 mg KOH/g oil and 197 mg KOH/g oil. Tunde-Akintunde *et al.* (2012) report that the saponification value of local sesame varied from 174-196.32 mg KOH/g oil and that of improved cultivars varied from 182.31-198.02 mg KOH/g oil. The free fatty acid content of the oil was 2.24%. Nzikou *et al.* (2009) reported 1.35% and 1.8%.

Fatty Acid Profile of the Sesame Oil

The gas chromatography analysis of fatty acids present in the seed oil is shown in Table 2. The results indicated that the oil was highly unsaturated (82.95%). The unsaturated fatty acids consists of 43.89% monounsaturated and 39.06% polyunsaturated fatty acids.

Unsaturated fatty acids reduce the concentration of low-density lipoprotein (LDL) cholesterol in the blood (Bender, 2006).

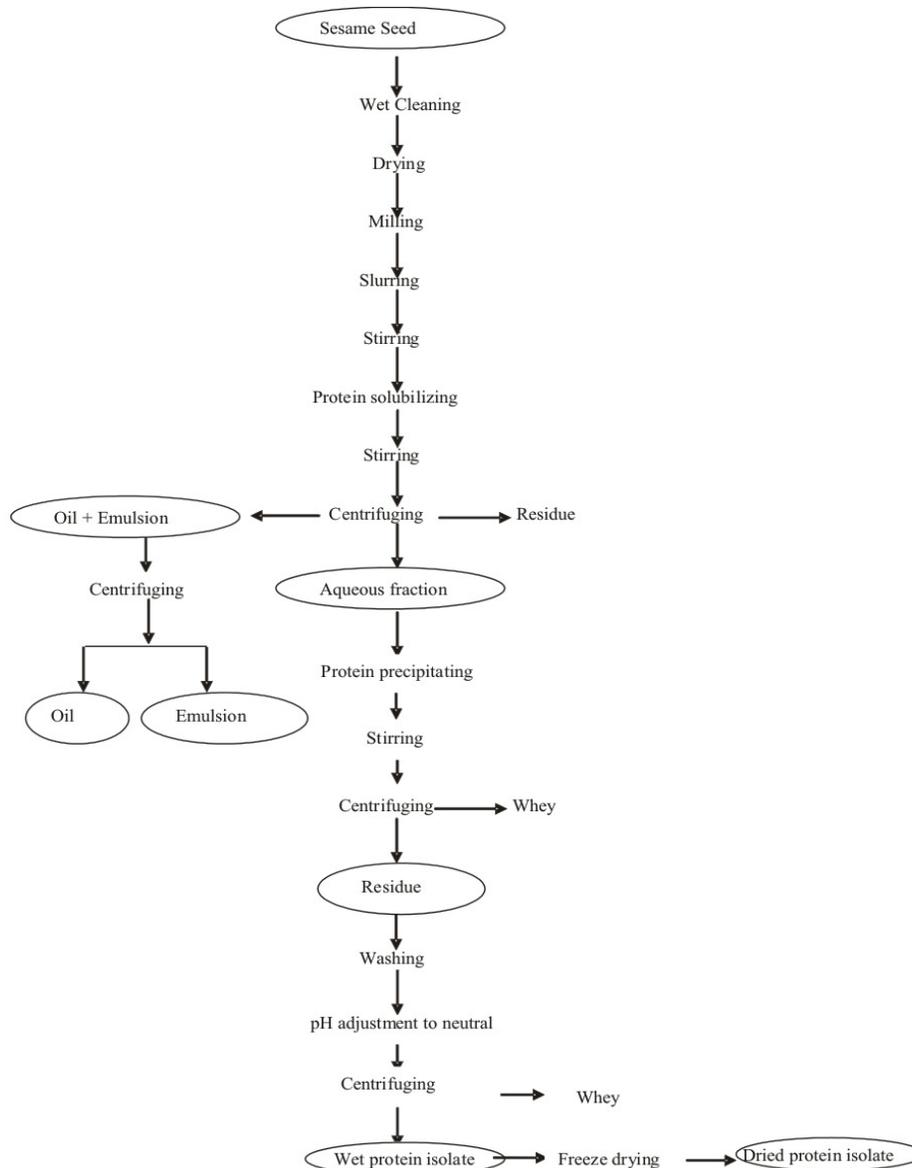


Fig. 1 Flow chart for simultaneous recovery of oil and protein isolate

LDL cholesterol is a major risk factor in heart disease. The results showed that the oil contained 43.59% oleic acid and 38.53% linoleic acid. These were in agreement with the report of Elleuch *et al* (2007); Borchani *et al* (2010) and Tunde-Akintunde *et al* (2012), which reported that sesame oil contains 35.9-47% oleic acid and 35.6-47.6% linoleic acid. According to Elkhier *et al* (2008), the fatty acids composition of sesame oil vary among different cultivars.

Betiku *et al* (2012) reported 43.74% and 24.01% for oleic and linoleic acids

respectively. Borchani *et al* (2010) reported 41.68% and 38.29% for oleic and linoleic acids respectively while Kemal and Hasan (2008) reported 41.53% and 41.65% for oleic and linoleic acids respectively.

Since the extracted oil contain more of oleic and linoleic acids (82.12% of the total fatty acid), sesame oil can be classified in the oleic-linoleic acid group. This was in agreement with the report of Nzikou *et al* (2009).

The value obtained for the palmitic and palmitoleic acids were 12.90% and 0.30% respectively.

Table 2 Fatty Acids Compositions of the Extracted Sesame Oil

Fatty Acid	Composition (%)
Palmitic acid, C16:0	12.90±0.65
Palmitoleic acid, C16:1	0.30±0.01
Stearic acid, C18:0	4.15±0.04
Oleic acid, C18:1	43.59±0.11
Linoleic acid, C18:2	38.53±0.81
Linolenic acid, C18:3	0.52±0.01
Saturated fatty acid	17.05±0.02
Unsaturated fatty acid	82.95±0.23
Monounsaturated fatty acid	43.89±0.21
Polyunsaturated fatty acid	39.06±0.43

Borchani *et al* (2010) reported 12.96% and 0.22% for palmitic and palmitoleic acids, respectively for sesame oil extracted using n-hexane. Betiku *et al* (2012) reported 17.80% and 0.71% for palmitic and palmitoleic acids, respectively for sesame oil using n-hexane under optimal conditions. The stearic and linolenic acids of the oil were 4.15% and 0.52% respectively. Teco (2005) reported the range 4-6% for stearic acid and maximum of 0.60% for linolenic acid for sesame oil extracted using n-hexane. Borchani *et al* (2010) reported 5.76% and 0.45% for stearic and linolenic acids, respectively for sesame oil using n-hexane.

Betiku *et al* (2012) reported 7.41% and 0.51% for stearic and linolenic acids, respectively for sesame oil using n-hexane under optimal conditions. Kemal and Hasan (2008) reported 5.76% and 0.53% for stearic and linolenic acids, respectively for sesame oil extracted using n-hexane at 20 °C. The variations in the fatty acids composition may be due to difference in extraction methods and conditions under which the extraction was carried out. The high content of monounsaturated fatty acids especially oleic acid is associated with a low incidence of coronary heart disease (CHD) because it decreases total cholesterol (Denny *et al.*, 2006; Eqbal *et al.*, 2011).

Dietary intake of certain unsaturated fatty acids, in particular conjugated linoleic and fat-soluble antioxidants (such as α -tocopherol, carotenoids) has been linked to potential health benefits (Gillian *et al.*, 2008; Eqbal *et al.*, 2011). Although sesame oil contain more

unsaturated fatty acids than saturated acids, the oil showed a remarkable stability to oxidation, which could be attributed to endogenous antioxidants such as tocopherols, sesamin, lignins and sesamolin (Elleuch *et al.*, 2007; Lee *et al.*, 2008., Tunde-Akintunde *et al.*, 2012).

Physicochemical and Functional Properties of Sesame Protein Isolate

The results of physico-chemical and functional properties of the sesame protein isolate (SPI) are presented in Table 3. The bulk density of the sesame protein isolate was 0.173 g/ml. This was in agreement with the report of Kanu *et al.* (2007) for sesame protein isolate (0.169 g/ml). The extracted sesame protein isolate (SPI) was less dense than the commercial soy protein isolate (0.216 g/ml) according to the report of Kanu *et al.* (2007). The bulk density of the SPI was lower than that of conophor nut protein isolate (0.660 g/ml) as reported by Gbadamosi *et al.* (2012).

Some reports have also attributed low bulk density of protein isolates to the fact that since protein isolate is rich in protein there will be little or small amount of carbohydrate that usually increase the bulk density of most food product (Krause *et al.*, 2002; Kanu *et al.*, 2007). Increase in bulk density is desirable in that it offers greater packaging advantage as a greater quantity may be packed within a constant volume (Fagbemi, 1999).

The pH of the SPI was slightly acidic (6.16). The present result (6.16) was slightly lower than the value obtained by Gandhi and Srivastava (2007) for sesame protein isolate, which was 6.40. The pH of protein suspension affects the functional properties such as solubility, emulsifying activity, foam properties and foam stability.

The WAC of the SPI was 296.55%. This was slightly lower than the report of Kanu *et al.* (2007) for sesame protein isolate (302 %). The present finding agreed with the results reported by Bandyopadhyay and Ghosh (2002) in the preparation and characterization of papain-modified sesame protein isolates. Interaction of water with proteins are very important in food systems because of the effect on the texture of

foods. The intrinsic factors affecting water binding of food protein include amino acid composition, protein conformation and surface polarity/hydrophobicity (Barbut, 1999; Kanu *et al.*, 2007). The high water-binding capacity of the isolate may possibly be due to high proportion of hydrophilic amino acids. The WAC of the SPI was higher than soy protein isolate (289%) and peanut protein isolate (135%) as reported by Kanu *et al.* (2007) and Wu *et al.* (2009) respectively. The result showed that SPI has good WAC and could be used in several food formulations such as meat and pastry products.

Fig. 2 shows the effect of temperature on the WAC of the sesame protein isolate (SPI). The WAC ranged between 296.55% and 333.90%. The WAC increased with increase in temperature from room temperature (30 °C) to 90 °C. Aletor *et al.* (2002) reported that WAC ranging from 149.10 to 471.50% is considered critical in viscous foods such as functional ingredients in soups and baked products. It could also be used as thickeners in some foods.

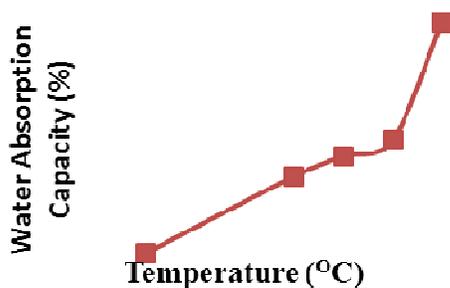


Fig. 2 Water absorption capacity of sesame protein isolate (SPI) as a function of temperature

The oil absorption capacity (OAC) of the sesame protein isolate (SPI) was 131% (Table 3). The interaction of oil with proteins are very important in food systems because of the effects on the flavour of foods. Present finding was in line with the results reported by Kanu *et al.* (2007) for sesame protein isolate (129%) and soy protein isolate (134%). Kanu *et al.* (2007) and Graham and Philips (1976) explained oil absorption as a physical

entrapment of oil and several authors have related the OAC to the non-polar side chains of the protein as well as to the different conformation features of the proteins. Ogunwolu *et al.* (2009) reported 442% for cashew nut protein isolate while Eltayeb *et al.* (2011) reported 102.29% for Bambara groundnut protein isolate. Oil absorption capacity is important since oil acts as flavour retainer and increases the mouth-feel of foods (Aremu *et al.*, 2007). It has been reported that variations in the presence of non-polar side chains may be responsible for differences in the oil binding capacities (Adebowale and Lawal, 2004).

Table 3 Physicochemical and Functional Properties of Sesame Protein Isolate

Functional Characteristics	Mean Value
Bulk density (g/ml)	0.173 ± 0.00
pH	6.16 ± 0.01
Water absorption capacity (%)	296.55 ± 0.03
Oil absorption capacity (%)	131.00 ± 0.47
Emulsifying activity index (m ² /g)	13.76 ± 0.03
Emulsion stability index (%)	44.13 ± 0.06
Foam capacity (%)	64.63 ± 0.10
Foam stability (%)	11.24 ± 0.12
Least gelation capacity (%)	5.00 ± 0.00

The least gelling capacity of the SPI was 5%. The least gelling concentration (LGC) is the lowest protein concentration at which gel remained in the inverted tube, which is used as index of gelation capacity. The lower the LGC, the better the gelling ability of the protein ingredient (Akintayo *et al.*, 1999; Eltayeb *et al.*, 2011). Eltayeb *et al.* (2011) reported 18% for bambara groundnut protein isolate. The variation in the value obtained compared to other products like bambara groundnut protein isolate, pumpkin seed protein concentrate and isolate might be linked to the relative ratio of different constituents – protein, carbohydrates and lipids as suggested by Aremu *et al.* (2007) that the interaction between such components may affect functional properties.

The ability of protein to form gels and provide a structure matrix for holding water, flavours, sugars and food ingredients is useful in food applications and in new product development, thereby providing an added dimension to

protein functionality (Oshodi *et al.*, 1997; Eltayeb *et al.*, 2011). The low gelation concentration observed may be an asset in the use of this isolate for the formation of curd or as an additive to other gel forming materials in food products (Aremu *et al.*, 2007; Eltayeb *et al.*, 2011).

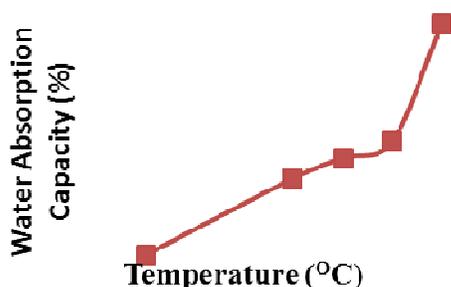


Fig. 2 Water absorption capacity of sesame protein isolate (SPI) as a function of temperature

The emulsifying activity index (EAI) of the sesame protein isolate (SPI) at natural pH was 13.76 m²/g. This was closed to the report of Kanu *et al.* (2007) for sesame protein isolate (14.80 m²/g). The emulsion stability index (ESI) of the SPI was 44.13%. Ogunwolu *et al.* (2009) reported a similar result for cashew nut protein isolate (12.48%) and cashew nut protein concentrate (13.68%). The foam capacity and stability at the natural pH of the SPI was 64.63% and 11.24% respectively.

The result obtained for foam capacity was higher than the report of Gbadamosi *et al.* (2012) for conophor protein isolate who reported the value of 50% and Mao and Hua (2012) reported foam capacity of 46.34% for walnut protein isolate. The present finding was lower than the report of Kanu *et al.* (2007) who observed 79 % foam capacity for sesame protein isolate and 76% for soybean protein isolate, which were extracted from defatted flour.

The variation may be due to the extraction method used. Foam formation is governed by factors such as transportation, penetration and reorganization of the molecule at the air-water interface. Therefore, to exhibit good foaming, a protein must be capable of migrating at the air-water interface, unfolding and rearranging at

the interface (Ogunwolu *et al.*, 2009). Foam capacity and stability are enhanced by greater protein concentration, which is attributed to increase in viscosity and facilitates the formation of a multilayer, cohesive protein film at the interface (Damodaran, 1997; Ogunwolu *et al.*, 2009).

The low foam stability of the SPI showed that the protein isolate may not be suitable as whipping agent in food formulations.

4. CONCLUSIONS

The sesame protein isolate (SPI) exhibited high oil and water absorption capacities, and could be employed in the formulations of food products such as doughnut, pancakes and baked food products and as food thickener.

The extracted oil exhibited desirable physico-chemical qualities of edible vegetable oil. The high smoke and flash points make the oil suitable for deep frying and other cooking operations. Therefore, sesame oil and protein could be obtained simultaneously using aqueous extraction method without any adverse effect on the physico-chemical, function and nutritional properties of both the oil and protein.

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