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Sesame Protein 11: Functional Properties of Sesame (*Sesamum indicum* L.) Protein Isolate as Influenced by pH, Temperature, Time and Ratio of Flour to Water During its Production

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Abstract: The functional properties of sesame (*Sesamum indicum* L.) protein isolate were studied. The Sesame Protein Isolate (SPI) was produced by varying four parameters (pH, temperature, time and ratio of flour to water). The aim of the study was to compare the SPI with a commercial soya protein isolate to see if the production had some negative effects to the SPI. According to the results, the functional performances of SPI compared to the commercial soya protein isolate were not significantly different ($p<0.05$). Both of them showed very similar solubility curves when subjected to the same pH treatment. But the commercial soya protein showed very low protein solubility between pH 4-5.5 (5-10%) for that product but the solubility of SPI was higher (15-19%). For fat absorption and water holding capacity SPI was observed to show low (129 g) and high (302 g), respectively, for the bulk density the SPI was also low (0.169 g mL^{-1}). We observed similar performance for the viscosity at both low and high temperatures (40 and 60°C) and it exhibited good foaming capacity below and above its pI. Similar dispersibility characteristics for both of them and good whipping properties but the SPI exhibited when whipped, a higher foam expansion of 79%, as against 76% for the commercial soya protein isolate. SPI displayed good functional properties which could provide the food industry with new high protein food ingredients to be used as protein supplementation in different food formulations.

Key words: Sesame, functional properties, protein isolate

INTRODUCTION

Today plant proteins play significant roles in human nutrition, particularly in developing countries where average protein intake is less than that required. Because of inadequate supplies of animal proteins, there has been a constant search for new protein sources, for use as both functional food ingredients and nutritional supplements (Onweluzo *et al*., 1994). Although plant protein products are gaining increased interest as ingredients in food systems throughout many parts of the world, the final success of utilizing plant proteins as additives depends greatly upon the favorable characteristics that they impart on foods. Therefore, the interrelationships of protein quality and processing parameters, like pH, temperature, time and ratio, that affect the functional performance of plant protein products, is worthy of an extensive investigation.

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The development of SPI from defatted sesame flour would provide the food industry with new high protein food ingredients for product formulation and protein fortification. The latter is critically needed in many developing countries particularly in Africa where protein deficiencies remain a major health problem, especially among children (Lawal, 2004).

Functional properties of food protein are important in food processing and food product formulation. Some of these properties are solubility, water holding capacity, oil binding, emulsification, foaming properties, bulk density and viscosity (Jung *et al*., 2005; Bandyopadhyay and Ghosh, 2002). Nonetheless, some of these properties are affected by the intrinsic factors of proteins such as molecular structure and size and some environmental factors, including the method of protein isolation from the seed (Fuhrmeister and Meuser, 2003). The importance of these properties varies with the type of food products in which the protein isolate is to be used. For instance protein isolates with high oil and water binding capacities are desirable for use in meat, sausages and bread, while proteins with high emulsifying and foaming properties are good for salad dressing, confectionaries, frozen foods and soups (Ahmedna *et al*., 1999).

Attention on plant protein isolates has been focused mainly on cotton seed, peanut, rapeseed, soya protein and sunflower seed and in some areas commercial preparations are available (Anonymous, 1979; Schenz and Morr, 1996). In contrast the functionality of sesame protein has received little attention particularly when different production parameters say more than two are combined to isolate the protein from sesame that could be used in food formulations. The few studies that have been made are mainly on the properties of the defatted flour or meal, sesame oil, the antioxidant property of sesame and functional properties of sesame protein as influenced by pH only (Khalida *et al*., 2003; Shahidi *et al*., 2006; Aly *et al*., 2000). Very limited information is available for the functional properties of sesame isolate as influenced by other factors during its protein extraction from dehulled sesame seeds.

Thus, the objectives of this study were to study the functional properties of sesame protein isolate which was produced in lab where the pH, temperature, time and ratio of flour to water were varied during it production. Compared some of its functional properties with those of a commercial soya protein isolate.

MATERIALS AND METHODS

Materials

The SPI was produced in the Key Laboratory, School of Food Science and Technology, Southern Yangtze University Wuxi, P.R. China and the commercial soya protein isolate was purchased from a supermarket in Wuxi, P.R. China, produced by Fuxin Flour mill Company, Shanghai, P.R. China. This research was conducted in the key laboratory of Food Science and Technology, Southern Yangtze University, Wuxi, PR China between September, 2006 to January 2007.

The chemicals and reagents used were of analytical and food grade quality obtained from the chemical store of Southern Yangtze University Wuxi, P.R. China, manufactured by (SCRC) Sinopharm Chemical Reagent Co., Ltd. Shanghai P.R. China.

Methods

The Sesame Protein Isolate (SPI) was prepared from defatted sesame flour as described in the flow chart (Fig. 1). The isolation was done by varying the pH, temperature, time and ratio of flour to water as 12, 45°C, 45 min and 6/100 g mL^{-1}, respectively. The response surface methodology technique was used to optimize the recovery process of the SPI and the maximum protein recovered was 94% at the above working parameters, thus making them the working parameters employed for the production of the SPI used in this research. The particle size was determine after freeze drying the SPI by passing it through a 100 mm sieve which was taken that all the particles of the SPI were less than 100 mm in size.

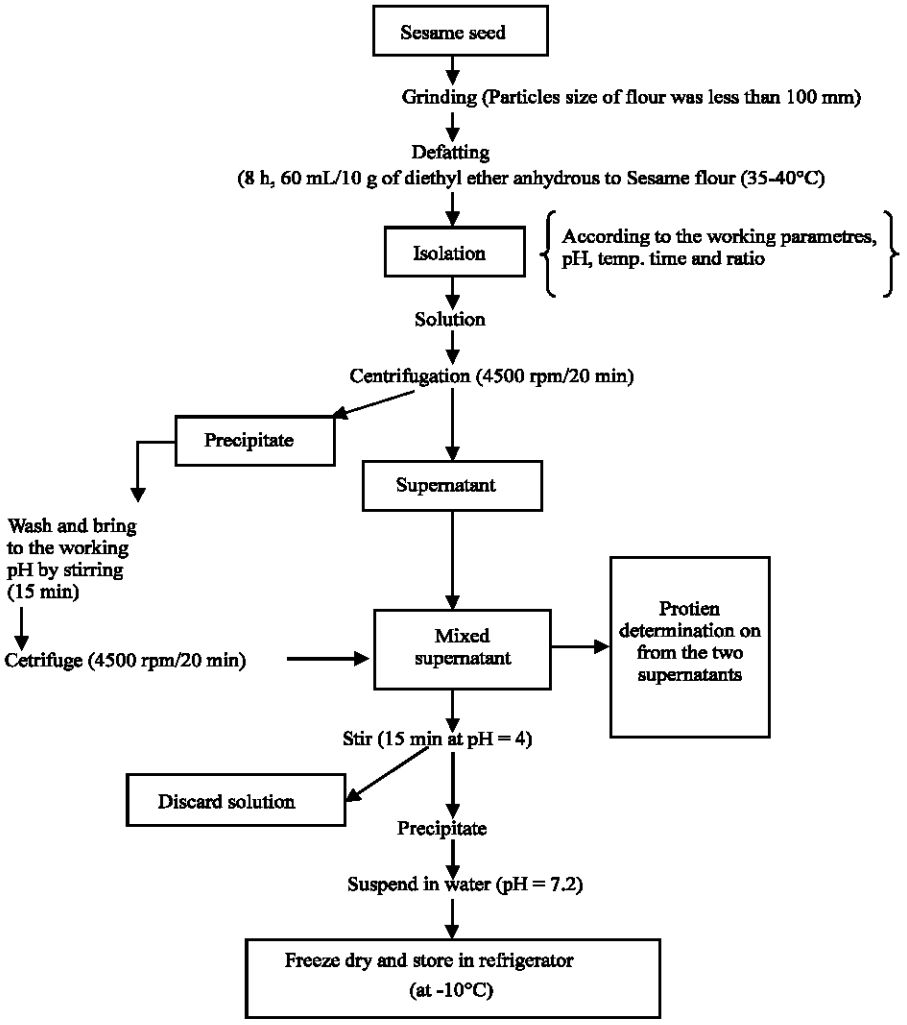

Fig. 1: The isolation of the sesame protein and the production of the Sesame protein isolate

Solubility

Nitrogen solubility of the proteins isolates was determined by the method of Beuchat *et al.* (1975) over a pH range of 1-14. The dispersions were stirred at different pHs at 24°C for 30 min and then centrifuged in a Beckman Coulter centrifuge (Avanti J-26XPI; USA) at 4500 rpm for 20 min for both the SPI and the commercial soya protein isolate. Protein content of the supernatants was determined by the method of AOAC (1995) using 6.25 as conversion factor:

$$PR\% = \frac{PS(mg)}{PIS(g)} \times 100$$

Where

PS = Amount of protein in supernatant

PIS = Protein in initial sample

PR% = Protein Recovered in percentage

Protein solubility was expressed as percent of the protein content of the sample.

Water-and Oil-Holding Capacity

Water absorption was calculated using the method described by Makri *et al*. (2005). The estimations were performed in triplicates. For the fat absorption the method of Carcea-Bencini (1986) was used with slight modifications. One gram of protein sample was stirred in 10 mL of distilled water or corn oil and then centrifuged at 3000 rpm for 30 min. The volume of the supernatant was measured. The oil-holding capacity was expressed as the number of g of oil held by 1.0 g of protein sample for both the SPI and the commercial soya protein isolate.

Bulk Density

The bulk density was determined according to Wang and Kinsella (1976) using samples of 20 g and a 150 mL graduated cylinder. Bulk density was calculated as g mL^{-1}. Estimations were performed in triplicates for both SPI and commercial soya protein isolate.

Viscosity

Apparent viscosity of the SPI, at different pH levels, was determined by the method of Quinn and Beuchat (1975). The samples were heated at 40 and 60°C as these are temperatures considered to be moderate and high, respectively. The apparent viscosity was determined at those two temperatures with a Brookfield (Model RVT) viscometer equipped with a No. 1 spindle. Apparent viscosity in cetipoises (cps) was reported as the average of three readings.

Emulsification Properties

Emulsification properties were investigated ssentially according to the procedure of Yasumatsu *et al*. (1972) for the two samples. Samples (5 g) were suspended in deionised water (40 mL). The pH was adjusted to pH 7 using 1 N, NAOH or HCL. After stirring for 15 min, the pH was checked again to confirm that it was still reading pH 7 and the volume made up to 50 mL. Soy oil (50 mL) was added and blended for 3 min (MSE homogenizer, at Maximum speed). The emulsion was divided between two 50 mL centrifuge tubes and centrifuged (4500 rpm for 20 min). The ratio of height of the emulsified layer to the total height of fluid was calculated and the emulsification activity expressed at this ratio ×100. Emulsion stability was determined by the same procedure except that the emulsion was heated at 60°C for 30 min and then cooled under running tap water for 15 min prior to centrifugation.

Dispersibility

The dispersibility of the SPI and commercial soya protein isolate at different pH levels were measured according to the method of Karuna *et al*. (1991) with minor modifications. Dispersibility was measured by placing 10 g of the sample in a 100 mL stoppered measuring cylinder, adding distilled water to reach a volume of 100 mL, stirring vigorously and allowing it to settle for three hour. The volume of settled particles was subtracted from 100 and the difference reported as percentage dispersibility. Three replicates of measurements were carried out and the mean was taken.

Whipping Properties

The whipping properties of dispersion were investigated by the method described by Lin *et al*. (1974) with slight modifications. Samples (10 g) were dispersed in deionised water (200 mL) and the pH adjusted to 7.0 using 0.1 N, NaOH and HCl. The suspension was homogenized at full speed Moulinex Blender for one minute. Suspensions were then whipped on speed 7 in a Kenwood

chef food mixer for 10 min, using the wire whip attachment. The resulting foam was immediately poured into a litre measuring cylinder and the foam height and volume of liquid collecting in the bottom of the cylinder, was measured at intervals.

The percentage foam expansion was calculated according to the method described by Lawhon *et al*. (1972). Foam volume as a percentage was calculated taking the foam volume at zero time as 100%. Leakage was calculated as volume of liquid collected over volume of liquid before whipping ×100. The apparent viscosity was measured in triplicates immediately after whipping using a Brookfield viscometer (Spindle 3, 30 rev min^{-1}). Triplicates whips were prepared for all experiments.

Foaming Capacity

Foam capacity and stability at different pH levels were determined according to Aruna and Parakash (1993). One hundred milliliters of deionised water at different pH were separately added to 3 g of defatted sesame protein isolate and commercial soya protein isolate and the mixture homogenized at 400 rpm for 3 min in a Virtis homogenizer at 25°C and transferred to a measuring cylinder. The volume of foam was measured and the volume increase was expressed as percentage foam capacity. The foam stability was determined by measuring the decrease in volume of foam as a function of time at 15, 30 and 60 min.

Statistical Analysis

The results were subjected to statistical analysis of variance (ANOVA), using a Statistical Analysis System (SAS Institute, Inc. 2002) The Significant of difference between means were determined by Duncan's Multiple Rang Test (DMRT), where $p<0.05$ was considered for significant difference.

RESULTS AND DISCUSSION

Solubility

Solubility curves obtained for both SPI and commercial soya protein isolate were not significantly different ($p<0.05$), (Fig. 2). Both isolates showed a minimum solubility in the region of between pH 4-5.5. (10-15% for SPI and 10-15% for the commercial soya protein isolate) This is some how higher than the reported isoelectric points (pI) of pH 4.4 and pH 4.8 of sesame α-globulin, which was prepared by different method (Prakash and Nandi, 1978). Our report obtained was in agreement with

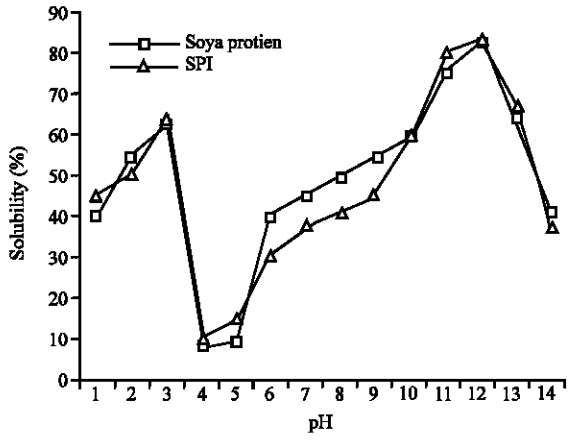

Fig. 2: Solubility of SPI and commercial soya protein isolate

previous reports when promine-D (a protein component of soya bean) was isolated from soya protein (Kinsella, 1979; Wolf, 1970). At pH values between 1-3 for SPI the solubility result obtained was 45-65% while for soya protein was 40-63%. Above the pI region which was observed to be above pH 5.5, the solubility for the SPI increased but <40% between pH 5.5-7, for soya protein within that region of pH it was observed showing a solubility profile <50%. The solubility of the SPI rose sharply to values above 40% for the SPI after pH 7 and for soya protein above 45%. We observed an increase in protein solubility below and above the pI regions for both proteins. It might be so because protein solubility in aqueous solutions is dependent on pH. At pH values above and below the isoelectric pH, proteins carry a net charge; electrostatic repulsion and ionic hydration promote solubililization of protein. For most proteins, minimum solubility occurs at their pI region, where electrostatic repulsion and ionic hydration are minimum and hydrophobic interaction between surface nonpolar patches is maximum (Basha and Pancholy, 1982). However, some proteins like whey protein have higher solubility characteristics at their isoelectric pH (pI = 4.8-5.2) because the exposed surfaces of these proteins contain a high ratio of hydrophilic to hydrophobic groups (Zhu and Damodaran, 1994). This could be the reason why the SPI showed higher solubility at the region of its pI or it can also be attributed to the possibility that the SPI underwent considerable denaturation during preparation. Solubility of our product was a good indication of functional potential which could be used in protein supplementation to foods as it did not show significant difference ($p<0.05$) of solubility characteristic with the commercial soya protein isolate.

Water-and Oil-Holding Capacity

Interactions of water and oil with proteins are very important in food systems because of their effects on the flavor and texture of foods. Intrinsic factors affecting water binding of food protein include amino acid composition, protein conformation and surface polarity/hydrophobicity (Barbut, 1999). However food processing methods have important impacts on the protein conformation and hydrophobicity. During the processing of the SPI since the temperature was a little bit moderate (45°C) it is possible that the proteins were likely denatured at that temperature exposing more hydrophobic sites, which explained the high water retention of the SPI then the commercial soya protein that was significantly different ($p<0.05$), (Table 1). The decrease in oil absorption capacity could be due to irreversible denaturation caused by the working temperature (45°C) for the processing. Present findings were consistent with the results reported by Bandyopadhyay and Ghosh (2002) in the preparation and characterization of papain-modified sesame (*Sesamum indicum* L.) protein isolates. Though the commercial soya protein showed a higher water holding capacity more than the SPI but lower in fat absorption (Table 1) but were not significantly different ($p<0.05$). SPI had a water-holding capacity of 302 g, similar to that reported by Prakash and Narasinga (1986) and within the range of the commercial values of protein concentrates which was (300-320 g), as reported by Lin and Zayas (1987) as SPI was 302 g water absorption while soya protein was 289 g. It has been reported that the protein concentrate exhibits poor water-binding capacity compared to that of the isolate (Bandyopadhyay and Ghosh, 2002). This is likely due to the fact that the protein isolate has greater ability to swell, dissociate and unfold, exposing additional binding sites, whereas the carbohydrate and other components of the protein concentrate may impair it (Kinsella, 1979). In food applications, the water-holding capacity or water-uptake capacity of a protein is more important than hydration

Table 1: Water-and oil-holding capacity and bulk density of SPI and commercial soya protein isolate

Sample	Fat absorption (g)	Water absorption (g)	Bulk density (g mL^{-1})
SPI	129±0.66[b]	302±1.00[a]	0.169±0.001[a]
Soya protein	134±2.00[a]	289±0.58[a]	0.216±0.001[a]

[a]Values represent Means±Standard Deviation; means values with different letters in the same column are significant at level ($p<0.05$)

capacity. Water-holding capacity refers to the ability of a protein matrix, such as protein particles, protein gels, or muscle, to absorb and retain water against gravity. This water includes bound water, hydrodynamic water, capillary water and physically entrapped water. The physically entrapped water, however, is the largest fraction. It imparts juiciness and tenderness in various foods (Scheraga *et al*., 1962).

Sesame proteins showed a lower oil-holding capacity than soybean flour though not significantly different ($p<0.05$) but had a higher value than chickpea flour (Marina, 1986). Kinsella (1979) explained the mechanism of fat absorption as a physical entrapment of oil and several authors have related the oil absorption capacity to the nonpolar side chains of the protein as well as to the different conformational features of the proteins (Graham and Philips, 1976). Present results suggested that SPI had both good water-holding and good oil-holding capacity. Though slightly lower than the commercial soya protein isolate; it was seen as a good functional property that could be used in several food formulations that needs to utilize the above functional property.

Bulk Density

SPI produced less dense mixture than the commercial soya protein the difference was significant ($p<0.05$, Table 1). Difference in particles size may account for such difference in bulk density between the two proteins. SPI was passed through a mesh sieve of 100 mm while the commercial soy protein isolate was passed through a mesh sieve 80 mm according to the producer of that product. Several authors have attributed solubility, hydrodynamic properties, hydrophobicity and microstructure of proteins plays an important role in the bulk density of any protein isolate (Anon *et al*., 2001; Kruse *et al*., 2001) but some reports have also attributed it to the fact that since protein isolate is rich in protein it will have low bulk density as there will be little or small amount of carbohydrate that usually increases the bulk density of most food product (Krause *et al*., 2002; Paulson and Tung, 1989). Present result (0.169 g mL^{-1}) was in consistent with Wang and Kinsella (1976) they extracted protein from an alfalfa leaf by both chemical (NaCl) and water but reported that the protein isolate from the water extraction has a lower bulk density as the SPI.

Viscosity

From the results obtained (Fig. 3) it was observed that SPI was able to form a low viscosity solution even at high temperature (60°C) the viscosity was still low at pH 12 (210 cps) which is still within an acceptable range (Schenz and Morr, 1996). As it has been reported that most of the food items particularly infant foods prepared within the range of 40 and 60°C as they are considered as

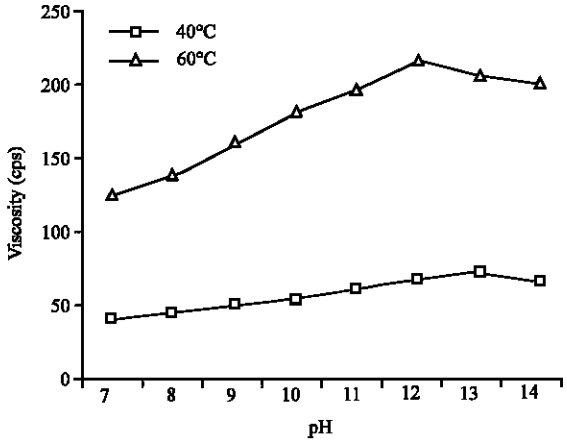

Fig. 3: Viscosity of SPI at different pH at 40 and 60°C

moderate and high temperatures, respectively, will exhibit a viscosity that will be good for infant formulation (Kulkarni *et al*., 1991). At temperature 60°C SPI exhibited a gradual increase as the pH was increased; this was observed because solution conditions, such as pH, ionic strength and temperature affect viscosity of protein solutions. The viscosity of the SPI at 60°C was higher than SPI at 40°C and the difference was significant ($p<0.05$) because the high temperature helped the denaturation of the protein that increases the viscosity. It was reported that the viscosity of globular proteins generally decreases as the pH and temperature are decreased and increases when the two are increased (Modler and Emmons, 1977). The viscosity of SPI is actually dependent on the high protein concentrate in sesame seed. Present result was in accordance with the results of Dench *et al*. (1981) they studied selected functional properties of sesame (*Sesamum indicum* L.) flour and two protein isolates. The low viscosity of SPI may be useful in the development of high protein drinks, juice-based beverages and its supplementation in infant formulation without suffering the adverse consequences of high viscosity (Frokjaer, 1994; Sze-Tao and Sathe, 2000).

Emulsification Properties

Proteins are composed of charged amino-acids, non-charged polar amino acids and nonpolar amino acids, which make proteins possible emulsifiers. The surfactant possessing both hydrophilic and hydrophobic properties is able to interact with both water and oil in food system (Chove *et al*., 2002). As shown in Fig. 4 SPI was a good emulsifier as the difference showed by the commercial soya protein isolate was not significantly different ($p<0.05$) from the SPI. The two proteins according to Fig. 4 have a higher emulsifier capacity at pH 2 where 170 mL oil mg^{-1} was observed, but fell when the pH was adjusted to 3, 4, 5 and 6 and increased again between pH 7-10 for both of them. They only dropped slightly at pH 11 and 12. This is so because protein exhibited low emulsification properties when expose to a very pH (11-14) (Jung *et al*., 2005). Present results showed that proteins of both SPI and commercial protein isolate exhibited good emulsion capacity at pH 2, neutral and higher in an alkaline region. This could be attributed to the fact that most proteins of plant origin can be solubilized below the pI region and above that region as well. It could also be explained that the presence of salts as during the production of the SPI both HCl and NaOH were use to control the pH during the process sodium chloride which is salt developed that might contributed to the denaturation of the protein that increased the emulsion properties of SPI (Jung *et al*., 2005). It is possible that the pH values influenced the emulsion capacity of the SPI which could also be possible for the commercial soya protein isolate. Denaturation could improve the emulsifying properties of the proteins due to increased hydrophobic

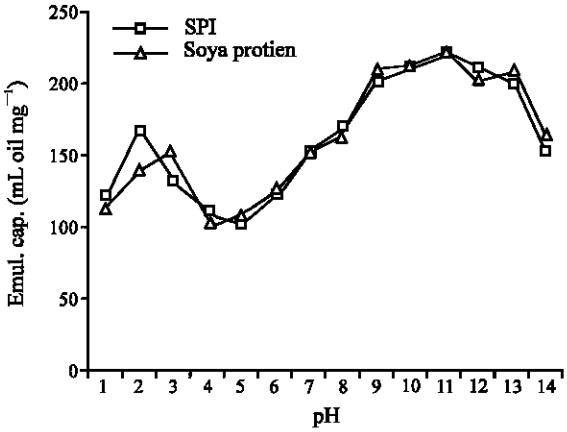

Fig. 4: Emulsification properties of SPI and Commercial soya protein isolate

surface and flexibility could also be possible for the SPI since it was processed under a temperature that might denature the protein. Present findings were in accordance with the reports of Gonzalez-Perez *et al*. (2005). They studied the emulsion properties of sunflower and reported similar results to SPI.

Dispersibility

The reconstitution property of SPI, in terms of dispersibility, was significantly higher at pH 8, 9, 10 than the commercial soya protein (Fig. 5). But when the pH was adjusted to pH 11 the commercial soya protein isolate exhibited higher disperseability though the difference was not significant ($p<0.05$). However as the pH was increased the dispersibility of commercial soya protein kept on increasing and the difference was significantly different ($p<0.05$). Thus suggesting that when pH is within the range of 8-10 for SPI it will display a very good dispersibility which will be a very good functional property if this protein isolate is to be supplemented to foods like weaning foods that are supposed to disperse upon mixing so that they do not form a mat at the bottom while preparing them with water for the consumption of babies as weaning food was shown to have good dispersibility attribute at pH between 8-10 as reported by Kulkarni *et al*. (1991). The dispersibility of our product supported the results of Volkert and Klein (1979) who reported very similar range of pH for the higher dispersibility of their product. It was however reported that higher dispersibility enhances the emulsifying and foaming properties of proteins, which was observed during the making of bread, macaroni and cookies (Kinsella, 1979). That could be the reason why SPI displayed good emulsification properties as its dispersibility was significantly good for certain foods formulation or protein supplementation.

Whipping Properties

Various whipping properties of the SPI products were compared with commercial soya protein isolate. According to Table 2, it was observed that for foam expansion, SPI had a higher foam expansion. For the foam volume when the foam was left to stand for some time to investigate the

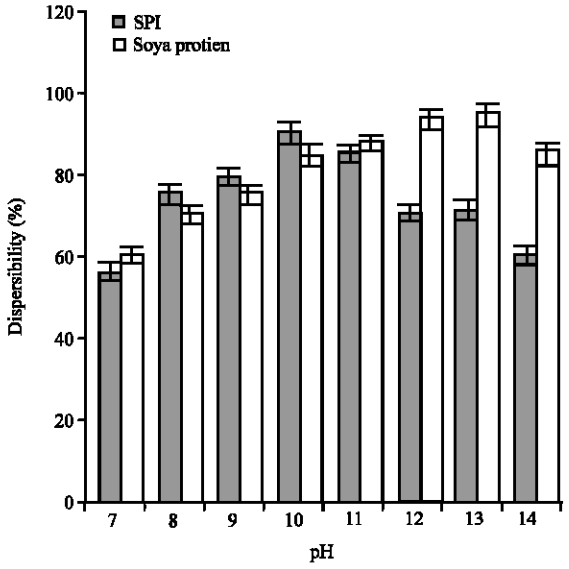

Fig. 5: Mean scores±standard deviations which are not significant at level ($p<0.05$), for dispensability

Table 2: Whipping properties of SPI and commercial soya protein isolate

Sample	Foam expansion (%)	Foam 15 min	Volume 30 min	(%) 60 min	Foam 15 min	Leakage 30 min	(%) 60 min
SPI	79±0.05[a]	95±0.52[a]	80±0.09[a]	70±0.52[a]	86±0.17[a]	57±0.06[a]	60±0.05[a]
Soya protein	76±0.04[a]	93±0.18[b]	82±0.16[a]	65±0.09[b]	83±0.06[b]	76±0.08[a]	75±0.03[b]

[a]Values represent Means±Standard deviation; means values with different letter(s) in the same column are significant at level ($p< 0.05$)

of SPI and commercial soya protein isolate at different pH as shown on top of each bar stability of the foam, at 15 min the SPI was higher but at 30 min the commercial soya protein isolate displayed a higher foam volume and when the time was increased to 60 min the soya protein dropped but was still higher than the SPI. For the foam leakage, the same time was also used and it was observed that the leakage was like the foam volume where at 15 min, the SPI was higher but as the time was increased, it kept on dropping and the soya protein was higher. According to present results product could only have good whipping properties at a very short time if that protein isolate was to be used in foods that should have good whipping properties like in the preparation of cakes. Both foam volume and leakage were measured as indices of foam stability. Increases in foam leakage were not always accompanied by corresponding decrease in foam volume (Yasumatsu *et al*., 1972) it can be due to adherence of the foam to the sides of the vessel. Apparent viscosity of foam was taken as an estimate of foam strength.

When compared with SPI from defatted sesame flour, the flour gave the poorest expansion, stability and the weakest foam. The protein content of the defatted flour is approximately half that of the isolate. It might be the reason why the whipping properties of the flour are poor. So it is advisable to isolate the protein for better whipping quality than both the defatted sesame flour and the commercial soya protein isolate but the product should not be left to stand for a very long time (not more than 15 min.).

The two proteins formed soft foams which were self-supporting and which rapidly coarsened and broke up as it was left for a longer time to stand. The colour of the foam rapidly darkened from white and speckled cream to yellow for the SPI and brown for the commercial soya protein isolate.

Sesame protein isolate showed excellent foam expansion which exceeded that of soya protein though the difference was not significantly different ($p<0.05$). Stability in terms of foam volume was similar to the commercial soya protein isolate foams. Leakages for the SPI and the commercial soya protein isolate were similar as both of them reduced as they were left to stand for some time but SPI showed greater leakage than the commercial soya protein isolate. Lawhon *et al*. (1972) compared the foam expansion and viscosities of a number of oilseeds, present results corroborated with their report. SPI was prepared according to Fig. 1 and spray-dried, the isolate was obtained in the powdered form. Viscosity of sesame isolate was consistently lower than commercial soya protein isolate. The SPI in this study performed well in comparison with the commercial soya protein isolate in the case of foam expansion, foam volume and foam leakage at 15 min.

Foaming Capacity

The foam capacity (FC) of SPI in (Fig. 6) was pH-dependent and was found to be lowest at pH within the region of it pI (4-5.5). The lowest FC was attributed to the protein behavior at its isoelectric point. Beyond pH 5.5, FC significantly increased, especially at pH 10 and 11. The higher FC at the above two pHs was likely due to the increased net charges on the protein, which weakened the hydrophobic interactions but increased the flexibility of the protein, this phenomenon (increase net charge) is applicable from pH 7-11 and decreases when the pH is increased to 12-14 for oil seed protein as reported by Fligner and Mangino (1991). The decrease of foam capacity after pH 11 needs to be investigated further. When the net charge increased up to pH 11, this allowed the protein to diffuse more rapidly to the air-water interface to encapsulate air particles and then enhance the foam formation (Aluko and Yada, 1995). The decrease of foam after pH 11 could be attributed that the

Fig. 6: Foaming capacity of SPI at different pH treatment

solution might have more net charges that have been release during the process, that could not permit more foam increase as it could have reach a maximum as the water was not increased to give room for more net charges to be released to entrapped more water molecules surround air droplets, this could be the reason for the drop in FC after pH 11, but this could be research up to ascertain the reason for such phenomenon. The profile of FC against pH for the protein isolate was more or less similar to that of its nitrogen solubility against pH. Present result on the FC supported the results of Sosulski and Fleming, (1977) but was different from the result of Fidantsi and Doxastakis (2002). SPI could be a good protein supplementation to food that caters for good foamingpropertiesforexample salad dressing.

CONCLUSIONS

In conclusion, total protein isolate from sesame seed was found to have very good functional properties that could be used in the formulation of different food as protein supplements. This is so because a commercially prepared soya protein isolate which was used to compare with the SPI did not show much significant difference ($p<0.05$). According to the findings the sesame protein isolate showed good functional properties that confirmed that the procedure used in its production was good enough and it could be used in protein supplementation in various food systems particularly for developing countries where protein deficiencies remain a major health problem for children.

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