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Original Article

Properties of industrial fractions of sesame seed (*Sesamum indicum* L.)

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Abstract

Whole sesame seed (WSS) was extracted for its oil using grinding press and defatted using hexane as solvent to obtain sesame cake (SC) and fully defatted sesame flour (DSF) respectively. The seed, cake and defatted flour as oil extraction industrial fractions were determined for its physical, functional, thermal properties and proximate composition to study the quality changes on industrial processing of sesame seed. Sesame cake showed significantly ($p<0.05$) low bulk density and greater porosity than whole seed and defatted flour. On removing fat, water holding and oil holding capacity of sesame flour were increased significantly at $p<0.01$. Foaming capacity was high for whole seed flour and at pH 8. The buffering capacity of defatted sesame flour was greater in alkaline medium than in acidic medium. Whole sesame seed consists of 18.3 g% of protein while defatted sesame seed flour contains 47.28 g% of protein. The thermal degradation temperature was increased on removal of fat. Sesame cake was further processed to remove the traces of oil and solvent if any and utilized as a low-cost composite flour component for supplementary food preparation.

Keywords: Whole sesame seed (WSS), Sesame cake (SC), Defatted sesame flour (DSF), Proximate composition, Physical, Functional, Thermal properties

1. Introduction

Sesame (*Sesamum indicum* L.) is a short duration crop grown throughout the year which belongs to the family *pedaliaceae*. It is called as "Queen of oil seeds" because of its excellent qualities of the seed, oil and meal. Sesame is one of the most important oilseed crops, cultivated in India, Sudan, China and Burma, which are the major sesame-producing countries, contributing to 60% of the global yield [1]. Sesame seed contains 50% of oil and 25% of protein [2]. Brown or black seeded are valued more for oil extraction, whereas white seeded are rich in iron. Sesame seeds are digestive, rejuvenative, antiaging and rich in vitamins E, A and B complex and minerals like calcium, phosphorus, iron, copper, magnesium, zinc and potassium. The oil rich in linoleic acid can be readily hydrogenated to medium melting fats for use in margarines, shortenings and vanaspathi, make the sesame nearly perfect food [3]. The sesame meal or cake is by-product after oil extraction. The defatted sesame meal is good source of nutrients, containing approximately 50% protein. One of the principal characteristics of this protein is its high methionine and tryptophan content [4] that distinguishes sesame from other oil seeds. This meal has high potential for use as a protein source or as an ingredient in the food industry. For plant proteins to be useful and successful in food application, they should ideally possess several desirable characteristics, referred to as functional properties, as well as providing essential amino acids [5]. Few studies have been done on the characterisation of sesame seed and proteins from defatted sesame meal [6]. Thus it is very important to explore functional potentiality and fundamental knowledge on properties of whole sesame seed and by products from oil industry. The present study was aimed to explore the characteristics of whole sesame seed, de-oiled cake and fully defatted sesame flour.

2. Materials and Methods

2.1 Materials

Whole sesame seed (WSS) were purchased from supermarket at Salem, TamilNadu, India. Seeds were thoroughly cleaned to free them from dirt, foreign matter, stubble, mould, rot and other infestation, washed with water and sundried. Sesame cake (SC) was obtained by extracting the oil from the whole sesame seed in an oil mill (traditional press method), solar dried and milled into flour. To obtain fully defatted sesame flour (DSF), sesame cake was repeatedly extracted with α-hexane till the fat content reduced to less than 0.05 %.

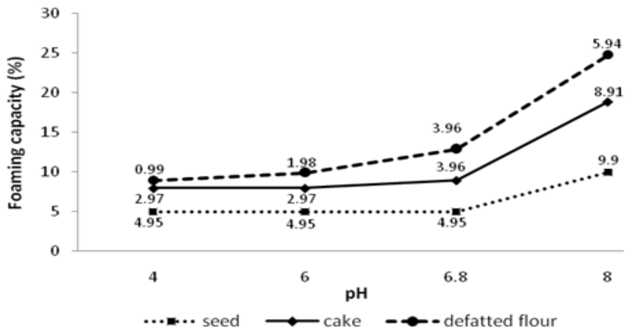

Fig.1. Foaming capacity of whole sesame seed, sesame cake and defatted sesame flour

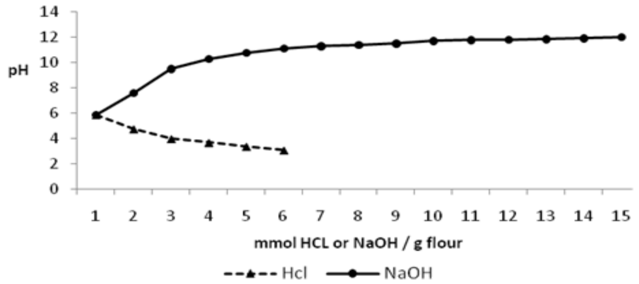

Fig.2. Buffer capacity of defatted sesame flour

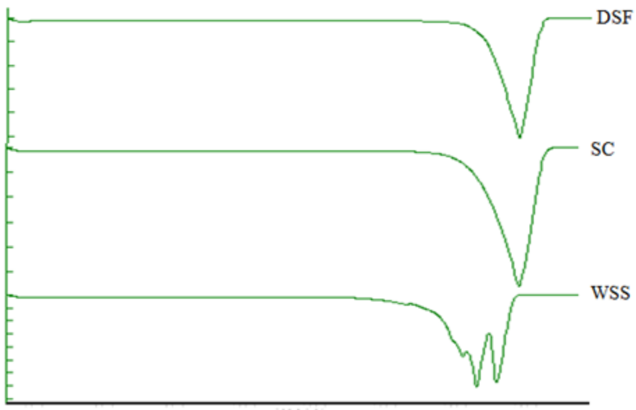

Fig.3. DSC thermogram of WSS, SC and DSF
WSS-Whole Sesame Seed, SC-Sesame Cake, DSF-Defatted Sesame Flour

2.2 Methods

2.2.1 *Physical properties*

Bulk density (g/ml) [5] and true density (g/ml) [7] of all samples were determined; porosity was calculated from bulk density and true density according to the formula indicated by Thompson and Isaac [8].

Table 1. Physical and functional properties of WSS, SC and DSF

Properties	**WSS**	**SC**	**DSF**
Bulk density (g/ml)	0.763 ± 0.01^{a}	0.67 ± 0.00^{b}	0.70 ± 0.00^{c}
True density (g/ml)	1.05 ± 0.12^{a}	1.10 ± 0.00^{b}	1.11 ± 0.00^{b}
Porosity (%)	27.33 ± 0.20^{a}	39.5 ± 0.25^{b}	36.22 ± 0.00^{c}
WHC (%)	65.236 ± 1.895^{c}	84.11 ± 1.01^{b}	234.70 ± 1.09^{a}
FAC (%)	70.533 ± 1.08^{c}	150.42 ± 0.73^{b}	181.61 ± 2.66^{a}

WSS-Whole Sesame Seed, SC-Sesame Cake, DSF-Defatted Sesame Flour, WHC-Water Holding Capacity, FAC- Fat Absorption Capacity.

Table 2. Proximate composition of WSS, SC and DSF

Nutrients	**WSS (Gopalan et al [27]**	**WSS**	**SC**	**DSF**
Moisture (g %)	5.3	5.18 ± 0.86^{b}	7.8 ± 0.8^{a}	4.06 ± 0.3^{c}
Fat (g %)	43.3	44.53 ± 0.6^{a}	0.76 ± 0.4^{b}	0.05 ± 0.02^{c}
Protein (g %)	18.3	18.30 ± 0.14^{c}	44.51 ± 0.73^{b}	47.28 ± 0.25^{a}
Crude Fiber (g %)	2.9	3.67 ± 0.15^{a}	2.36 ± 0.2^{c}	2.45 ± 0.16^{b}
Ash (g %)	5.2	4.13 ± 0.7^{c}	9.18 ± 0.6^{a}	8.68 ± 0.43^{b}
Carbohydrate (g %)	25	24.19 ± 0.72^{c}	35.39 ± 0.95^{a}	37.48 ± 0.6^{b}

WSS-Whole Sesame Seed, SC-Sesame Cake, DSF-Defatted Sesame Flour

Table 3. Onset, peak, conclusion thermal degradation temperature and enthalpy of degradation of WSS, SC and DSF

Sample	**Thermal Degradation Temperature**			**Enthalpy ΔH (J/g)**
	T_o	**T_p**	**T_c**	
WSS	137.5 ±12.6^{a}	168.5 ± 4.8^{a}	182.15 ± 4.60^{a}	1.47 ± 0.39^{a}
SC	146.4 ± 2.12^{a}	174.8 ± 2.55^{a}	185.10 ± 1.98^{a}	1.57 ± 0.06^{a}
DSF	155.0 ± 0.64^{a}	178.4 ± 3.04^{a}	187.75 ± 3.32^{a}	1.19 ± 0.01^{a}

WSS-Whole Sesame Seed, SC-Sesame Cake, DSF-Defatted Sesame Flour; Values are the average of two determinants. T_o – Onset temperature (°C), T_p – Peak temperature (°C), T_c – Conclusion temperature (°C)

2.2.2 *Functional properties*
Water holding capacity (WHC) (%) [9], fat absorption capacity (FAC) (%) [9], foaming capacity (%) [10], foaming stability (%) [10] and buffering capacity [11] were determined as functional properties of WSS, SC and DSF.
2.2.3 *Proximate composition*
Moisture by hot air oven method [12], protein by microkjeldhal method [13], fat by soxhlet method [13], ash by gravimetric method [12], crude fibre by acid and alkali digestion method [13] and total carbohydrate by difference method [14] were determined.
2.2.4 *Thermal properties*
Differential Scanning Calorimetry (DSC 6220 SII model, Japan) was used to determine thermal denaturation characteristics of WSS, SC and DSF [15]. The sample was mixed with distilled water at 10% in hermetically sealed aluminium container, sealed and kept at room temperature for one hour to equilibrate the sample with water. The sample was heated in DSC from 30°C to 200ºC at the rate of 10ºC/min. The deionised water (10 mg) was used as reference. Onset, peak and conclusion thermal degradation temperatures (ºC), enthalpy of degradation (ΔH in J/g) were noted to describe thermal nature of samples.
2.2.5 *Statistical analysis*
All determinations were done in triplicate. The data were analyzed using one way analysis of variance (ANOVA) and means were compared by Duncan multiple range test (DMRT) with mean square error at 5% probability using SPSS 17.0.

3. Results and Discussion

3.1 Physical properties
Determining the physical properties of food is of high significance as they reflect the interaction between the components, structure, confirmation, physicochemical properties, and nature of the environment or the food matrix [16]. Bulk density of WSS was significantly ($p<0.01$) greater than SC and DSF (Table 1). The bulk density depends on the combined effects of interrelated factors such as the intensity of attractive inter particle forces, particle size, and number of contact points [17].
The high porosity of SC revealed higher rate of auto-oxidation than WSS and DSF. Higher porosity resulted in greater contact with atmospheric oxygen thereby higher rate of auto-oxidation [18]. Thus SC was more deteriorative than fully DSF and WSS.
3.2 Functional properties
Water and oil holding capacity of DSF was significantly greater than WSS and SC (Table 2). It has been reported that DSF exhibits poor WHC compared to that of defatted groundnut cake (306.67 %) [19] and soy protein isolates (289 %) [20]. The higher protein content in the flour might be responsible for high hydrogen bonding and high electrostatic repulsion as suggested by Altschul and Wilcke [21]. The greater OAC of DSF might be due to enhanced hydrophobic character, non polar side chain and different confirmation features of proteins in the flour [22]. Kinsella [23] suggested that OAC was important, as oil acts as a flavour retainer and improves the mouth feel of foods.
Whole sesame seed (WSS) exhibits maximum foaming capacity with respect to SC and DSF at different pH (4, 6, 6.8 and 8) (Fig.1) and foaming capacity was increased significantly at $p<0.05$ while increasing the pH of the sample which was likely due to increased net charge on the protein, which weakened the hydrophobic interactions but increased the flexibility of the protein as said by Kanu et al [24]. Similar observation was reported for field pea flour [25]. The foam was stable for 5-10 minutes irrespective of samples.
One gram of defatted sesame flour when dispersed in 40 ml distilled water had an initial pH of 5.9. The addition of 0.5 M HCl and 0.3 M NaOH brought about changes in pH of the solution (Fig.2). At acidic pH range 5.9 – 3.1, an average of 2.28 mmol of 0.5 M HCl and at alkaline pH range 5.9 – 10.1, an average of 1.1 mmol of 0.3 M NaOH was required per gram of DSF to change the pH by one unit. Thus the higher buffer capacity of DSF was noted in alkaline than in acidic medium.
3.3 Proximate composition
Proximate composition of WSS, SC and DSF was indicated in Table 2. The WSS had significantly ($p<0.05$) high fat (44.53%) and crude fiber (3.67%) compared to SC and DSF. The moisture and ash content of SC were significantly ($p\leq 0.05$) greater than WSS and fully DSF. Protein content of DSF (47.8 g%) was greater than defatted groundnut flour (43.58 g%) reported by Sulieman and Mabrouk [26]. The proximate composition of WSS was statistically comparable with values reported by Gopalan et al [27] (Table 2).
3.4 *Thermal properties*
The temperature T_o and T_p were the measure of protein denaturation [28] and influenced by heating rate and the protein concentration. In this respect, the higher T_o and T_p of DSF (Table 3) indicated that a less heat stable group of protein had been denatured during the process. As stated by Biliaderis [29], the native to denatured change in the protein state was a co-operative phenomenon that accompanied by significant heat uptake which seen as an endothermic peak in the DSC thermogram (Fig.3). The transition heat (ΔH) was calculated by integrating the area below endothermic peak and used to monitor the proportion of protein that does not denature during a process [29, 30]. The DSF showed lower ΔH (Table 3) compared to SC and WSS which suggest that a lower proportion of protein underwent denaturation during the process. DSC thermogram parameters of WSS, SC and DSF were not significantly different at $p<0.05$.

4. Conclusion

The greater water absorption capacity and oil absorption capacity indicated the suitability of defatted flour for the preparation of cake, biscuit, sausages, noodles and other macaroni products. Study on modification of protein to reduce the protein denaturation temperature through various method of processing will throw light on further value addition towards the preparation of high protein food supplement using defatted sesame flour like soy flour.

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