Effect of Dehulling Methods and Desolventizing Temperatures on Proximate Composition and Some Functional Properties of Sesame (*Sesamum indicum* L.) Seed Flour

U.E. Inyang* and J.O. Ekanem

Department of Food Science & Technology, University of Agriculture, Makurdi Benue State, Nigeria

ABSTRACT: Sesame seeds were dehulled mechanically and in 10% sodium chloride solution before oil extraction and drying to obtain the flour. The effect of these dehulling methods on the proximate composition, oil and water absorption, emulsification, and foaming properties of the flour was investigated. The effect of desolventizing temperatures (80, 90, and 100°C) on these properties was also investigated. Protein contents of seeds, dehulled mechanically (MDSF) and in 10% NaCl solution (SDSF), were 58.5 and 52.1%, respectively. Carbohydrate and ash contents of both flours also varied. The oil and water absorption capacities of the flours were 268 and 252% for MDSF and 370 and 410% for SDSF, respectively. The emulsion capacity of the MDSF sample was slightly lower (20.0 mL oil/g sample) but more stable than the SDSF sample, whose value was 20.4 mL oil/g sample. The foam capacity of MDSF was, however, higher (48.5%) but less stable than SDSF (33.7%). An increase in desolventizing temperatures of the meal led to increases in oil and water absorption capacities of the flours. Foam and emulsion capacities, on the other hand, decreased with increase in temperature. Desolventizing temperatures had no effect on the stability of the formed emulsion but had a decreasing effect on the stability of the foam.

JAOCS 73, 1133–1136 (1996).

KEY WORDS: Dehulling methods, desolventizing temperatures, functional properties, proximate composition, sesame seed flour.

Sesame (*Sesamum indicum* L.) is an oil-bearing seed and is ranked as one of the highest in oil content (1). The meal obtained after oil extraction is a good source of protein, ranging from 400–500 g/kg dry matter, depending on the method of oil extraction (2). Sesame protein is high in methionine (3.2%), which is unusual for most plant proteins (3,4), and the defatted meal prepared from dehulled seeds does not contain undesirable pigments (4). These unique properties render sesame seed an excellent protein source for supplementing soybean, peanut, and other vegetable proteins, which lack sufficient methionine, to increase their nutritive qualities.

In conventional processing where oil is the major product, the whole seed is usually crushed and the oil is extracted. The by-product (meal) is usually fed to animals as a protein source. But, in areas where the meal is eaten by human beings, dehulling is necessary because the hull contains undesirable oxalic acid (2–3%), which could complex with calcium and reduce its availability (5). The hull also contains undigestible fiber, which impairs digestibility of the protein and imparts a dark color to the meal. Dehulling improves the nutritional and flavor characteristics of the meal and leads to the production of a glossy white product (3). It also leads to an increase in protein content, reduction in fiber content, and improvement in the functional characteristics of the protein.

Several dehulling methods have been reported by various investigators (5–7). However, the effect of these dehulling methods on the functionality of the sesame seed flour has not been investigated. Also, because most protein products would require exposure to rather severe heat treatment, the effect of such processing conditions on functionality merits investigation. This study was, therefore, designed to provide basic information on the effect of dehulling methods and desolventizing temperatures on the proximate composition, oil and water absorption, emulsification, and foaming properties of sesame seed flour.

MATERIALS AND METHODS

Sesame seeds were purchased from three different markets in Makurdi, the capital of Benue State, Nigeria. The seeds were thoroughly mixed to obtain the composite sample used for this study. The mixed seeds were divided into two equal portions. The first portion was dehulled in 10% NaCl solution, and the second portion was mechanically dehulled in an abrasive dehuller.

Dehulling by soaking in 10% NaCl solution. The method as described by Toma *et al.* (6) was followed. This was done by soaking one portion of the mixed seeds in 10% NaCl solution for 14 h. The seeds were then washed with tap water and,

*To whom correspondence should be addressed at Department of Food Science & Technology, University of Agriculture, P.M.B. 2373, Makurdi Benue State, Nigeria

while washing, they were rubbed by hand to decorticate them and to remove the salinity. Water was then drained off, and the seeds, together with the hulls, were sun-dried (31 ± 1°C) for 36 h. The seeds were separated from the hulls by winnowing and screening.

Mechanical dehulling. The abrasive dehuller, designed and fabricated by the Federal Institute of Industrial Research, Oshodi (FIIRO) (Lagos, Nigeria), was used for dehulling the second portion of the seeds. This was done by pouring the seeds into the abrasive machine. Enough water was added to cover the seeds. The machine was operated manually, and the seeds were dehulled within 10 min of operation. The seeds were separated from the hulls by the principle of flotation. The hulls were decanted with water. The seeds were further washed to remove the remaining hulls from the seeds. The seeds were then sun-dried (31 ± 1°C) for 36 h.

Preparation of sesame seed flour. Dehulled seeds were flaked and extracted with food-grade *n*-hexane (B.P. 60°C) in a continuous Soxhlet apparatus for 12 h. The meal was desolventized in an oven at 65°C for 8 h and milled to pass through a 75-mesh screen. Flour from mechanically dehulled seeds was designated as MDSF, and that from seeds soaked in salt solution prior to dehulling was designated as SDSF.

To study the effect of temperature on some functional properties of the flour, desolventization was carried out at 80, 90, and 100°C, respectively.

Analytical procedures. Moisture, fat, protein, crude fiber, and ash were determined according to the procedures of the AOAC (8). The carbohydrate was calculated by difference (9).

Functional properties. Oil absorption, water absorption, and emulsion properties were determined by the methods described by Okezie and Bello (10). For foaming properties, the method described by Lin *et al.* (11) was followed. Foam capacity (FC) was expressed as percentage volume increase and calculated as:

$$FC = \frac{\text{vol after whipping} - \text{vol before whipping}}{\text{vol before whipping}} \times 100 \qquad [1]$$

Foaming stability was determined by measuring the foam height at intervals of 30, 60, 90, 120, 150, 180, and 210 min.

RESULTS AND DISCUSSION

Preliminary investigations revealed that dehulling in the abrasive equipment designed by FIIRO was faster (less than 10 min) than the method involving soaking the seeds in 10% sodium chloride solution for 14 h before washing to decorticate them. However, the dehulling methods did not affect the oil content of the seeds, flour color, and yield.

Proximate composition of the flours. The proximate compositions of both flours (MDSF and SDSF) are shown in Table 1. The protein content of MDSF was higher (58.5 ± 0.5%) than that of SDSF, whose value was 52.1 ± 0.4%. Sesame protein is mostly made up of salt-soluble globulins (5). Therefore, the low protein content in the SDSF sample might be due to leaching out of part of the soluble proteins into the salt solutions during soaking for 14 h. The low ash content in sample SDSF may also be due to leaching of some of the constituents into the salt water. Bencini (12) reported earlier that the soaking of seeds caused loss of ash content. Carbohydrate levels in the flours were 20.0 ± 0.1% and 28.1 ± 0.3% for MDSF and SDSF, respectively. This variation may be attributed to the variation in other constituents, mainly protein. The percentage fiber for both flours shows that the level of decortication was the same.

TABLE 1
Effect of Dehulling Method on the Proximate Composition of Sesame Flours[a]

Constituents (%)	MDSF	SDSF
Moisture	7.0 ± 0.8	7.0 ± 0.9
Fat	5.0 ± 0.8	5.0 ± 0.6
Crude protein	58.5 ± 0.5	52.1 ± 0.4
Ash	6.5 ± 0.7	4.8 ± 0.5
Crude fiber	3.0 ± 0.6	3.0 ± 0.6
Carbohydrate	20.0 ± 0.1	28.1 ± 0.3

[a]Values are means ± standard deviations of triplicate determinations. MDSF, flour from seeds dehulled mechanically; SDSF, flour from seeds soaked in 10% NaCl solution before dehulling.

Oil and water absorption capacities. The results show that both flours (MDSF and SDSF) exhibited a high degree of oil absorption capacity at room temperature (Table 2). This could lead to improvement of mouth feel and flavor retention of foods. The oil absorption capacity of MDSF was, however, higher (268%) than that of SDSF (252%), which could be attributed to the higher protein content of MDSF. Kinsella (13) attributed the mechanism of oil absorption mostly to the physical entrapment of oil and its binding to the polar chains of protein. In spite of the differences in oil absorption capacity, the results show that both flours would perform well in formulated food products, such as coffee whiteners, dough, and cakes.

Variation in water absorption capacity of the two flours was observed, with SDSF having a higher absorption capacity (410%) than MDSF (370%) (Table 2). The higher carbohydrate content of SDSF could have contributed to its higher water absorption capacity.

Emulsion capacity and stability. Data in Table 3 show the emulsion capacity (EC) and emulsion stability (ES) of MDSF and SDSF. The EC of SDSF was slightly higher (20.4/mL oil/g sample) than that of MDSF (20.0/mL oil/g sample). It is likely that the sodium chloride solution in which the seeds

TABLE 2
Oil and Water Absorption Capacities of Sesame Flour from Seeds Dehulled Mechanically and in 10% NaCl Solution[a]

Sample	Oil absorption (%)	Water absorption (%)
MDSF	268 ± 0.3	370 ± 0.4
SDSF	252 ± 0.1	410 ± 0.5

[a]Values are means ± standard deviation of triplicate determinations. See Table 1 for abbreviations.

TABLE 3
Emulsion Capacity and Stability of Sesame Flours as Influenced by Dehulling Methods

Sample	Emulsion capacity (mL oil/g sample)	Emulsion stability [mL H_2O separated after time (min)] 30	60	90	120	150	180	210
MSDF	20.0 ± 0.3	0	0	0	0	0	0	0
SDSF	20.4 ± 0.0	3.5	4.0	4.5	5.5	5.5	5.5	5.5

[a]Values are means ± standard deviation of triplicate determinations. See Table 1 for abbreviations.

were soaked (14 h) prior to decortication had some effect on the conformational structure of the protein in SDSF and, hence, the higher emulsion capacity. McWatters and Holmes (14) reported, that, at pH 7.0 and above, soy flour suspended in water showed lower EC than soy flour suspended in 0.1 M and 1.0 M NaCl. Also, the higher level of carbohydrate content in SDSF might have contributed to its higher emulsification capacity.

The emulsion formed by MDSF was, however, more stable than that formed by SDSF because there was no separation between the oil and water during the period of observation. This agrees with the report of Lin *et al.* (11), who stated that whereas the EC decreases with protein concentration, the stability significantly increases, reflecting the formation of a thicker film around the emulsified droplet.

FC and stability. The foaming properties of the two flour samples varied (as shown in Table 4). MDSF with higher protein content gave higher foaming capacity (48.5%) than SDSF (33.7%). Shanmugasundaram and Venkataraman (15) associated foamability with the rate of decrease of surface tension of air/water interface caused by absorption of protein molecules. The result obtained in this study agrees with Kinsella *et al.* (16), who stated that the rate of absorption of protein is increased at high concentrations of protein. A stability study of the foam showed that MDSF was, however, less stable than SDSF (Table 4).

Effect of desolventizing temperature. Oil and water absorption capacities. The results show that increasing desolventizing temperatures resulted in increases in oil and water absorption capacities of the flour (Table 5). The increases ranged from 270 and 380% at 80°C to 321 and 416% at 100°C for oil and water absorption capacities, respectively. This could be attributed to a possible increase in the degree of denaturation and unfolding of protein molecules as temperature was increased. This would inevitably increase the number of binding sites that were previously unavailable, thereby enhancing its absorption capacity (16). Improvement in water-binding capacity of sunflower and winged bean protein due to denaturation has been reported by Lin *et al.* (11) and by Narayanae and Narasinga Rao (17). Also, Kinsella *et al.* (16) reported that fat-binding capacity of soy protein was enhanced by denaturation of the protein, which exposed apolar amino acids.

EC and ES. An increase in desolventizing temperatures of the meal resulted in reduction of the emulsifying capacity of the flour from 19.9 mL oil/g sample at 80°C to 17.3 mL oil/g sample at 100°C. A similar reduction in emulsifying capacity with increase in temperature was reported for soy and peanut proteins (14,16). The decrease in emulsifying capacity of the flour with increase in temperature might be due to the possible increase in the degree of protein denaturation as the temperature was increased. McWatters and Holmes (14) stated that protein denaturation at high temperatures reduces emulsifying activity; the effect may be due solely to decreased solubility. Smith and Circle (18) have stated that conventional processing, such as steam deodorization and desolventization, could cause concomitant denaturation of the major globulins in soy protein and loss in some functional properties. However, an increase in desolventizing temperatures up to 100°C did not affect the stability of the emulsion within the period of observation (210 min) because it did not separate any aqueous phase.

FC and foam stability. An increase in desolventizing temperature resulted in a decrease in foaming capacity, ranging from 28.7% at 80°C to 16.8% at 100°C (Table 6). A similar decrease

TABLE 4
Foaming Capacity and Stability of Sesame Flour from MDSF and SDSF[a]

Sample	Volume before whipping (mL)	Volume after whipping (mL)	Volume increase (%)	Foam stability 30	60	90	120	150	180
MDSF	101	150	48.5	141	137	127	127	119	117
SDSF	101	135	33.7	130	124	120	119	119	119

[a]Average of triplicate determinations. See Table 1 for abbreviations.

TABLE 5
Effect of Desolventizing Temperature on Oil and Water Absorption Capacities of Sesame Flour (MDSF)[a]

Sample	Treatment temperatures (°C)	Oil absorption capacity (%)	Water absorption capacity (%)
MDSF	80	270 ± 0.3	380 ± 0.1
	90	309 ± 0.2	393 ± 0.1
	100	321 ± 0.2	416 ± 0.3

[a]Values are means ± standard deviations of triplicate determinations. See Table 1 for abbreviation.

TABLE 6
Effect of Desolventizing Temperatures on the Foaming Capacity and Stability of Sesame Seed Flour (MDSF)[a]

Treatment temperature (°C)	Volume before whipping (mL)	Volume after whipping (mL)	Volume increase (%)	Foam stability [volume changes after time (min)] 30	60	90	120	150	180
80	101	130	28.7	124	118	118	116	114	114
90	101	122	20.8	118	116	114	110	107	102
100	101	118	16.8	115	112	110	110	109	108

[a]Average of triplicate determinations. See Table 1 for abbreviations.

in FC with increase in heat processing had been reported (17,19). Huffman *et al.* (19) associated the decrease in FC with an increase in temperature to denaturation of the protein and subsequent loss of solubility.

Stability of the foam also decreased with an increase in temperature (Table 6). This observation agrees with Kinsella *et al.* (16) who stated that limited surface denaturation is required to impart viscosity and rigidity to the interfacial film for foam stabilization, but excessive denaturation of proteins destabilizes the foam.

In conclusion, this study revealed that, besides being faster, mechanical dehulling produced flour with higher protein content, oil and foaming capacities, and ES. Water absorption, EC, and foam stability were, however, lower than that of flour from seeds soaked in 10% NaCl solution prior to decortication. High desolventizing temperatures led to increases in oil and water absorption capacities but to decreases in both emulsion and foaming properties.

REFERENCES

1. Glabe, E.F., P.W. Anderson, and A.F. Holterff, Improvement of Food Flavour, Fat Stability and Nutritional Value of Sesame Products, *Food Technol. 11*:185–188 (1957).
2. McDonald, P., R.A. Edwards, and J.F.D. Greenhalgh, *Animal Nutrition*, 3rd edn., Longman Group Ltd., Essex, England, 1980.
3. Johnson, L.A., T.M. Suleiman, and E.W. Lusas, Sesame Seed: A Review and Prospects, *J. Am. Oil Chem. Soc. 56*:463–468 (1979).
4. Daghir, N.J., M.F. Ullah, and R. Rotterstenk, Lysine Supplement of Sesame Meal, *Trop. Agric. 44*:235–242 (1967).
5. Kinsella, J.E., and R.R. Mohite, The Physicochemical Characteristics and Functional Properties of Sesame Proteins, in *New Protein Foods*, Vol. 5, edited by A.M. Altsechull and H.L. Wilcke, Academic Press Inc., New York, 1985, pp. 435–456.
6. Toma, R.B., M.M. Tabekhia, and J.D. Williams, Phytate and Oxalates Contents in Sesame Seed (*Sesamum indicum* L.), *Nutri. Reports Int. 20*:25–31 (1979).
7. Abou EL-Khier, Y.I.A., Y.C. Moharran, and H.O.A. Osman, Effect of Decortication on the Quality of Sesame Kernel and Products, *J. Food Agric. 1*:163–168 (1987).
8. *Official Methods of Analysis*, 14th edn., Association of Official Analytical Chemists, Washington, D.C., 1984.
9. Ihekoronye, A.I., and P.O. Ngoddy, *Integrated Food Science and Technology for The Tropics*, MacMillan Publishers, London, England, 1985.
10. Okezie, B.O., and A.B. Bello, Physicochemical and Functional Properties of Winged Bean Flour and Isolate Compared with Soy Isolate, *J. Food Sci. 53*:450–455 (1988).
11. Lin, M.J.N., E.S. Humber, and F.W. Sosulski, Certain Functional Properties of Sunflower Meal Products, *J. Food Sci. 39*:368–370 (1974).
12. Bencini, M.C., Functional Properties of Drum Dried Chickpea (*Circer arietinum* L.) Flour, *Ibid. 5*:1518–1521 (1986).
13. Kinsella, J.E., Functional Properties of Proteins in Foods: A Survey, *Crit. Rev. Food. Sci. Nutri. 4*:219–280 (1976).
14. McWatters, K.H., and M.R. Holmes, Salt Concentration, pH and Flour Concentration Effects on Nitrogen Solubility and Emulsifying Properties of Peanut Flour, *J. Food Sci. 44*:765–769 (1979).
15. Shanmugasundaram, T., and L.V. Venkataraman, Functional Properties of Defatted and Detoxified Madhuca (*Madhuca butyraceae*) Seed Flour, *J. Food Sci. 5*:351–353 (1989).
16. Kinsella, J.E., S. Damodaran, and B. German, Physicochemical and Functional Properties of Oilseed Proteins with Emphasis on Soy Proteins, in *New Protein Foods*, Vol. 5, edited by A.M. Altschul and H.L. Wilcke, Academic Press Inc., New York, 1985, pp. 108–176.
17. Narayana, K., and M.S. Narasinga Rao, Functional Properties of Raw and Heat Processed Winged Bean (*Psophocarpus tetragonolobus*) Flour, *J. Food Sci. 47*:1534–1538 (1982).
18. Smith, A.K., and S.J. Circle, *Soybeans: Chemistry and Technology*, Avi Publication Co. Inc., Westport, 1972.
19. Huffman, V.L., C.K. Lee, and E.E. Burn, Selected Functional Properties of Sunflower Meal (*Helianthus annuus*), *J. Food Sci. 40*:70–73 (1975).

[Received July 10, 1995; accepted July 8, 1996]