Studies on the Wet Dehulling of Sesame Seed to Obtain Superior Grade Protein Concentrates

M. C. SHAMANTHAKA SASTRY, N. SUBRAMANIAN and R. RAJAGOPALAN,
Central Food Technological Research Institute, Mysore, India

Abstract

Easy removal of the fibrous colored skin of sesame seed was accomplished by contacting the seed with lye solution under optimal conditions. The decuticled seed was dried mechanically and a yield of 85% on the raw material was obtained. Screw pressed or pre-press solvent extracted flour derived from the dehulled seed had an attractive white appearance, was free from bitterness and had a lower crude fibre and oxalic acid content. Both in the content of protein and its nutritional quality, the meal was found to be superior to commercial sesame cake. Heat treatment inherent to expeller operation was found to have beneficial effect on sesame protein.

Introduction

Sesame (*Sesamum indicum*), one of the major oilseeds grown in India, has special significance as a protein source containing high levels of sulfur amino acids, particularly methionine, as compared to other oilseeds (1). The main limitation in the use of sesame meal for human consumption, however, is the presence of the cuticle which contributes not only dark color but also bitterness to the product. Presence of the cuticle in the cake is responsible for appreciable amounts of calcium oxalate and crude fiber in the meal; foreign matter such as sand and silica in the commercial seed also adds to the acid insoluble ash content of the meal. Although sesame is produced in many parts of the country, it is seldom dehulled prior to oil extraction. Only a small fraction used directly in certain foods and confections is decuticled by the traditional method of soaking in water followed by rubbing, washing and drying.

One of the approaches to improve the quality of the meal is by sieving off the fibrous skin fractions from a directly solvent extracted sesame flour (2). Since the endosperm is not broken when the seed is passed through the flaking rolls, this tissue along with spermoderm could be easily separated by simple screening through a 60 mesh screen; the flour has, however, an appreciable amount of calcium oxalate as some of the epidermal fractions also pass through the sieve.

The most satisfactory method of getting an edible sesame flour has been found to be one based on processing the decuticled seed (3). Numerous wet processing methods have been reported in the literature for decuticling sesame. These include soaking the seeds in warm water, treatment with lye or subjecting to the action of hot dilute alkali such as sodium hydroxide, sodium borate or sodium hypochlorite to loosen or disintegrate the hulls (3–5). A continuous process which works at very low moisture levels has been developed in Mexico, which is based on a frictional operation technique (6). A mechanical method of decuticling sesame seed but involving the traditional approach of soaking in water has also been reported (7). The present work deals with the standardization of a lye treatment process using aqueous sodium carbonate, sodium bicarbonate or sodium hydroxide for the wet dehulling of sesame seed. Data collected on the laboratory and bench scale processing of sesame and on the nutritional quality of the edible protein concentrate obtained from the decuticled seed are presented.

Experimental Procedures

Laboratory Trials

Clean, good quality black sesame seed obtained locally was added to near boiling alkaline solutions of sodium bicarbonate, sodium carbonate or sodium hydroxide, with continuous stirring. The lye treated wet seed was drained on a screen and washed with water sprays. Mild rubbing of the seed at this stage facilitated easy removal of the loosened husk, which was washed off. The thoroughly washed and drained seeds were then dried in a cabinet drier. The process variables such as seed-to-water ratio, concentration of the lye solution, temperature and time of contact on the efficiency of decuticling were studied.

On the basis of preliminary studies, it was found that the optimum volume of lye solution needed for proper soaking of a 100 g sample of seed in a 0.5 L beaker was 160 ml. Lesser volumes of solution resulted in a thick slurry difficult to handle. Likewise, studies on varying the temperature indicated that for an effective decuticling without any penetration of alkali into the endosperm, short period contact at near boiling temperature of the lye (96 C) was preferable. Depending upon the nature of the alkali used, the time required under these conditions varied from 1 to 15 min.

The concentration of sodium hydroxide, sodium carbonate and bicarbonate in the lye solution was varied from 0.5% to 10% (w/v). It was found that the time of contact and the concentration of the lye needed were much higher in the case of sodium carbonate and bicarbonate as compared to sodium hydroxide. With sodium bicarbonate in the lye solution, a concentration of 6% (w/v) and a contact period of 15 min were found optimum, while with sodium carbonate, a concentration of 5% (w/v) was equally effective for decuticling. When the concentration of the lye was below these optimum levels, incomplete

TABLE I
Composition and Yield of Sesame Seed Subjected to Different Wet Dehulling Treatments[a]

Constituents	Black variety sesame seed	Decuticled sesame seed treatments			
		0.6% NaOH 1 min	6% $NaHCO_3$ 15 min	5% Na_2CO_3 15 min	Traditional method of decuticling (water)
Moisture	5.20	4.13	4.35	3.89	4.00
Fat (ether extractives)	49.80	60.23	60.06	61.96	60.83
Protein (N × 6.25)	19.15	22.14	22.13	21.54	22.50
Total ash	5.67	3.21	2.86	2.94	2.32
Acid insoluble ash	0.15	0.01	0.01	0.01	0.01
Crude fibre	4.12	3.07	3.06	2.98	2.36
Oxalic acid	2.30	0.13	0.13	0.10	0.12
Calcium	1.20	0.23	0.32	0.25	0.21
Yield of decuticled seeds	....	84.50	84.00	84.00	82.00

[a] Values g/100 g of the material.

TABLE II

Chemical Composition of Whole and Decuticled Sesame Flour[a]

Constituents	Whole black sesame flour		Decuticled sesame flour	
	Expeller pressed	Solvent extracted	Expeller pressed	Solvent extracted
Moisture	6.60	4.80	5.80	6.84
Fat (ether extractives)	10.70	0.50	10.00	0.40
Protein (N × 6.25)	41.40	43.10	54.40	56.10
Total ash	8.70	8.10	6.20	6.08
Acid insoluble ash	0.12	0.21	0.06	0.08
Crude fibre	6.80	6.75	5.10	4.93
Oxalic acid	3.71	4.00	0.24	0.26
Calcium	1.74	1.84	0.31	0.35

[a] Values g/100 g of the material.

removal of the cuticle was observed. The use of sodium hydroxide in the lye solution considerably reduced the concentration and time of contact as compared to sodium carbonate and bicarbonate. Even at a very low concentration of 0.6%, a contact time of 1 min was adequate. At higher concentration or with longer contact period, the decuticled seed showed discoloration (yellowish brown). This was possibly due to excessive absorption of alkali into the endosperm leading to undesirable changes. Following the lye treatment, it was necessary to wash the seeds thoroughly with light rubbing on a wire screen (40 mesh) to wash off the pigments along with the ruptured seed coat. The color of the washed seed was considerably improved by giving a final wash with a dilute 1% solution of acetic acid or hydrochloric acid; this treatment had the advantage of neutralizing the residual alkali, if any, in the washed material.

Microscopic examination of the decuticled seed revealed that, out of the two membranes which make up the cuticle, only the outer membrane having the pigments and calcium oxalate was removed.

In order to compare the efficiency of the above lye treatment procedure with the traditional method of decuticling, a few batches were processed by soaking the seeds overnight in cold water followed by scrubbing and separation of the skin.

Bench Scale Trials

From the laboratory studies, it was apparent that from the consideration of concentration of lye and time of contact, the use of sodium hydroxide was more advantageous; therefore, bench scale trials were carried out using 0.6% sodium hydroxide solution. Thirty-two L of the lye solution were heated in a stainless steel jacketed kettle to 96 C and 20 kg of cleaned seed was added. After a contact period of 1 min, the dark colored extract was drained. Excess cold water was added to cool down the seed and also to lower the strength of the alkali in contact with the seed. The seed which resulted from this treatment was transferred onto a Gyro-Screen with 40 mesh sieve and provided with a rubber scrubbing device. The seed was gently scrubbed for 2–3 min of continuous washing with a spray of water. The wet decuticled seed holding about 50% moisture was dried at 60 C for 3 hr in a cabinet drier.

Processing for Oil and Meal

In order to obtain the protein rich meal and also to determine the comparative recovery of oil from the decuticled and original seed, batches of 150 kg each of the decuticled and unprocessed black seed were screw pressed using a low capacity (0.5 tons/8 hr) expeller. The yield of oil and cake from the black seed was 47% and 48% respectively, while that from the decuticled seed was 55% and 40% respectively. Since the decuticled sesame seed contained a higher percentage of oil, the yield of cake was consequently less than in the case of the commercial black variety.

For nutritional studies, 5 kg lots of the black and decuticled sesame seeds were flaked to 0.1 mm thickness by passing through a twin roll flaker and directly solvent extracted in a percolator using food grade hexane as solvent.

TABLE III

Essential Amino Acid Composition of Sesame Protein in Expeller Processed Flours[a]

Amino acid	Whole black sesame flour	Decuticled sesame flour
Lysine	2.5	2.4
Available lysine	2.2	2.1
Arginine	13.0	12.5
Histidine	2.1	2.1
Cystine	1.2	1.2
Methionine	2.7	2.6
Valine	6.7	5.9
Phenyl alanine	4.8	4.4
Iso-leucine	4.7	4.0
Leucine	5.1	4.2
Tryptophan	1.7	1.8
Threonine	4.2	3.2

[a] One gram per 16 g nitrogen.

Analytical and Evaluation Methods

The seed samples and processed flours were analyzed using the AOCS Official and Tentative Methods (8). Oxalic acid in samples was estimated by the method of Baker (9). The essential amino acid composition of the samples were determined by microbiological assay using the method of Barton-Wright (11). The method of Carpenter was used to determine the free-*epsilon* amino group of lysine (10). Protein efficiency ratio of the proteins was determined according to the standard procedure (12).

Results and Discussion

The different wet dehulling methods studied using short period contacts with hot lye solutions at optimal concentration or traditional method yielded about 82–84% of the decuticled seed having nearly similar chemical composition (Table I). As evident from the recovery of fat and protein in the decuticled seed, there is no appreciable loss of these constituents due to hot lye treatment under the conditions employed. The crude fibre content in the decuticled seed is about 3% as compared to 4% in the original sample. There is a marked reduction in the oxalic content after decuticling from 2.3% in the original to 0.12% in the processed sample. Data given in Table II, show that the protein content of the flour from decuticled sesame seed is about 55%, significantly higher than in the case of flour from the black seed (42%). The crude fibre and oxalic acid contents of the edible flour, are also significantly lower as compared to the control samples.

Data on the essential amino acid composition of whole black sesame flour and decuticled sesame flour are given in Table III. Though sesame proteins are found to be rich in methionine, cystine and tryptophan, they are deficient in lysine. It is observed that the available lysine content of the samples is only slightly lower as compared to the total lysine, which indicates that the expeller processing in the preparation of the meal has very little adverse effect on lysine availability. Some recent reports have, however, indicated that heat developed during expeller pressing may severely damage protein quality and lysine availability (13,14).

Data on the average weight gains of rats fed on diets based on the processed sesame flour at 10% protein level in comparison with the black sesame flour (unprocessed) are given in Table IV. The Protein efficiency ratio (PER) values of the whole black sesame seed subjected to direct solvent extraction and expeller pressing are 1.46 and 1.61

TABLE IV

Diet Consumption, Gain in Body Weight of Rats and Protein Efficiency Ratio of Processed Sesame Flours

Source of protein	Average initial weight, g	Average protein intake, g	Average food intake, g		Average gain in weight, g		Protein efficiency ratio, PER	
Black sesame direct solvent extrated flour	36.2	14.7	144.1		21.5		1.46	
Black sesame expeller pressed flour	35.7	16.0	150.5	± 2.80[b]	25.8	± 1.49[b]	1.61	± 0.07[b]
Decuticled sesame direct solvent extracted flour	36.0	20.4	190.2		30.5		1.49	
Decuticled sesame expeller pressed flour	36.1	22.3	195.2		39.6		1.77	

[a] Ten male rats in each group, randomized block design, four weeks duration, 10% protein in diet.
[b] Standard error of the mean based on 27 degrees of freedom.

respectively whereas the PER values of the processed flours from decuticled seeds are 1.49 and 1.77 respectively. It is seen that by either method of fat extraction, expeller pressing or direct solvent extraction of the seed, the protein concentrates from the decuticled seed give significantly improved diet consumption and weight gain in rats. However, this improvement is not significantly reflected in the PER values.

The differences in response of rats fed on directly solvent extracted and screw pressed sesame samples are also striking. The average weight gains on whole black sesame seed subjected to direct solvent extraction and expeller pressing are 21.5 g and 25.8 g respectively with the corresponding PER values of 1.46 and 1.61 respectively. Similarly the decuticled seed subjected to direct solvent extraction and expeller pressing has given weight gains of 30.5 and 39.6 g respectively, with the corresponding PER values of 1.49 and 1.77 respectively. The diet consumption on the respective solvent extracted and expeller pressed flours are not, however, significantly different. These results indicate that the heat treatment inherent to expeller operation has a beneficial effect on the nutritional quality of sesame protein.

The removal of pigments, bitter principles, oxalic acid and a part of crude fibre by dehulling followed by expeller pressing to recover oil has thus resulted in nutritionally superior sesame protein concentrates.

ACKNOWLEDGMENT

The help of the Micro-Assay unit in the amino acid analysis, Mrs. Indira Murthy in statistical analysis of the nutritional data, and the interest of H. A. B. Parpia in the work are acknowledged.

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[Received March 25, 1969]

Latin American Congress and Food Trade Fair Planned

A Latin American Congress on Food and Economic Development is to be held December 1–5, 1969, in Sao Paulo, Brazil. Promoted by the Brazilian Organizacao de Entidades Nao Governamentais, an agency cooperating with the United Nations, the Congress will serve as a preparatory meeting aimed at developing discussion that will be useful to the Second World Food Congress to be held at the Hague in June 1970. The main objective of the Congress will be to examine the relations between agricultural development, particularly in the food sector, and the socio-economic development of the countries of the region.

To be held simultaneuosly with the Congress in an adjoining area, the First International Food Trade Fair will run from November 22 through December 7. The main purposes of the Fair are demonstration of the most modern technological advances in all sectors connected with food, agriculture, industry, marketing, and services, and activation of specific commercial trade between industrialized countries and Latin American private enterprises and government agencies.

At present, over 80 industries, representing Central and South America, Europe, and the United States, will have exhibits. An "International Food Supermarket," which will display and sell food products from throughout the world, is expected to be a feature attraction to the 500,000 visitors to the Fair.

India Inaugurates Marketing of Refined Soybean Oil

Refined soybean oil is being made available for the first time to India's consumers. In a ceremony at Bombay's Indian Merchants Chamber, Indian vegetable oil officials last month announced distribution of edible soybean oil in the cities of Bombay, Poona, Nagpur and Sholapur.

Previously, soybean oil was used only in the manufacture of Indian vanaspati, a shortening-like cooking product. Vanaspati was distributed in cans in suspended form, much like lard and cooking fat. No liquid soybean oil was available for edible uses.

The Honorable H. G. Vartak, Minister of Food, Civil Supplies and Fisheries in India's Maharashtra State, made the formal announcement. He was accompanied by C. V. Mariwala, President of India's Vegetable Oils Association. Their joint announcement pointed out that this was the first time in India's history that edible soybean oil in liquid form was made available to consumers. Initial marketing efforts will be made through the State Consumer Cooperatives in the four Indian cities. A trial lot of 500 metric tons of oil will be made available.

Processors within the Indian Vegetable Oils Association moved to assure availability of top quality refined oil following the marketing announcement. At the same time, Indian processors worked on plans to supply economically priced soybean oil to all consumers markets. Initial prices per kilogram indicated that soybean oil would sell at half the price of refined peanut oil.