# Germination of Soybeans and Its Modifying Effects on the Quality of Full-Fat Soy Flour

F. SUBERBIE, D. MENDIZÁBAL and C. MENDIZÁBAL,
Industrial de Alimentos, S.A., Mexico City

## ABSTRACT

Usually, full-fat soy flour has some disadvantages in flavor, odor and stability. A soybean germination process was developed to improve the quality of full-fat soy flour. Advantages of the process were evaluated determining protein dispersibility index (PDI), trypsin inhibitor (TI) and lipoxygenase activities, milling capacity, odor and flavor score during the different stages of the process. In the final stages of the process, a marked decrease in lipoxygenase and TI activities were observed. The PDI increased with germination time in unheated soybeans. Odor and flavor scores improved substantially. Milling capacity dropped as germination time was increased.

## INTRODUCTION

The need for a high-protein, high-fat, low-cost human food for underdeveloped countries has been emphasized (1,2). Soybeans provide a low-cost source of protein and fat that can substitute for animal protein and fat. To overcome some of the disadvantages of soybeans, such as flavor, odor and trypsin inhibitors, a germination process was developed in Mexico in 1967 (3). Later, researchers in other countries (4-6) confirmed the benefits of soybean germination. Increased ascorbic acid content and hydrolysis of raffinose and stachyose are linked to flatulence problems (7).

Our process has been improved for a good quality, full-fat soy flour. Lipoxygenase catalyzes oxidation of unsaturated fatty acids (8,9) of soybean lipids producing off flavors, odors and poor shelf-life stability (10,11). During germination, trypsin inhibitor (TI) is reduced (4). Heat treatment is the usual way for obtaining very low TI values (12-14). There is a relationship between TI and protein dispersibility index (PDI) (15).

## EXPERIMENTAL

### Processing

Jupiter variety soybeans with 11% moisture from the state of Tamaulipas were cleaned and soaked with water at room temperature for 3 hr and then pumped to the germination floor.

Germination time was 12, 24, 36, 48 and 72 hr, under controlled temperature and humidity. At the end of germination, direct steam was injected into the germination floor for 2 hr. Steam was shut off and the drying cycle started. Moisture of dried beans was 6%. Dry beans were pearled to eliminate most of the hull. Cotyledons were milled with a hammer-air, cooled-type mill to obtain a 90% full-fat soy flour with a final moisture content of 5.5% through a 100-mesh sieve.

### Materials and Methods

The following samples were taken for analysis: raw beans, soaked beans, germinated beans (12, 36, 48 and 72 hr), germinated and steamed beans (12, 36, 48 and 72 hr), germinated, steamed and dried beans (12, 36, 48 and 72 hr), germinated, steamed, dried and pearled beans (12, 36, 48 and 72 hr). The second and third samples were lyophilized in a USIFROID Reiutord, Model SMJ, Louis Rey System. All samples were milled to pass through a 100-mesh sieve.

The pH was determined by the official AACC method (16). PDI also was run by AACC methods (16) and is expressed as relative protein dispersibility index, where raw soybeans represent 100.

The TI activity was determined by the method of Kakade et al. (17), in which 0.5-g samples passing through a 100-mesh sieve were extracted with 25 ml of 0.01 N NaOH. Material from unheated beans was extracted for 1 hr, whereas material from heated beans had to be extracted 3 hr for maximal activity. Bovine trypsin (2X crystallized, salt-free, lyophilized, 217 trypsin units/mg protein from Millipore Corporation, Freehold, NJ) was used as the enzyme to hydrolyze the substrate, benzoyl-DL-arginine-*p*-nitroanilide (BAPA) hydrochloride. One trypsin unit is arbitrarily defined as an increase of 0.01 absorbance units at 410 nm/10 ml of reaction mixture under specified conditions (18). Values are recorded as % residual activity.

Lipoxygenase activity was measured by standard AACC methods (19) and is expressed in terms of % residual activity.

Milling capacity was determined when 0-hr germinated soybeans cotyledons were fed to a horizontal, hammer-type mill with air cooling and the capacity was recorded

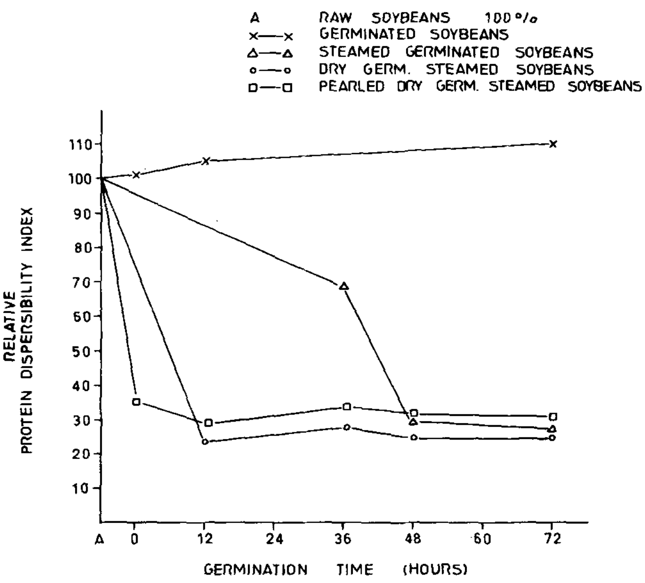


FIG. 1.

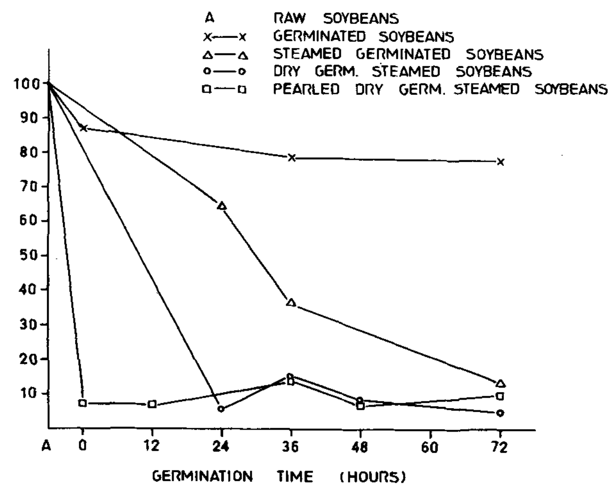


FIG. 2.

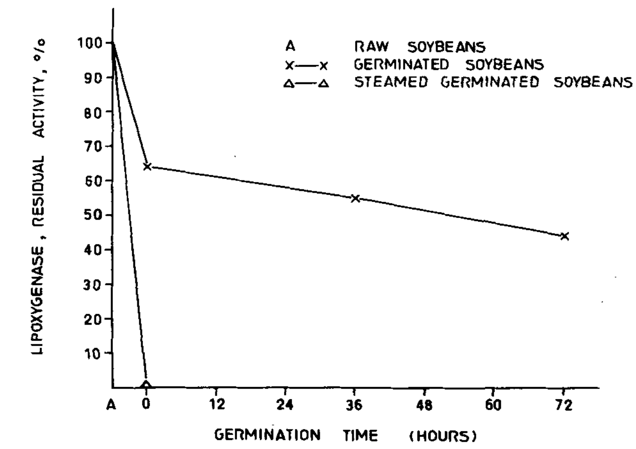


FIG. 3.

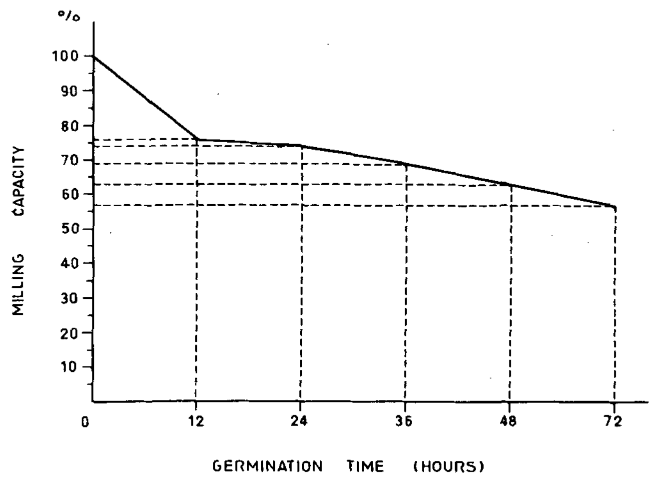


FIG. 4.

as 100%; milling capacities at 12, 36, 48 and 72 hr were referred to 0 hr germination time.

Organoleptic analysis was done using a panel test to evaluate differences in flavor and odor of the flour obtained in each stage of the process. The 8-member panel test evaluated 6% dispersions samples in water. Scores for flavor and odor were rated on a scale of 10, where 10= bland, 9-7=weak, 6-5=moderate, 3-4=strong, and 1-2=very strong. Each sample was referred to milled, raw soybeans. Each panelist gave a description of flavor and odor.

## RESULTS AND DISCUSSION

### pH

There is a small drop in pH during the soaking and germination process. Changes in pH were not significant.

### Protein Dispersibility Index (PDI)

The relative PDI referred to raw soybeans is 100. In germinated soybeans, there is an increase of PDI due to enzymatic partial hydrolysis of nondispersable proteins. Steamed, germinated soybeans showed a decreased PDI mostly because of heat treatment. The value at 36 hr germination time could be explained by the migration of carbohydrates and oil that possibly makes a barrier which does not permit the proper penetration of steam and heat. Decrease in PDI is sharp at 48 and 72 hr. Germinated, steamed, dried soybeans show a sharp decrease in PDI due to a long heat treatment. Soybeans that were germinated, steamed, dried and pearled showed an even sharper PDI decrease due to the hull removal and mechanical heating of cotyledons in the pearling machine (Fig. 1).

### Trypsin Inhibitor (TI) Activity

In germinated soybeans, TI activity is decreased, possibly by the internal heat generated by germination. In steamed, germinated soybeans, the penetration of steam and heat decreased TI consistently with increased germination time. In dried, germinated soybeans the long temperature exposure produces a sharp decrease in TI. In the pearled, dried, germinated soybeans the temperature generated by friction and the elimination of hull produces the sharpest decrease in TI. At 72 hr germination time, the TI values for steamed, germinated soybeans, dried, germinated, steamed soybeans and pearled, dried, steamed, germinated soybeans are very

TABLE I

Correlation of Flavor and Odor Ratings

| Soybean sample | Flavor score | Flavor description | Odor score | Odor description |
|---|---|---|---|---|
| Germinated 0 hr | 6.6 | Bitter, beany, disagreeable | 7.1 | Beany, agreeable |
| Germinated 36 hr | 6.1 | Beany | 5.5 | Beany, agreeable |
| Germinated 72 hr | 6.1 | Disagreeable, bitter | 5.3 | Characteristic |
| Germinated 36 hr, steamed | 7.6 | Agreeable | 6.5 | Agreeable |
| Germinated 72 hr, steamed | 8.3 | Agreeable, sweet | 8.3 | Agreeable |
| Germinated 0 hr, steamed, dried, pearled | 6.3 | Slightly beany, disagreeable | 7.6 | Disagreeable |
| Germinated 36 hr, steamed, dried, pearled | 6.9 | Agreeable, slightly beany | 8.6 | Agreeable |
| Germinated 72 hr, steamed, dried, pearled | 8.0 | Agreeable | 8.0 | Agreeable |

close (Fig. 2).

Nutritionally, flours obtained by the germination process with very low TI values are of high quality (15).

### Lipoxygenase Activity

Soaked and germinated soybeans showed a decrease in lipoxygenase activity as this enzyme is thermolabile and some heat is generated during germination. Steam destroys lipoxygenase rapidly (Fig. 3).

Full-fat soy flour has no lipoxygenase activity and thus high stability, as shown by shelf-life testing.

### Milling Capacity

During germination, there is a mobilization and partial hydrolysis of carbohydrates; oil also migrates. So, as germination time is extended, oil migration makes the milling difficult. A 43% decrease in milling capacity was observed at 72 hr germination time (Fig. 4). This is a disadvantage that could be overcome by using a pin-type mill.

### Flavor Score

As lipoxygenase activity decreased, flavor scores improved. The increase in flavor scores is higher with steaming and drying of soybeans, which eliminate the bitter flavor.

### Odor Score

There is a relationship between odor and flavor scores (Table I). Germination helps improve the odor scores if steaming and drying follows. Soybean germination modifying effects are important to the quality of the full-fat soy flour because as flavor and odor scores increase, stability is improved, nutritional improvement because of the low TI is observed and the reduction of oligosaccharides means much less flatulence.

REFERENCES


1. Srikantia, S.G., in "Food and Nutrition," Food and Agriculture Organization of the United Nations, 5(1):1979.
2. Bourges, L.H., "Experiencia del Programa Nacional de Alimentación (Mexico) con el uso de la Soya," Memorias, Primera Conferencia Latinoamericana Sobre la Proteina de Soya, México, 1975, pp. 33-40.
3. Suberbie, M.F., Mexican Patent 94, 712 (1969).
4. Bau, H.M., and G. Debry, JAOCS 56:160 (1979).
5. Rackis, J.J., J.E. McGhee, I.E. Liener, M.L. Kakade and G. Puski. Cereal Sci. Today 19:513 (1974).
6. Standal, B.R., J. Nutr. 81:279 (1963).
7. Smith and Circle, "Soybeans: Chemistry and Technology," Vol. I-Proteins, AVI Publishing Co., 1972, p. 380.
8. Dolev, A., T.L. Mounts, W.K. Rohwedder and H.J. Dutton, Lipids 1:291 (1966).
9. Tappel, A.L., P.D. Boyer and W.O. Lundberg, J. Biol. Chem. 199, 267 (1952).
10. Mustakas, G.C., W.J. Albrecht, J.E. McGhee, L.T. Black, G.N. Bookwalter and E.L. Griffin. Jr., JAOCS 46:623 (1969).
11. Mustakas, G.C., Ibid. 48:815 (1971).
12. Baker, E.C., and G.C. Mustakas, Ibid. 50:137 (1973).
13. Ellenrieder, G., H. Geronazzo and A.B. De Bojarski, Cereal Chem. 57:25 (1980).
14. Altschul, A.M., in "Processed Plant Protein Foodstuffs," Chapter V, Academic Press, Inc., New York, 1958.
15. Mustakas, G.C., W.J. Albrecht, G.N. Bookwalter, J.E. McGhee, W.F. Kwolek and E.L. Griffin, Jr., Food Tech. 24:102 (1970).
16. "Approved Methods of the American Association of Cereal Chemists," Seventh Edition, AACC, St. Paul, MN, 1969, 02-52 (hydrogen-ion activity); 46-24 (protein dispersibility Index).
17. Kakade, M.L., J.J. Rackis, J.E. McGhee and G. Puski, Cereal Chem. 51:376 (1974).
18. Kakade, M.L., N. Simons and I.E. Liener, Ibid. 46:518 (1969).
19. "General Laboratory Methods," Seventh Edition, American Association of Cereal Chemists, AACC, St. Paul, MN, 1962, 22.


# The Art of Soybean Meal and Hull Grinding

G.R. THOMAS, Prater Industries Inc., Chicago, IL 60650


## ABSTRACT

Grinding soybean meal and hulls may be considered an art—rather than a pure science—because of the need to blend properly all of the parameters involved to produce the desired finished product. Grinding soymeal for a protein supplement to animal feed is best achieved by using a side-fed mill, with plenty of air throughput and a large screen area. However, for the fine grinding of soymeal or isolate products (50-mesh or finer), an impact turbo mill with closely controlled clearances is generally used. Soybean hull grinding requires a mill with a high hammer-tip speed, wear-resistant grinding elements, good air flow, and again, large screen area. The size and speed (rpm) of each mill in a system is usually a function of the location of the mill in the system, and the type of system selected to deliver the desired finished product.


Soybean meal grinding is a very complex endeavor, not only from the point of view of all of the parameters involved in the selection of a pulverizer to perform the reduction—such as air, screen area, tip speed of hammers—but also from the simple placement of the grinder in relation to other pieces of equipment to achieve the desired end-product. Because it requires proper manipulation of all these parameters, we call this endeavor an "art," rather than a simple science.

*Changes in the preparation of meal prior to the grinding* process have caused some significant changes in the effectiveness of meal grinding. Most people remember what probably was the most significant change, i.e., the change from the expeller cake process to the solvent extraction process. Then, in recent years, the advent of head-end dehulling greatly improved the capacity and quality of meal grinding.

The soybean industry has basically standardized on a finished meal specification, which primarily is "everything through a 10 mesh screen, with 50% maximum through a 24 mesh screen, and 1% maximum through an 80 mesh screen." This grinding specification can be more easily achieved if we have good screening efficiencies on the screen ahead of the grinding process. Too often, many acceptable fines (minus 10-mesh) are carried to the grinder where they are, unfortunately, further reduced simply because the bed depth on the vibrating screen was too great, or other complications arose in the screening process causing the fines to carry over.

Needless to say, dehulled solvent extracted meal is very friable. Therefore, the selection of a grinding process which will not grind this friable meal too fine is important. The