Sensory Evaluation of Commercial Soy Flours, Concentrates, and Isolates[1]

J. E. KALBRENER, A. C. ELDRIDGE, HELEN A. MOSER, and W. J. WOLF, Northern Regional Research Laboratory, Peoria, Illinois 61604

ABSTRACT

Flavor is one of the main factors limiting wider use of soybean products in foods. To determine the nature of the flavors and their intensities, various commercial soybean flours, concentrates, and isolates were evaluated by a 17-member taste panel. Two-percent dispersions of the samples in charcoal-filtered tap water at room temperature were rated for odor and flavor intensity on a 10-point scale where 10 is bland and 1 is strong. Odor scores ranged from 5.8 to 7.7; and flavor scores, from 4.2 to 7.0. Odor and flavor responses varied for different samples. Odor responses included beany, corn meal, musty, and toasted. Flavor descriptions included beany, bitter, chalky, and astringent. Sample detection thresholds were determined for a raw, defatted flour (laboratory prepared), a concentrate, and two isolates. Beany and bitter flavor thresholds were also determined on the same four samples. The data indicated differences in the various samples but that none were truly bland. The threshold values showed that the flavor constituents are detectable in very low concentrations.

Food use of soybeans has been increasing about 5 to 7% annually, but this amount accounts for only about 275,000 tons, or 2% of the meal produced each year in the U.S. (1). Because of their functional properties, soy-protein products find outlets in a variety of processed foods. Low concentrations of soy, usually 3 to 5%, are used in most of these food products.

Although more soy flour is produced for human consumption than any other soy products, soy proteins are also available as concentrates and isolates. In the U.S., soy protein is concentrated by three procedures (2). All three involve the removal of water-soluble nonprotein constituents present in soy flours and yield products with a protein content of 70%. One process starts with flakes that have been heat-treated to denature the protein. These flakes are extracted with water several times, dried, and ground (3). In the second process, unheated flakes are washed with aqueous alcohol several times, followed by drying and grinding. The alcohol has a denaturing effect on the protein so that the product is relatively insoluble, making it similar to that obtained from the first process. In the third process (4), soy flour is mixed with water and the pH of the mixture adjusted to 4.6, the isoelectric point of the protein. The solids are washed with water and either dried directly or neutralized and then dried. The product obtained from this process may have functional properties different from the other two types of concentrate because little denaturation of the protein occurs.

Soy-protein isolates are generally produced by extracting raw (unheated) flakes

---

[1]Presented at the 55th Annual AACC Meeting, Minneapolis, October 1970. Contribution from the Northern Regional Research Laboratory, Peoria, Ill. 61604. This is a laboratory of the Northern Utilization Research and Development Division, Agricultural Research Service, U.S. Department of Agriculture. The mention of firm names or trade products does not imply that they are endorsed or recommended by the U.S. Department of Agriculture over other firms or similar products not mentioned.

with dilute alkali (pH 8 to 9) and adjusting the pH of the extract to 4.6 to precipitate the protein. The protein is washed with water, neutralized, and finally spray-dried. This product contains at least 90% protein.

One of the main factors limiting the increased use of soybean proteins for human consumption is flavor (1). Potential uses for a bland protein product are many. Currently, imitation dairy products are the best example (5). Numerous processes and treatments have been tried to produce bland soy products (6). Identification of the flavor constituents has also been attempted (7,8,9). Little, however, has been published on quantitative odor and flavor evaluation of soy-protein products.

Nelson et al. (10) had a taste panel evaluate soybean flakes as a ground-meat extender. Their preliminary consumer panel indicated that the acceptable percentage of soy flakes in an extended meat product varied among individuals, with acceptability for some as high as 37%. Breaded, deep-fried soybeans were evaluated by Collins and Ruch (11) as a high-protein snack. Research by Moser et al. (12) showed that a taste panel could effectively measure flavor intensity and characterize the flavors of soy flour. They studied different methods of tasting and scoring soy flour mixed with wheat flour at various concentrations. Effects of solvents, variety differences, and steaming on the flavor of soy flour were also determined.

The evaluation of commercial soy protein products was undertaken to provide a basis for further improvement in the flavor of soy products.

MATERIALS AND METHODS

The samples used in the study represent most commercial methods of producing soy flours, concentrates, and isolates. All seven flour samples had been hexane-defatted, with several having from 3 to 15% lecithin added. Nitrogen solubility index (NSI) measurements indicated that the amount of heat applied to desolventize the flakes varied. Protein contents of the flours ranged from 50 to 60%. In addition to the commercial samples, one laboratory sample of raw, hexane-defatted flour was used. It was prepared by extracting soybean flakes with *n*-hexane at room temperature for 6 hr. and air drying. The five concentrates represented all three processes of preparation. Six commercial isolates also were included in our evaluations.

The samples were evaluated in a room specifically designed for taste-panel studies (13). It is equipped with daylight fluorescent lights, as well as red fluorescent lights to obscure color differences between samples.

Charcoal-filtered tap water was used for all taste-panel studies. For evaluation of odors and flavors, samples were submitted to a 17-member panel as 2% dispersions in water at room temperature. Two 7.5-ml. samples were presented simultaneously each day in a random order to each panel member. Pairing was at random and changed at each tasting to prevent sample interaction. Panel members also received water at 98°F. for rinsing their mouths between samples.

The score sheet ranged from 1 to 10, where 10 is bland and 1 is strong. The panel members scored both odor and flavor intensities of each sample and described the predominant odors and flavors present. Statistical differences between samples were determined by analysis of variance.

Sample detection thresholds were determined through tasting decreasing concentrations of sample in water against a water control until no significant difference remained between sample and control. To determine thresholds for the beany and bitter flavors, a range of sample concentrations around the expected threshold was prepared as dispersions in water several hours before tasting. The majority of solids were then removed by filtering through tea-bag paper, since tests showed no significant differences between filtered and unfiltered samples. Five samples were presented at each tasting, which included one or two water controls. The panel was asked to indicate whether or not the flavor in each sample was beany, bitter, or both. The average panel threshold was calculated as described by Patton and Josephson (14).

NSI values of the flour samples were determined according to AOCS Official Method Ba 11-65 (15).

RESULTS AND DISCUSSION

Table I contains average values of all the tastings of each sample. Since daily fluctuation in panel scoring was expected, at least two evaluations were made for each sample. Generally, sample replications were within ± 0.3 units of the average sample score.

Odor and flavor descriptions listed in Table I are those reported by at least 20 and 25% of the panel, respectively. Odors or flavors reported less frequently were not included. These levels were chosen arbitrarily, and since there was usually less panel agreement on odors than on flavors, the lower percentage limit was used for the odor descriptions. On several occasions, odor responses varied so greatly that no predominant odor could be given, but this difficulty does not indicate that odor was absent. The variability in odor descriptions possibly arose because odors were less intense and, therefore, more difficult to describe precisely.

The scores indicate that the particular processing a soybean product receives may change odor responses. A raw, laboratory-prepared defatted flour (sample H, Table I) had an odor score of 5.8 with a beany odor description, but isolate A had a score of 7.7 and the beany odor response was greatly reduced. Other samples indicate that as the objectionable beany odor is removed, corn meal, wheat flour, or stale odors are noted.

A characteristic odor was reported in several of the samples, but panel members had no suitable term to describe the odor. Attempts to duplicate this odor failed, but it was similar to the odor of a mixture of cereal[2] and singed wool yarn in water; hence, we tentatively designate it as CW in Table I. Since the odor was detected in six different samples, it may be associated with some processing procedure, such as slight heating during grinding. The CW odor was generated in hexane-defatted soy grits by repeated grinding in a Wiley mill through a 60-mesh screen.

Among the commercial samples, flour A had the lowest odor and flavor scores. The laboratory-prepared, hexane-defatted flour (sample H), which received no heat treatment, had odor and flavor scores almost identical to flour A. Since no major differences are known between the commercial soy flours other than the amount of heat treatment received, the progressively increasing flavor scores of flours B

[2]This was a ready-to-eat, shredded, oat cereal with added protein and nutrients.

TABLE I. ODOR, FLAVOR, AND NSI[a] OF COMMERCIAL SAMPLES

Sample	Odor		Flavor		NSI
	Score[b]	Description	Score[b]	Description	
Soy flours					
A	5.8a[c]	NP[d]	4.2a	Bitter, beany, green beany	80
B	6.2abc	NP	4.5b	Beany, bitter, green beany	75
C	7.0defg	Beany	5.5c	Beany, bitter, green beany	60
D	7.1cdefg	NP	5.8cd	Bitter, beany, toasted	22
E	6.5abcd	NP	6.3cde	Beany, bitter	36
F	7.4efg	Toasted, corn meal, vanilla	6.6de	Toasted, beany, bitter	22
G	7.5g	CW[e], vanilla	6.7de	Beany, bitter	48
H[f]	5.8ab	Beany	4.1ab	Raw beany, beany, bitter, green beany	92
Concentrates					
A	6.4abcd	CW, beany, stale, corn meal	5.6c	Bitter, beany	...
B	6.6bcde	Beany, CW, musty, toasted	5.9cd	Beany, bitter, astringent	...
C	6.9cdefg	NP	6.3cde	Beany	...
D	7.3efg	Beany	6.5de	Bitter, beany	...
E	7.4fg	NP	7.0e	Beany	...
Isolates					
A	7.7g	Musty, corn meal	5.9cd	Beany, cardboard	...
B	7.2efg	CW, musty	6.0cd	Bitter, astringent	...
C	7.3efg	CW, beany, musty	6.0cd	Beany, chalky, bitter	...
D	7.5fg	Beany	6.2cde	Beany, mealy	...
E	6.8cdef	Spoiled, CW	6.3cde	Bitter, cereal, toasted	...
F	7.4efg	Flour	6.4cde	Beany, flour, nutty, chalky, bitter	...

[a]NSI = Nitrogen solubility index.

[b]10 = bland; 1 = strong.

[c]Scores with letters in common are not significantly different at the 0.05 level of probability as determined by Duncan's multiple range method (16).

[d]NP = None predominant.

[e]CW = Odor similar to a combination of high-protein oat cereal and singed wool in water.

[f]Laboratory-prepared defatted soybean flour.

through G probably reflect more heating during processing.

That NSI of soy flour decreases with the time of steaming is well known; consequently, NSI values were determined on the various flours (Table I). Apparently a good correlation exists between NSI values and flavor scores of these flours (Fig. 1). The data points were analyzed and a line was calculated by least squares. The correlation coefficient, r, is −0.870, which is significant at the 1% level.

Moser et al. (12) showed that the flavor of soy flour can be improved by steaming and that flavor scores will increase up to a limit with time of steaming. Their study demonstrated that intensity of the raw beany flavor decreased upon steaming, and although a beany flavor was present, it was accompanied by toasted and nutty responses. Flavor descriptions of the lower-rated commercial flours (A, B, and C) include green beany, whereas the flours with the higher flavor scores do not.

Of all the samples evaluated, concentrate E received the highest flavor score:

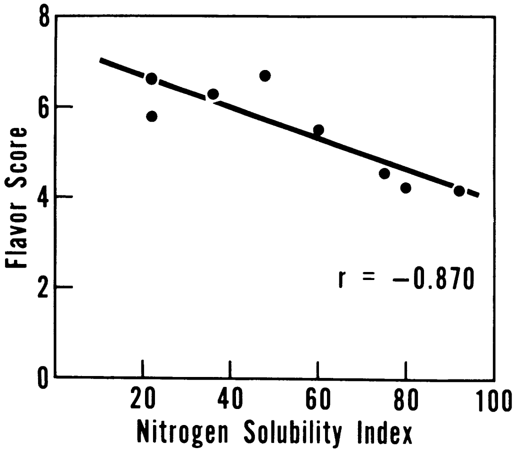

Fig. 1. Correlation between NSI and flavor scores of soy flours.

7.0. It is sold under the same trade name as concentrate B, which had a score of 5.9. The only known difference between the two samples is that the particle size of concentrate E is larger than that of concentrate B. The correlation of larger particle size and higher flavor score probably indicates that a lesser quantity of flavor constituents is being dispersed in the water and is then reaching the sensory organs of the tasters. This observation agrees with our experience that a flour tasted dry is less intense in flavor than the same flour dispersed in water.

Since all isolates are produced basically by the same process, it is not surprising that the difference between the highest and lowest flavor scores is only 0.5 unit. However, if the flavor components are nonprotein constituents, one would expect definite flavor improvement in the concentrates and isolates over that of the flours since they have received considerably more processing to remove the nonprotein constituents. The flavor scores of the samples (Table I) do not show a great reduction in flavor intensity when flours are processed to yield concentrates and isolates. Indeed, the scores of the higher-rated flours are quite similar to those of the concentrates and isolates. However, differences exist between flavor descriptions of the concentrates and isolates and flavor descriptions of the flours. It is in these differences that some flavor improvement can be seen.

The sample-detection thresholds for raw defatted flour, concentrate D, and isolates E and F are given in Table II. Sample-detection threshold is the concentration of sample where the panel could detect any flavor other than water in a dispersion of sample in water. Raw defatted flour was detectable at a level about one-tenth the level of the concentrate and two isolates. Because beany and bitter flavors associated with soy products are considered the most objectionable, average panel thresholds of those flavors were determined on the same four samples. Those thresholds are somewhat higher than the sample-detection thresholds. In general, the threshold values indicate that the undesirable flavor constituents must be present in very low concentrations, and that they are quite intense to be detectable at such low levels.

TABLE II. FLAVOR THRESHOLDS OF SOYBEAN PRODUCTS

Sample	Thresholds[a]		
	Sample detection %	Beany %	Bitter %
Flour H	0.005	0.033	0.04
Concentrate D	0.04	0.16	0.20
Isolate E	0.06	1.25	>3.0
Isolate F	0.06	0.20	2.00

[a]Percent sample in charcoal-filtered tap water.

Most of the samples evaluated showed flavor improvement compared to raw defatted flour, which was used as the control. Apparently, a truly bland soy product is not yet available commercially. Research continues at the Northern Regional Laboratory to produce soy products with improved flavor.

Literature Cited

1. ELEY, C. P. Food uses of soy protein. In: Marketing and transportation situation, p. 27. U.S. Dep. Agr. ERS-388 (August 1968).
2. MEYER, E. W. Soy protein concentrates and isolates. Proc. Int. Conf. Soybean Protein Foods, p. 142. U.S. Dep. Agr. ARS-71-35 (1966).
3. McANELLY, J. K. Method for producing a soybean protein product and the resulting product. U.S. Patent 3,142,571 (1964).
4. SAIR, L. Proteinaceous soy composition and method of preparing. U.S. Patent 2,881,076 (1959).
5. McCORMICK, R. D., and BECK, K. M. Do the "imitation" milks offer a solution to low dairy profits? Food Prod. Develop. 2: 26 (1968).
6. ELDRIDGE, A. C. A bibliography on the solvent extraction of soybeans and soybean products 1944–1968. J. Amer. Oil Chem. Soc. 46: 458 (1969).
7. TEETER, H. M., GAST, L. E., BELL, E. W., SCHNEIDER, W. J., and COWAN, J. C. Investigations on the bitter and beany components of soybeans. J. Amer. Oil Chem. Soc. 32: 390 (1955).
8. HONIG, D. H., SESSA, D. J., HOFFMAN, R. L., and RACKIS, J. J. Lipids of defatted soybean flakes: Extraction and characterization. Food Technol. 23: 95 (1969).
9. ARAI, S., KOYANAGI, O., and FUJIMAKI, M. Studies on flavor components in soybean. Part IV. Volatile neutral components. Agr. Biol. Chem. 31: 868 (1967).
10. NELSON, A. I., STEINBERG, M. P., McGILL, J. N., and PIPPITT, R. Use of dehulled extracted soybean flakes as a ground meat extender. Soybean Dig. 23: 23 (1963).
11. COLLINS, J. L., and RUCH, B. C. Breaded, deep-fried vegetable soybeans. Food Prod. Develop. 3: 40 (1969).
12. MOSER, HELEN A., EVANS, C. D., CAMPBELL, R. E., SMITH, A. K., and COWAN, J. C. Sensory evaluation of soy flour. Cereal Sci. Today 12: 296 (1967).
13. MOSER, HELEN A., DUTTON, H. J., EVANS, C. D., and COWAN, J. C. Conducting a taste panel for the evaluation of edible oils. Food Technol. 4: 105 (1950).
14. PATTON, S., and JOSEPHSON, D. V. A method for determining significance of volatile flavor compounds in foods. Food Res. 22: 316 (1957).
15. AMERICAN OIL CHEMISTS' SOCIETY. Official and tentative methods (3rd ed.). The Society: Chicago (1965).
16. DUNCAN, D. B. Multiple range and multiple F tests. Biometrics 11: 1 (1955).

[Received November 30, 1970. Accepted April 28, 1971]