Effects of Soybean Cultivars on Soymilk Quality

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Summary

Soymilk was prepared from twelve soybean cultivars grown under the same environmental conditions to evaluate their effects on soymilk characteristics. Significant correlations were observed between the chemical composition of the seeds and the resultant soymilk. Soymilk solids were significantly affected by seed size and seed phosphorus contents. Cultivars with dark hilum produced soymilk with less attractive colour.

Résumé

Effets des cultivars de soja sur la qualité de leur lait
Douze cultivars de soja ont été produits dans les mêmes conditions environnementales afin d'évaluer leur influence sur les caractéristiques de leur lait. Des corrélations significatives ont été observées entre la composition chimique des fèves et leur lait. La teneur en matières solides du lait a été significativement affectée par la grosseur et la teneur en phosphore des fèves. Les cultivars à hile sombre ont produit un lait de soja de couleur peu attrayante.

Introduction

Soymilk is obtained by hot-water extraction of wet-ground soybean. It is considered a high quality cholesterol-free source of protein. Having the appearance and consistency of cow's milk, it is a popular warm breakfast in Taiwan, and is gaining popularity in Japan and many western countries (4). In the United States of America, a marked increase in the consumption of traditional Asian soyfoods such as soymilk and tofu has been reported during the past decade. This increase has been attributed to a number of factors including health, ethics and the environment. Medical reports link high fat diets to cardiovascular disease and obesity (10). Kenneth (6) has reported that addition of soy protein to the diet lowers total and low-density lipoprotein cholesterol levels in individuals with hypercholesterolemia. Soybeans contain in relatively high concentrations, several compounds with demonstrated anticarcinogenic activity (10). Current soy research is focused on isoflavones, a unique class of plant hormones found primarily in soy protein with a demonstrated ability to inhibit cancer cell growth. Researchers have reported that minimally processed soy ingredients have isoflavones in concentrations similar to unprocessed soybeans (7). Soymilk is considered a minimally processed ingredient compared to tofu, a protein gel-like product widely consumed in many oriental countries. It is obtained by coagulation of hot soymilk using a calcium or magnesium salt, followed by molding and pressing to remove the whey.

Soymilk manufacturers need precise information about characteristics in the soybean seeds that contribute to the production of good quality soymilk. Soymilk is typically made from whatever bean is available. However, some manufacturers prefer high protein soybeans. Also, studies conducted to determine the relationship between soybean seed characteristics and soymilk quality attributes will provide breeders with specific guidelines for their selection.

In this study, soybean cultivars with different seed size and hilum colour were grown in the same location under the same environmental conditions to determine their effects on soymilk characteristics.

Material and methods

Twelve soyfood cultivars selected for their protein contents, seed size and hilum colour were grown in two replications of a randomized complete block design at the Agronomy Research Center of Kansas State University at Ottawa in 1997, to evaluate their effects on soymilk quality characteristics.

In this experiment, plots consisted of four 6 m long rows, spaced 76 cm apart, planted in the middle of May and harvested upon maturity. The soil is an abruptic argiaquoll, fine montmorillonitic at the test site. Seed harvested from the center rows of each plot was used for all evaluations.

Evaluation of seed characteristics

About 20 g of seeds from each replication was analyzed for protein and oil concentration using near infrared reflectance. Determination of phosphorus was based on colorimetric method in which a blue color was formed by the reaction of ortho-phosphate, molybdate ion followed by reaction with ascorbic acid at an acidic pH (11). The phosphomolybdenum complex formed was then red at

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660 nm. Determination of seed size was based on the weight in gram of 100 seed samples.

Preparation of soymilk

Soymilk was prepared using a modification of the method described by Lim *et al.* (8). To prepare soymilk, 150 g of soybeans were soaked in 500 ml of distilled water at room temperature for about 16 h in order to reach complete hydration. Hydrated beans were drained, rinsed and blended for 4 min with 400 ml of distilled water followed by addition of 600 ml boiling water (the water to bean ratio was 10 to 1 by weight). The slurry obtained was strained through 4 layers of cheesecloth to separate soymilk from insoluble residue.

Evaluation of soymilk

Samples of soymilk were evaluated for phosphorus, protein, solid contents and pH. Determination of soymilk phosphorus was based on the colorimetric method using a Technicon Auto-Analyzer II system (11). Soymilk protein was determined using LECO protein Analyzer model FP 2000 series (Leco corp. St. Joseph, MI). The sample protein was converted to nitrogen oxide which was converted over to crude protein (1). A fisher Accumet pH meter was used to measure the pH of the soymilk. Commercially prepared buffer solutions of pH 4.0 and 7.0 were used to standardize the pH meter. Duplicate soluble solids determinations were made on a few drops of soymilk using Reichert refractometer.

Determination of soymilk colour

Soymilk colour was determined on curd obtained from the soymilk and was expressed in L, a and b values using a Mini Hunter (Lab) instrument. L-value measures lightness or whiteness of the sample, a-value measures redness when positive, greenness when negative and b-value measures yellowness when positive and blueness when negative. The instrument was standardized using a standard white tile. Each sample was scanned at three different locations and averaged to determine L, a and b values (5).

Data were examined by analysis of variance and cultivars means were compared using Fisher's LSD estimates (P= 0.05). Correlation coefficients were determined to measure degree and significance of association between seed and soymilk characteristics.

Results and discussion

Cultivars means are the average of four measurements, two for each cultivar, except for colour parameters, which represent the average of six measurements, three for each replicate.

Seed characteristics

Chemical composition and seed size of the twelve cultivars are shown in table 1. Data obtained from this study using soybean cultivars planted at the same location permit an accurate comparison of cultivar differences. Significant differences among cultivars were noted for seed protein, oil and phosphorus contents, and also for seed size. The chemical composition had the following ranges: protein contents from 42 to 45.7%, oil from 18.1 to 22.2% and phosphorus from 0.55 to 0.67%. Seed size ranged from 7.9 to 27.9 g per 100 seeds. Among the cultivars studied, 'IL2', 'A93-651012' and 'PI385.942' had the highest protein contents. A significant negative correlation was noted between protein and oil contents (r = -0.67). Gurdip *et al.* (4) reported that protein and oil contents vary widely among varieties of soybean and exhibit a very strong negative correlation. 'Mercury' and 'IL2', both small-seeded cultivars showed the highest phosphorus contents. Phosphorus is found in soybeans in form of phytic acid. Lolas *et al.* (9) reported a high correlation (r = 0.98) between phosphorus and phytic acid in soybean. Phytic acid has the ability to prevent osteoporosis (10), suggesting that addition of high phosphorus soybeans to the diet has a potential health benefits.

Table 1
Means of seed characteristics for 12 soybean cultivars grown at Ottawa in 1997

Genotypes	Protein	Oil	Phosphorus	Seed size
		%		g/100 seeds
A93-651012	45.1	20.6	0.63	19.1
FG1	43.5	21.8	0.61	21.4
FG2	42.9	21.7	0.60	22.9
IA3002	42.0	22.2	0.61	23.3
IL2	45.7	19.8	0.66	10.6
KS4694	43.0	20.3	0.55	15.7
LS301	43.5	20.8	0.62	20.6
Macon	44.2	22.1	0.60	18.4
Mecury	43.2	22.1	0.67	7.9
PI385.942	45.3	18.1	0.63	22.6
Saturn	43.2	20.9	0.61	27.9
U92-3808	44.0	20.1	0.61	8.9
Mean	44.4	20.5	0.61	16.1
LSD (0.05)	1.5	0.6	0.04	0.8

Table 2
Means of soymilk characteristics of 12 soybean cultivars tested at Ottawa in 1997

Genotypes	pH	Protein	Phosphorus	Solids
		%		
A93-651012	6.59	4.94	0.67	9.5
FG1	6.71	4.73	0.67	9.9
FG2	6.56	4.68	0.66	9.9
IA3002	6.52	4.66	0.64	9.4
IL2	6.48	5.14	0.65	8.1
KS4694	6.52	4.73	0.57	9.3
LS301	6.51	4.87	0.65	9.2
Macon	6.68	5.05	0.59	9.1
Mecury	6.66	4.68	0.69	8.4
PI385.942	6.52	5.27	0.67	9.3
Saturn	6.72	4.77	0.69	9.7
U92-3808	6.62	4.92	0.68	9.6
Mean	6.60	4.91	0.60	9.09
LSD (0.05)	NS	0.19	0.10	0.58

Soymilk properties

The properties of soymilk obtained from the different cultivars are shown in table 2. There were no significant differences among cultivars for soymilk pH. The ionic strength of soymilk can affect its pH. The phosphorus content ranged from 0.57 to 0.69%. Protein contents

varied from 4.66 to 5.27%. These concentrations depend on the water to bean ratio used to prepare the soymilk. Significant differences among cultivars were observed for soymilk solid contents ranging from 8.1 to 9.9. 'FG1' and 'FG2' produced soymilk with the highest solid contents. According to Lim *et al.* (8), high protein, low fat and high soluble solids are desirable soymilk characteristics for consumers.

Relationships between seed and soymilk characteristics

Seed size was significantly correlated with soymilk solids (r = 0.65). Cultivars with large seeds tended to yield soymilk with high solid contents. Soymilk solids were negatively correlated with seed phosphorus (r = -0.62).

Significant positive correlations between the same components in soybean and soymilk were noted for protein (r = 0.89) and phosphorus (r = 0.66), indicating that cultivars with high protein and phosphorus contents are necessary to produce soymilk with high protein and phosphorus. Lim *et al.* (8) also found seed protein and phytic acid to be significantly correlated with the corresponding components in soymilk. However, this can depend on the method of soymilk preparation. Factors such as protein extractability from soybean resulting from differences in soybean hydration, grinding time and temperature, variation in extent of filtration in soymilk preparation are possible causes of variation in soymilk composition. Soymilk oil content was not determined, but it was expected that the ratio of protein to oil in the seed would affect the same ratio in the soymilk.

Soymilk colour

Soymilk differed significantly for L-value or degree of whiteness and b-value or degree of yellowness (Table 3). White or creamy white colour is a desirable soymilk characteristic (2). Soymilk produced in this study had L-values ranging from 90.4 to 93. This range was close to the standard white tile (L= 93.9). 'Macon' and 'FG1' both with dark hilum colour had the lowest L-values indicating the negative impact of dark hilum seed on soymilk colour.

Table 3
Soymilk colour parameters and seed hilum colour from 12 soybean cultivars

Genotypes	Hilum colour	L	a	b
A93-651012	Yellow	92.3	0.30	12.5
FG1	Yellow	92.8	0.21	12.4
FG2	Black	91.3	0.25	13.3
IA3002	Yellow	92.3	0.48	12.4
IL2	Yellow	92.3	0.39	13.7
KS4694	Brown	91.8	0.31	12.6
LS301	Yellow	92.5	0.27	12.7
Macon	Black	90.4	0.18	12.5
Mecury	Brown	92.3	0.29	14.2
PI385.942	Yellow	93.0	0.13	12.6
Saturn	Yellow	92.7	0.26	11.9
U92-3808	Yellow	92.3	0.47	13.9
Mean	-	92.1	0.38	12.7
LSD (0.05)	-	0.8	NS	1.4

Cultivars 'Mecury', 'U92-3808' and 'IL2' produced soymilk with the highest b-values. Evans *et al.* (3) have reported that the colour of soybean products is an important trait in the selection for export to the edible soybean industry in Japan. This is because soybean products such as soymilk and tofu become yellow as they age, and consumers will discriminate against soybean cultivars that produce yellow products. There were no significant differences among cultivars for a-values.

Conclusion

Soymilk properties such as chemical composition, solid contents and colour differed significantly among soybean cultivars. Large-seeded cultivars tended to produce soymilk with high percent solids and cultivars with dark hilum produced soymilk with less attractive colour. This study showed that soybean cultivars play an important role in soymilk production.

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Literature

1. Association of Official Analytical Chemists, 1996. Official methods of analysis of the Association of Official Analytical Chemists. 16th ed. AOAC Inc, Arlington, VA.
2. Chiun-Chuan R. W. & Chang S. K., 1995. Physicochemical properties and tofu quality of soybean cultivar Proto. J. Agric. Food Chem., 43: 3029-3034.
3. Evans D. E., Tsukamoto C. & Nielson N. C., 1997. A small scale method for the production of soymilk and silken tofu. Crop Sci., 37· 1463-1471.
4. Gurdip S. B. & Carter T. E., 1993. Genetic improvement of vegetable crops. pp 427-455. Pergamon Press Ltd. NY.
5. Hunter R., 1958. Photoelectric colour difference meter. J. Opt. Sec. Ames., 48: 985-990.
6. Kenneth C., Review of clinical studies on cholesterol-lowering response to soy protein. Perspectives in Practice, 91: 820-826.
7. Kuhn M. E., 1996. 'Soy in spotlight'. Food Proc., **57** (5): 52-58.
8. Lim B. T., de Man J. L. & Buzzel R. I., 1990. Yield and quality of tofu as affected by soybean and soymilk characteristics. J. Food Sci., 55: 1088-1092.
9. Lolas M. Palamidis, N., & Markis P.. 1976. The phytic acid total phosphorus relationship in barley, oats, soybean and wheat. Cereal Chem., 53: 867-869.
10. Messina M. & Messina V., 1991. Increasing use of soyfoods and their potential role in cancer prevention. J. Am. Dietetic Ass., 91: 836-840.
11. Technicon, 1976. Individual and simultaneous determination of nitrogen and phosphorus in block or acid digests. Technicon Instruments Corporation, Tarrytown, N.Y.

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