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Nutrient contents, color, texture, and sensory evaluation of 12 Arkansas grown soybean cultivars in canned products

Quyen T. Nguyen, Navam Hettiarachchy†, and Srinivas J. Rayaprolu§*

ABSTRACT

Soybean was introduced in the U.S. in the 1800s, and it has been proven to have several health benefits. New cultivars of soybeans with varying hull colors have been developed using plant-breeding technology. Canning is one of the effective processing methods to extend the shelf life of products. However, very little information is available on canned soybeans. This research studied the composition of 12 soybean cultivars including two cultivars with brown seed coat (R08-4014 and R09-349), three cultivars with black seed coat (R07-1927, R07-10396, and R09-345), and seven regular cultivars with yellow seed coat (R05-1772, R05-4969, R07-2001, R08-4005, R08-4006, UA Kirksey, and JYC-2) grown in Arkansas and investigated the effect of the canning process on the color, texture, and sensory properties. The data showed that the 12 soybean cultivars had lower moisture content values ranging from 6.7% to 9.1% in comparison to higher levels of moisture (13%) present in commercial lines. The protein content ranged from 40.2% to 51.0% which was higher than the expected approximate content of commercial soy (30-40%). The canning process increased the redness (+a values) of the beans but neither off-flavor nor bitterness was observed in the canned products. Among the soybean cultivars with yellow seed, the canned products of JYC-2 were the most preferred according to sensory panelists. In conclusion, canned products of soybeans can be prepared under optimized conditions to produce a product that is acceptable to consumers.

* Quyen Nguyen was a senior majoring in Food Science while working on this project. She is now a graduate student working towards her M.S. degree. This paper is based on a special problems research conducted by her in the Department of Food Science, University of Arkansas.

† Navam Hettiarachchy is the faculty mentor and a University Professor in the Department of Food Science.

§ Srinivas J. Rayaprolu is a Program Technician and a Ph.D. candidate in the Department of Food Science.

MEET THE STUDENT-AUTHOR

Quyen T. Nguyen

I am from Vietnam and I came to the United States to start my college career in the Fall of 2008 at Northwest Arkansas Community College. I transferred to the University of Arkansas beginning in the Fall 2009. I have enjoyed my time learning in the Department of Food Science by participating in various activities of the Food Science Club as well as being a member of the Product Development Team and College Bowl Team for many Institute of Food Technologists' Student Association Competitions. I have also had the honor of receiving the Outstanding Senior Student Award in the Department of Food Science.

During my junior year, I joined the protein chemistry laboratory of Dr. Navam S. Hettiarachchy. By working in Dr. Hettiarachchy's lab I have gained valuable experience in conducting food science research. During the summer of 2012, I had the opportunity to conduct undergraduate special problem research under the much appreciated support and guidance of Dr. Navam S. Hettiarachchy and her laboratory team. I graduated with my B.S degree majoring in food science and a minor in agribusiness in December 2012. After graduation, I began working towards my M.S. degree in Food Science under Dr. Hettiarachchy's guidance at the University of Arkansas. In the future, I will pursue my career as a product and process developer. Since I love children, I want to devote my career path in research and development of healthy food to prevent childhood obesity.

I would like to thank Dr. Navam S. Hettiarachchy, who provided tremendous support as my mentor throughout my special problem project, and everyone who is part of the protein chemistry research group in the Department of Food Science for all their guidance and help during this project and their ongoing support for my education.

INTRODUCTION

Soybean (*Glycine max*) has been used as a food ingredient for 5,000 years due to its beneficial nutrients such as proteins, isoflavones, and dietary fiber (Nutraceuticals World, 2010). This subtropical plant was introduced into the United States in the 1800s (Nutraceuticals World, 2010). The U.S. Department of Agriculture has been funding projects to develop and improve cultivars of soybean using genetic selection and hybridization (Marsland, 2000). New cultivars of soybean have higher yields, short crop season, pest and disease resistance, and other enhanced attributes in comparison to ancient Asian cultivars (Marsland, 2000). Approximately half of the worldwide supply of soybeans comes from Midwestern U.S. states (Nutraceuticals World, 2010). Apart from improved nutritional benefits, new cultivars of soybean also differ in their seed coat color with pigmentations including yellow, black, brown, red, or green (Messina, 1999). Despite numerous health benefits, raw soybeans are difficult to consume due to the presence of trypsin inhibitor (Singh, et al., 2008). Hence, heat treatment is used to improve the digestion by inactivating most of the trypsin inhibitor in soybean seeds. Cooking not only enhances the nutritional quality but also reduces the off-flavor of soy products (Mozzoni et al., 2009b). Among numerous processing techniques, canning is considered a safe and economical way to preserve food (USDA Guide 4, 2009). Recently, Mozzoni et al. (2009a) studied the effects of blanching duration and brine composition used in the canning process on the texture, color, and lipoxygenase activity of the final canned soybean product. However, the consumer acceptability of canned soybeans with varying seed coat colors has not been studied. In addition, most studies on soybeans have focused on only a few cultivars but not on comparing the composition of different cultivars of soybean at the same time. Hence, the objectives of this research were to (1) compare the composition of 12 soybean cultivars which were categorized into 3 different colors: yellow, black, and brown; (2) determine the effect of the canning process on the texture and color of the soybeans; and (3) evaluate the sensory qualities of canned products. The results may provide useful information for the soybean industry to choose the most acceptable cultivar for commercial canned soybean.

MATERIALS AND METHODS

Materials. Twelve soybean cultivars, including two brown cultivars (R08-4014 and R09-349), three black cultivars (R07-1927, R07-10396, and R09-345), and seven yellow cultivars (R05-1772, R05-4969, R07-2001, R08-4005, R08-4006, UA Kirksey, and JYC-2) grown in Arkansas were supplied by Dr. Pengyin Chen, Professor in the Department of Crop, Soil, and Environmental Sciences at the University of Arkansas.

Proximate Composition Analysis. All of the 12 cultivars of soybean were ground, passed through a 60-mesh sieve (250-µm), and stored at ambient temperature. Moisture content was determined according to the AACC Official Method [44-19] by weighing 2.0 g sample before and after drying for 2 h in a hot air oven at 135 °C (AACC, 2000). Total mineral content (ash content) was determined according to AACC Official Method [08-03] in which exact weights of ground samples (2 g) were placed in a muffle furnace, preheated to 600 °C, for 2 h (AACC, 2000). Protein content was determined by AACC Method [46-11A] "Improved Kjeldahl Method, Copper Catalyst Modification" (AACC, 2000). Samples were weighed (approximately 0.2 g) to the thousandth of a gram and were transferred to Kjeldahl digestion flasks with the addition of a copper catalyst tablet and 10 mL of 10 N sulfuric acid. The samples were digested at 410 °C for 60 min in a Digestor (Foss Tecator, Hillerød, Denmark) and cooled to ambient temperature in a fume hood. The protein contents of the samples were measured in an automatic Kjeltec™ 2300 Distillation Unit (Foss Tecator, Hillerød, Denmark). Lipid content was determined using AACC Official Method [30-25] in which dried samples were treated with petroleum ether solvent to extract the lipid by Soxhlet extraction (AACC, 2000). After 8 h of extraction, the solvent from flasks was evaporated and crude fat was dried to constant weight at 100 °C and the percentage of the lipid content (by weight) in each sample was calculated. The mineral analysis was conducted at the Central Analytical Laboratory, University of Arkansas, Fayetteville, Ark., using inductively coupled plasma emission spectroscopy.

Canning Process. Dried soybeans (50 ± 1 g) were soaked in tap water at ambient temperature for 12 h (Fig. 1). Immature and defective soybeans were removed. Approximately 120 g of the soaked seeds were weighed, and placed in 130 g of 1% NaCl brine solution. The cans were sealed, and processed in a steam sterilizer at 250 °F (121 °C) by maintaining the pressure at 15 PSI (10.3 MPa) to guarantee the safety of food (USDA Guide 4, 2009). After 10 min, cans were removed and cooled in tap water for 2 min, cooled, and stored at ambient temperature. The details of the canning process are provided in Table 1.

Texture Analysis. The texture of canned soybeans was determined using a Texture Analyzer Model XT2i (Stable Micro Systems, Surrey, UK). Canned navy beans were used for comparison. An incisor knife blade bell lock (TA-45) was used to test the shearing force when passed through a sample. The instrument was calibrated with a load scale of 5 kg. Force-time curves were recorded at a constant rate of 1 mm/s and the average maximum force of ten replications, in Newton, with standard deviation.

Color Analysis. The color of dried and canned soybeans were determined using the 'L*, a*, and b*' Hunter Lab system where, L* axis represents lightness from 0 (absolute black) to 100 (absolute white), a* axis represents either green (-a) or red (+a), and b* axis represents either blue (-b) or yellow (+b), which were measured using a CR 100 Minolta Chroma Meter (Minolta Camera Co., Ltd., Osaka, Japan). The colorimeter was calibrated for L = 93.6, a = 0.6, and b = -2.3 values.

Sensory Evaluation. Eight untrained panelists (graduate students, Department of Food Science, University of Arkansas) participated in tasting the canned soybeans. The soybeans, which were canned the day before, were warmed up in microwave for 1 min before serving. Commercial canned navy beans were used as control for comparison. Panelists rated samples based on the following sensory attributes: color and aroma attributes before tasting the samples, and taste, mouth-feel, texture and saltiness attributes after tasting the samples. The samples were grouped in three different categories based on their color: two brown samples (R08-4014 and R09-349), three black samples (R07-1927, R07-10396, and R09-345), and seven yellow samples (R05-1772, R05-4969, R07-2001, R08-4005, R08-4006, UA Kirksey, and JYC-2). The panelists were also asked to choose the one they preferred most in each group by ranking. The scores of the color, aroma, and taste attributes were recorded on a 7-point hedonic scale where 1 = " dislike very much" and 7 = "like very much" while the mouth-feel, texture, and saltiness attributes were recorded on 5 point JAR (Just About Right) category scale where 1 is a low score and 5 is a high score.

Data Analysis. All tests on chemical composition analyses were run in triplicate for each variety of dried soybeans. The twelve cultivars of soybeans seeds were canned in triplicate. Color analysis was read in five replicates per sample. Texture properties were analyzed in ten replicates. Values are expressed as mean ± standard deviation. Analysis of variance (ANOVA) was run to compare among the 12 cultivars and Student's *t*-test was used to study the significant differences ($P < 0.05$) using JMP software.

RESULTS AND DISCUSSION

Proximate Composition Analysis. The moisture contents of the 12 soybean cultivars ranged between 6.7% and 9.1% (Table 2). The moisture contents of the brown, black and yellow cultivars ranged from 8.1-8.9%, 7.9-9.0%, and 6.7-9.1%, respectively. None of the 12 soybean cultivars had moisture content higher than 13% which is the recommended moisture content for storage for dried soybean (Boge et al., 2009). The advantage of having low moisture content is the stability in chemical and microbial reactions that should not become a problem during storage (Boge et al., 2009). On the dry weight basis, the protein content of defatted samples of the 12 different cultivars ranged from 40.2-51.0%. The total lipid content of all samples varied between 15.0% and 30.5%. Among these samples, R08-4006 had the highest protein content (51.0%) and lowest lipid content (15.0%). Cultivars JYC-2 and R08-4014 had the lowest protein content (40.2% and 41.0 %, respectively). Both R08-4006 and JYC-2 are yellow soybean cultivars. Cultivar UA Kirksey had the highest lipid content (30.5%) with a protein content of 46.5 %. Lee and Cho (2011) indicated that most soybean cultivars contain about 30-40% protein and 21-28% lipid on an average; protein content is higher in many of these cultivars. The lipid content in soybeans is considered highest compared to other beans and legumes, and they are rich in omega-3 fatty acids like α-linolenic acid which help in health promotion (Messina, 1999). Total mineral content of 12 soybean cultivars determined by the ash method varied from 2.1% (R09-349) to 6.5% (R07-1927). The differences observed could be due to variation in cultivars and possibly environmental conditions as well (Wolf et al., 1982).

Texture Analysis. Among the 12 cultivars, the R05-4969 variety was numerically the hardest (6.5 N) after the canning process (Table 3). In contrast, R05-1772, R08-4005, R09-345, and UA Kirksey cultivars were the softest and their textures were comparable with that of Navy beans (control). Compared to the control (canned navy bean with 3.5 N), all the 12 canned soybean samples had numerically higher values (4.1-6.5 N), and statistically significant difference was seen among the cultivars ($P > 0.05$; Table 3). The extent of hardness observed could be due to the species differences. Extending the canning process time may be useful to obtain hardness comparable to that of commercial canned beans.

Color Analysis. Although different values were observed among the 12 cultivars (Fig. 1), the canning process resulted in decreased L* (more luminous) for the brown and yellow soybeans and increased a* (more redness) values for soybeans of all three seed coat colors (Table 4) compared to dried soybeans. Among the black colored cultivars there was no change in the L* values before and after canning. However, numerically the b* values of the seven yellow cultivars (R05-1772, R05-4969, R07-2001, R08-4005, R08-4006, UA Kirksey, and JYC-2) and two brown cultivars (R08-4014 and R09-349) decreased, while the values for b* of three black cultivars (R07-1927, R07-10396, and R09-345) increased. The change in a* values of all samples during the canning process was due to the degradation of green hue of soybeans due to their exposure to hot water (Song et al., 2003).

Sensory Evaluation. The color, aroma (before tasting) and the taste, mouth-feel, texture, and saltiness of canned products of 12 soybean cultivars were investigated by sensory evaluation. Among these sensory qualities, the saltiness score of the samples were relatively the lowest and there was no significant difference among the twelve soybean cultivars (score 2.4-3.0 and $P > 0.05$, Table 5). This implied that the concentration of 1% of NaCl in the brine solution used in the canning process was not enough for an acceptable saltiness. The color of all samples had acceptable scores betwen 3.6 and 5.3. However, there was no statistically significant difference within each group of the same color and also among the 12 cultivars (Table 5). The aroma and taste scores of the 12 samples were also high (scores 3.8-5.4 and 3.4-5.0, respectively) and no statistically significant differences were observed among the 12 samples ($P < 0.05$).

Based on the feedback from all the panelists, the aroma of all 12 canned products was acceptable. In addition, there was neither bitterness nor off-flavor (data not shown). An acceptable ‘beany’ flavor was reported by all panelists (data not shown). The mouth-feel and texture scores of the samples were within the range of 3.1-4.0 and there was no significant difference among the 12 cultivars ($P < 0.05$). The panelists were also asked to choose the most preferred soybean in each group of samples which were distinguished by color: yellow, black, and brown. There was significant difference among the seven yellow soybean cultivars ($P > 0.05$), and JYC-2 was the most preferred sample according to the panelists (data not shown). There was no significant difference among the 3 brown soybean cultivars ($P < 0.05$) where both R07-10396 and R09-345 had same high score as the R07-1927 cultivar. Also, between the 2 black soybean cultivars, there was no statistically significant difference ($P > 0.05$) in preference.

CONCLUSION

The proximate compositions of the 12 soybean cultivars in this study had no statistically significant difference. However, most of these cultivars had higher content of protein (40.2%-51.0%) in comparison to that in commodity soybeans (30-40%). The R08-4006 cultivar had a high protein content of 51.0% and UA Kirksey had high lipid content of 30.5%. The canning process increased the redness (+a values) of the beans. No off-flavor or bitterness was detected in the 12 canned products. Among the 12 soybean cultivars, the canned JYC-2 soybean seeds were the most preferred by the sensory panelists.

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Table 1. Summary of canning process.

Processing conditions	Canning technique
Mass of dried sample (g/can)	50 ± 1.0
Mass of soaked sample (g/can)	120 ± 1.0
Net weight of can (g/can)	250 ± 1.0
Soaking time	12 hour in cool water at room temperature
Can size	65 mm diameter x 80 mm height
Brine solution	NaCl soluion (10g kg^{-1})
Headspace	8 mm
Thermal process	10 min at constant 15 PSI

Table 2. Proximate compositions of 12 dried soybean cultivars.†

Soybean cultivars	Moisture content (%)‡	Protein (%)§	Lipid (%)§	Carbohydrate (%)¶	Ashing (%)‡
		Yellow seed coat cultivars			
R05-1772	8.4 ± 0.5^{abc}	48.0 ± 0.4^{b}	17.8 ± 1.0^{fg}	25.8	4.9 ± 0.4^{cde}
R05-4969	8.4 ± 0.4^{abc}	43.0 ± 0.2^{g}	25.1 ± 0.6^{bc}	23.5	4.5 ± 0.5^{de}
R07-2001	9.1 ± 0.4^{a}	42.3 ± 0.1^{h}	26.5 ± 3.7^{b}	22.1	5.8 ± 0.0^{abc}
R08-4005	8.6 ± 1.5^{abc}	44.3 ± 0.3^{f}	24.3 ± 0.7^{bcd}	22.8	6.0 ± 0.0^{ab}
R08-4006	8.7 ± 0.2^{abc}	51.0 ± 0.2^{a}	15.0 ± 1.1^{g}	25.3	5.4 ± 0.0^{bc}
UA Kirksey	6.7 ± 0.1^{e}	46.5 ± 0.5^{c}	30.5 ± 4.1^{a}	16.3	4.1 ± 0.1^{e}
JYC-2	7.1 ± 0.2^{de}	40.2 ± 0.6^{i}	23.2 ± 1.8^{bcde}	29.5	4.2 ± 0.2^{e}
		Brown seed coat cultivars			
R07-1927	8.4 ± 0.1^{abc}	43.0 ± 0.2^{g}	23.8 ± 3.2^{bcd}	24.8	6.5 ± 0.1^{a}
R07-10396	9.0 ± 0.3^{a}	45.4 ± 0.0^{e}	20.0 ± 0.5^{ef}	25.6	6.0 ± 0.1^{ab}
R09-345	7.9 ± 0.1^{cd}	47.1 ± 0.2^{d}	21.0 ± 0.4^{def}	24.0	3.1 ± 1.8^{f}
		Black seed coat cultivars			
R08-4014	8.9 ± 0.4^{ab}	41.0 ± 0.2^{i}	15.3 ± 0.4^{g}	34.8	5.2 ± 0.0^{bcd}
R09-349	8.1 ± 0.2^{bc}	40.6 ± 0.2^{h}	22.2 ± 0.8^{cde}	29.1	^{g}

† Mean of triplicate measurements ± standard deviation. Similar letters within the same column indicate no significant difference ($P < 0.05$).
‡ Reported on an as-is basis.
§ Reported on a dry basis.
¶ Calculated by difference.

Table 3. Textural properties of 12 soybean cultivars' canned products.†

Soybean cultivars	Texture of canned bean (N)‡
Yellow seed coat cultivars	
R05-1772	4.1 ± 1.4^{bc}
R05-4969	6.5 ± 1.9^{a}
R07-2001	5.0 ± 2.4^{ab}
R08-4005	4.5 ± 2.8^{bc}
R08-4006	4.9 ± 3.1^{ab}
UA Kirksey	4.1 ± 2.5^{bc}
JYC-2	5.2 ± 3.4^{ab}
Brown seed coat cultivars	
R07-1927	5.8 ± 2.2^{ab}
R07-10396	5.0 ± 2.0^{ab}
R09-345	4.4 ± 2.5^{bc}
Black seed coat cultivars	
R08-4014	4.6 ± 4.2^{ab}
R09-349	5.0 ± 1.7^{ab}
Navy bean (control)	3.5 ± 3.1^{c}

† Mean of quintuplicate measurements ± standard deviation.
‡ Texture of samples as, as maximum force in Newton. Similar letters indicate no significant difference ($P < 0.05$).

Table 4. Color properties of 12 dried soybean cultivars and their canned products as measured by a chroma meter.†

Soybean cultivars	Dried samples			Canned samples		
	$L^{*\ddagger}$	a^{*}	b^{*}	$L^{*\ddagger}$	a^{*}	b^{*}
Yellow seed coat cultivars						
R05-1772	62.0 ± 1.9^{a}	0.0 ± 0.3^{c}	20.9 ± 1.6^{bcd}	52.7 ± 3.8^{bcd}	3.9 ± 0.7^{cd}	16.0 ± 1.6^{abc}
R05-4969	59.4 ± 3.0^{b}	-0.2 ± 0.4^{c}	23.5 ± 2.8^{ab}	49.4 ± 2.8^{d}	2.3 ± 0.1^{fg}	13.5 ± 1.4^{cd}
R07-2001	61.7 ± 2.2^{a}	0.5 ± 0.5^{c}	19.9 ± 2.4^{cd}	56.4 ± 2.5^{a}	4.9 ± 0.6^{b}	17.5 ± 0.5^{a}
R08-4005	54.9 ± 1.6^{d}	0.1 ± 0.3^{c}	19.0 ± 1.9^{d}	54.2 ± 2.5^{ab}	3.1 ± 0.6^{def}	16.6 ± 1.4^{ab}
R08-4006	61.3 ± 0.9^{ab}	-0.2 ± 0.8^{c}	25.3 ± 2.3^{a}	53.0 ± 3.3^{abc}	2.9 ± 0.3^{ef}	15.9 ± 2.0^{abc}
UA Kirksey	60.7 ± 1.0^{ab}	-0.2 ± 0.4^{c}	22.0 ± 2.0^{bc}	52.0 ± 2.6^{bcd}	2.9 ± 0.7^{ef}	14.5 ± 1.3^{bcd}
JYC-2	57.4 ± 1.1^{c}	-2.8 ± 0.9^{d}	21.2 ± 1.2^{bcd}	50.6 ± 3.9^{cd}	1.9 ± 0.6^{g}	16.1 ± 3.0^{ab}
Brown seed coat cultivars						
R07-1927	32.2 ± 1.4^{g}	0.3 ± 0.2^{c}	-0.1 ± 0.1^{g}	32.9 ± 2.3^{g}	3.4 ± 0.7^{de}	2.1 ± 0.3^{f}
R07-10396	31.0 ± 0.9^{g}	0.4 ± 0.3^{c}	-0.3 ± 0.3^{g}	34.3 ± 2.4^{fg}	4.5 ± 1.2^{bc}	3.4 ± 1.1^{f}
R09-345	32.3 ± 1.3^{g}	0.5 ± 0.2^{c}	0.0 ± 0.2^{g}	33.1 ± 0.7^{fg}	4.0 ± 0.4^{bcd}	2.8 ± 0.5^{f}
Black seed coat cultivars						
R08-4014	41.4 ± 1.9^{f}	5.3 ± 1.3^{b}	9.9 ± 3.5^{f}	36.5 ± 1.9^{f}	8.2 ± 0.6^{a}	7.6 ± 1.6^{e}
R09-349	45.4 ± 0.6^{e}	7.0 ± 1.3^{a}	14.6 ± 2.8^{e}	40.4 ± 1.2^{e}	7.6 ± 1.0^{a}	13.0 ± 4.3^{d}

† Mean of quintuplicate measurements ± standard deviation. Similar letters within the same column indicate no significant difference ($P < 0.05$).

‡ L^{*} value describes the lightness of a product with values ranging from 0 (black) to 100 (white); a^{*} value describes the color of a product, ranging from red (positive values) to green (negative values); and b^{*} value describes the color of a product, ranging from yellow (positive values) to blue (negative values).

Table 5. Sensory qualities of canned products of 12 soybean cultivars.†

Soybean cultivars	Before eating		After eating			
	Color	Aroma	Taste	Mouthfeel	Texture	Saltiness
Yellow seed coat cultivars						
R05-1772	4.9 ± 1.1^{a}	4.9 ± 0.8^{a}	4.9 ± 1.1^{a}	3.1 ± 0.4^{a}	3.1 ± 0.4^{a}	2.8 ± 0.7^{a}
R05-4969	5.1 ± 1.4^{a}	4.6 ± 1.1^{a}	4.1 ± 1.0^{a}	3.3 ± 0.7^{a}	3.5 ± 0.8^{a}	2.9 ± 0.6^{a}
R07-2001	5.0 ± 1.2^{a}	4.5 ± 0.9^{a}	4.1 ± 1.3^{a}	3.5 ± 0.5^{a}	3.6 ± 0.5^{a}	2.9 ± 0.8^{a}
R08-4005	4.6 ± 0.9^{a}	4.5 ± 1.3^{a}	4.3 ± 1.4^{a}	3.3 ± 0.9^{a}	3.3 ± 0.7^{a}	2.9 ± 0.6^{a}
R08-4006	4.6 ± 1.3^{a}	4.1 ± 0.6^{a}	4.0 ± 1.1^{a}	3.1 ± 0.6^{a}	3.3 ± 0.7^{a}	2.8 ± 0.7^{a}
UA Kirksey	5.0 ± 1.3^{a}	4.5 ± 1.4^{a}	4.4 ± 1.5^{a}	3.3 ± 0.5^{a}	3.1 ± 0.4^{a}	3.0 ± 0.8^{a}
JYC-2	4.9 ± 1.6^{a}	5.4 ± 1.3^{a}	5.0 ± 1.9^{a}	3.1 ± 0.4^{a}	3.3 ± 0.7^{a}	2.8 ± 0.5^{a}
Brown seed coat cultivars						
R07-1927	3.6 ± 1.3^{a}	4.5 ± 1.4^{a}	4.4 ± 1.8^{a}	4.0 ± 0.8^{a}	4.0 ± 0.5^{a}	2.9 ± 0.6^{a}
R07-10396	4.4 ± 1.5^{a}	4.0 ± 0.9^{a}	4.3 ± 1.3^{a}	3.6 ± 0.7^{a}	3.6 ± 0.7^{a}	2.9 ± 0.6^{a}
R09-345	4.0 ± 1.4^{a}	3.8 ± 1.4^{a}	3.4 ± 0.7^{a}	3.9 ± 0.6^{a}	3.8 ± 0.7^{a}	2.8 ± 0.7^{a}
Black seed coat cultivars						
R08-4014	5.3 ± 1.0^{a}	5.0 ± 0.9^{a}	4.8 ± 1.3^{a}	3.5 ± 0.8^{a}	3.5 ± 0.5^{a}	2.8 ± 0.5^{a}
R09-349	5.1 ± 0.8^{a}	4.3 ± 1.6^{a}	3.4 ± 0.7^{a}	3.3 ± 0.5^{a}	3.5 ± 0.5^{a}	2.4 ± 0.5^{a}

† Mean of score graded by 8 panelists ± standard deviation. Similar letters within the same column indicate no significant difference.

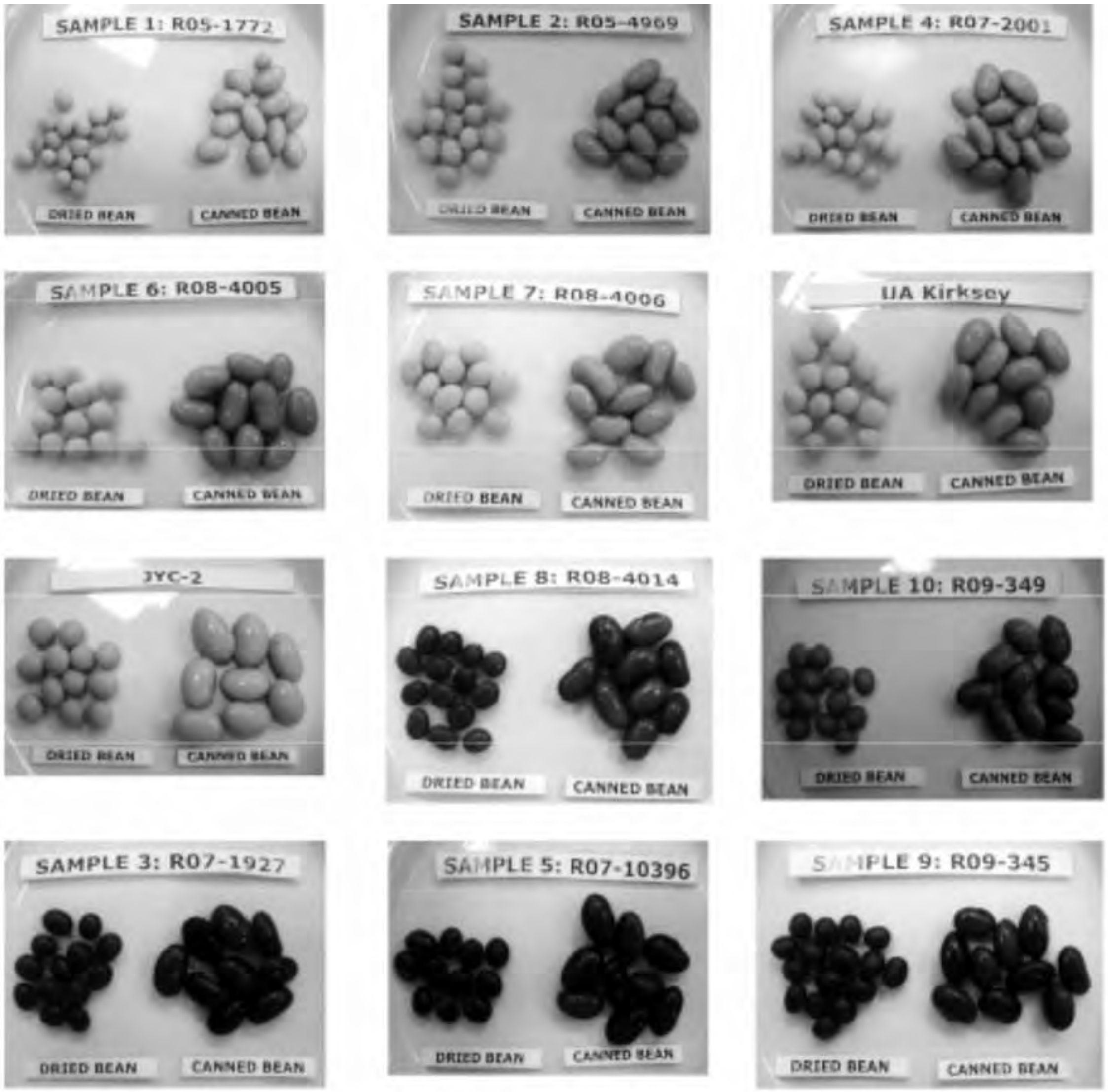

Fig. 1. Twelve dried soybean cultivars and their canned products.