

Consumer liking and descriptive analysis of six varieties of organically grown edamame-type soybean

A.L. Wszelaki ^{a,1}, J.F. Delwiche ^b, S.D. Walker ^a, R.E. Liggett ^b,
S.A. Miller ^c, M.D. Kleinhenz ^{a,*}

^a Department of Horticulture and Crop Science, The Ohio State University, Ohio Agricultural Research and Development Center,
1680 Madison Avenue, Wooster, OH 44691-4096, USA

^b Department of Food Science and Technology, The Ohio State University, 2015 Fyffe Road, Columbus, OH 43210, USA

^c Department of Plant Pathology, The Ohio State University, Ohio Agricultural Research and Development Center,
1680 Madison Avenue, Wooster, OH 44691-4096, USA

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Abstract

Six commercial varieties of organically grown edamame-type soybeans were compared using consumer testing and descriptive analysis. In the affective tests, 54 panelists rated pods and beans for appearance, and beans for aroma, taste, texture, aftertaste, and overall acceptability on a nine-point hedonic scale and willingness to buy on a nine-point category scale. The taste of ‘Sayam-umume’ was liked significantly better than all varieties except ‘Kenko’ and ‘Sapporo Midori’. ‘Kenko’ was also rated higher than ‘Sapporo Midori’, ‘Misono Green’, and ‘Early Hakucho’ for pod appearance. The texture of ‘Misono Green’ was liked less than that of all other varieties except ‘White Lion’. In the descriptive analysis, 10 trained panelists rated the beaniness, sweetness, nuttiness, and chewiness of the same six varieties. ‘Kenko’ was rated significantly sweeter than all other varieties except ‘Sapporo Midori’. ‘White Lion’ was rated as significantly lower in chewiness than all other varieties. Beaniness and nuttiness could not be consistently differentiated among varieties. The data suggest that consumer liking of bean taste varies, though subtly, among these six commercial edamame varieties and that preferences may differ between men and women. Results from descriptive analysis also suggest that panelists relied on texture (i.e., chewiness) and sweetness to differentiate edamame varieties. These results are particularly important in overall product quality management strategies as chewiness and sweetness may be influenced by production practices and harvest timing.

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1. Introduction

Product quality, particularly that related to flavor, affects food purchasing decisions (Farmakalidis, 1999; Glanz, Basil, Maibach, Goldberg, & Snyder, 1998;

Hilliam, 1995) as real or perceived quality shortfalls shape consumer desire to eat fresh produce and food sensory attributes drive immediate and future consumption (Shepherd, 1997). Indeed, concerns about reductions in taste quality can interfere with the adoption of healthy diets (Bowman, Lino, Gerrior, & Basiotis, 1998; Glanz et al., 1998), since consumers emphasize sensory experiences during consumption (e.g., appearance, texture, aroma, taste), with the pleasure derived from consumption as an important motivator in eating (Westenhoefer & Pudell, 1993).

* Corresponding author. Tel.: +1 330 263 3810; fax: +1 330 263 3887.
E-mail address: kleinhenz.1@osu.edu (M.D. Kleinhenz).

¹ Present address: Department of Horticulture, University of Puerto Rico, P.O. Box 9030, Mayaguez, PR 00681-9030.

Edamame is a popular food in Japan and increases in consumption of edible soybeans in the US have been attributed to their health benefits and flavor (Gaskell, 2001; Iwata, Sugiura, & Shirahata, 1982). Relative to soybeans used for other purposes, edamame-type soybeans are characterized by having a clear hilum, relatively large size and unique sensory characteristics. Edamame is also sold in intact pods, which must lack external defects, be bright green in color, have no or translucent pubescence, and contain at least two beans. And, unlike most soybeans, which are grown agronomically, edamame-type soybeans are grown as horticultural crops.

Edamame consumption has been common in Asian cultures for many years; for example, in Japan for 400 years. Germplasm enhancement and variety development of edamame-type soybeans is relatively new in the US, as most varieties can be traced to origins in Asia. And, as with other vegetables, the influences of major production factors (e.g., cultivar, management system) on key sensory quality-related properties in edamame and the roles of these properties in shaping consumer liking and willingness to purchase edamame, particularly in the expanding US market, are poorly understood.

Relative to conventional cropping systems, organic systems differ in soil, nutrient, weed, disease, and insect management. Contrasting soil and pest management tactics in conventional and organic systems may contribute to measurable shifts in plant biochemistry, and, by association, panelists' sensory responses to crops (Wszelaki et al., 2005). Therefore, it is important to note that previous work outlining edamame sensory quality has been conducted on samples grown conventionally. It is unclear whether similar results would be found in organically grown samples.

Edamame tends to have a mild or neutral yet unique flavor, reportedly derived from a distinctive combination of sweetness, sourness, and bitterness (Lee & Hwang, 1998). Sucrose contributes to sweetness, while saponin, isoflavonoids, and *L*-arginine add bitterness (Masuda, 1994; Masuda, Hashizume, & Kaneko, 1988). Flavor-related descriptors of edamame often include nutty, buttery, beany, oily, and flowery, while common textural characteristics include crispness and chewiness (Johnson, Wang, & Suzuki, 1999; Rodale Research Center, 1982; Young, Mebrahtu, & Johnson, 2000).

Previous sensory studies of edamame that have explored the effects of cultivar (Lee & Hwang, 1998), harvest date (Chung & Hwang, 1996), and interval between harvest and freezing (Masuda et al., 1988) have been conducted in Asia. Chung and Hwang (1996) compared four varieties and four harvest dates and reported that preference scores were significantly associated with the developmental stages at which beans were harvested. Lee and Hwang (1998) employed panelists to rate sweetness, taste, and chewiness in local cultivars with various

seed coat colors and indicated that sweetness, taste, and overall desirability scores were highest in the group containing green seed coats, while yellow soybeans scored highest for chewiness. However, it is important to note that Chinese consumers preferred high sugar and were more sensitive to acidity than American consumers in consumer acceptance studies of 'Redglobe' table grapes (Crisosto & Crisosto, 2002). Similarly, for edamame, US consumers appear to prefer beans with buttery flavor and buttery texture while Japanese consumers tend to prefer beans with a sweet, flowery flavor and crisp texture (Johnson et al., 1999).

Also, flavor attributes and desirability scores seem to vary across varieties grown in the US. For example, thirty lines and varieties were tested in Pennsylvania for field performance and sensory attributes. Shared characteristics of the 16 top-rated varieties included bright green color, mild aroma, firm but tender texture, and sweet, nutty, and buttery flavor (Rodale Research Center, 1982). Young et al. (2000) compared sensory characteristics, including texture, color, sweetness, nuttiness, oiliness, beaniness, and aftertaste in 16 lines and 15 named varieties of edamame and reported significant variability among genotypes for all parameters. Similarly, Kelley and Sanchez (2003) found that sensory panelists had clear preferences for texture and overall appeal among three edamame varieties. However, no reports that compare the variety preference or flavor characteristics of organically grown edamame soybeans appear to be available.

The potential influence of specific crop production practices on vegetable and fruit quality, including sensory perception, is well documented (Dris, Niskanen, & Jain, 2001; Kader, 1992; Kleinhenz et al., 2003; Rado- vich, Kleinhenz, Delwiche, & Liggett, 2004; Scheerens et al., 2003; Wszelaki et al., 2005) and suggest that additional studies are required to more fully explain and manipulate (in commercial settings) factors controlling edamame sensory quality. Therefore, we set out to: (1) identify which of six organically grown edamame varieties, currently available to growers, was most liked by consumers, and (2) further characterize the qualities that make particular varieties desirable to Ohio consumers. We hypothesize that improved cultural procedures, including variety selection, may facilitate increases in edamame consumption, as suggested previously for other crops (Collins, 1999; Scheerens, 2001; Schneeman, 2000).

2. Material and methods

2.1. Bean production

Six varieties of edamame ('Sapporo Midori', 'White Lion', 'Early Hakucho' (Osborn International Seeds;

Mount Vernon, WA, USA), ‘Sayamusume’, ‘Misono Green’ (Territorial Seeds Company; Cottage Grove, OR, USA), and ‘Kenko’ (Just This Farm; Galloway, OH, USA) were grown organically at the Ohio Agricultural Research and Development Center (OARDC), Badger Farm, in Wooster, OH, USA during the 2002 growing season on a Wooster silt loam soil. Prior to edamame planting, the field was planted in winter wheat and then prepared for edamame planting using a plow, disk, and spring-tooth harrow on 2, 4, and 22 May, respectively. Plots were direct-seeded on 23 May with seeds treated with *Bradyrhizobium japonicum* (3.4 g inoculum/kg seed, Urbana Laboratories; St. Joseph, MO, USA). Plots contained four, 26 m rows (76 cm between rows) sown at a rate of 20 seeds/m. Plots were arranged in a randomized complete block design with four replications. Each plot was hand-weeded weekly and cultivated biweekly from 13 June to 31 July. Pods were harvested at horticultural maturity from the middle 6 m of the two inside rows of each plot from 6 to 20 August. Maturity was assessed using a combination of published days to harvest information for the varieties and visual examination of pods, as in Bernard (2004). Harvests were made when pods were bright green and beans had reached a size where they were only just beginning to touch each other in the pod. Pods were removed from plants in the field, placed in open plastic containers, and transferred within 3 h to dark, refrigerated storage until further processing.

2.2. Bean preparation

Within one day of harvest, pods were cleaned of debris, sorted into those containing 1, 2, or 3 beans per pod, and blanched for 3 min in boiling tap water, followed immediately by immersion in cold tap water. After blanching, pods were double bagged in 946 cm³ Ziploc freezer bags, labeled and placed in a standard freezer ($\approx 2^{\circ}\text{C}$). Prior to sensory evaluation, pods were taken from the freezer and immersed in boiling tap water for 1 min. Heated pods were placed in coded bags in an Iso-temp 220 hot water bath (Fisher Scientific, Pittsburgh, PA, USA) at 60 °C to maintain temperature until serving. All samples were used within 45 min of being placed in the water bath.

2.3. Affective tests

All methods for testing human subjects were approved by the Office of Responsible Research Practices (ORRP) at The Ohio State University before testing began. Beans were evaluated by a panel at the OARDC on 17 March, 2003 from 2:00 pm–5:00 pm. Panelists were given no time limit for the evaluation, though most panelists took 10–15 min to complete the rating of all of the samples. Fifty-four panelists (ages 20–60 years,

25 females, 50 non-smokers, 30 who had previously consumed edamame) evaluated each of the six samples in a randomized and counterbalanced order. Panelists were volunteers from the research center and community who responded to an announcement for the evaluation on the OARDC website. Panelists were untrained but familiar with product sensory evaluation, most having participated in previous related projects (Kleinhenz et al., 2003; Radovich et al., 2004; Scheerens et al., 2003; Wszelaki et al., 2005). Samples consisted of two pods containing 2–3 beans each. Panelists were instructed on bean consumption and evaluation. As edamame is not a “mainstream” vegetable in the US, some panelists were unfamiliar with the product; therefore, clear instructions were given to remove the beans from the pod before consumption. Seven characteristics were evaluated and panelists were instructed on the order in which to evaluate these characteristics: (1) visually examine the intact bean pod; (2) remove the beans from the pod and visually examine the beans; (3) evaluate the bean aroma; (4) consume the beans and score for bean taste, texture, and aftertaste; and (5) rate the overall acceptability of the sample. For each sample, panelists scored their liking of these seven characteristics using the nine-point hedonic scale (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, and 9 = like extremely). Panelists also indicated their willingness to buy each sample using a nine-point scale (1 = extremely unwilling, 2 = very much unwilling, 3 = moderately unwilling, 4 = slightly unwilling, 5 = neither willing nor unwilling, 6 = slightly willing, 7 = moderately willing, 8 = very much willing, and 9 = extremely willing).

Pods were served to panelists on 18 cm \times 23 cm white Styrofoam® trays, pre-labeled with randomly selected three-digit codes. Panelists were seated at 2.4 m \times 0.8 m tables for the evaluations. Tables contained six partitions for individual panelists. The evaluation site was lit by a combination of standard fluorescent fixtures and sunlight provided by large, unshaded windows. Panelists were provided with Dannon® bottled water and white, Italian bread to cleanse their palates between samples.

2.4. Descriptive analysis

The same six varieties of edamame-type soybeans were also examined using descriptive analysis to characterize the properties of edamame flavor underlying potential consumer preferences for specific varieties. Ten panelists (age 20–60 years, 5 males, 8 non-smokers), with previous experience in sensory evaluation (affective and/or descriptive analysis) participated in three training sessions and three evaluation sessions.

Training sessions were 2 h each. The first training session consisted of panelists tasting four sweet (0, 1, 2, and 4% sugar), salty (0, 0.1, 0.2, and 0.4% salt), and bitter (0, 1, 2, and 4% quinine hydrochloride) solutions, which were randomly numbered with 3-digit codes, and rating them from less to more by placing a vertical line corresponding to their perception of these characteristics on a labeled, 9 cm horizontal line scale, with one scale per sample. This training session also included a brainstorming activity to identify descriptive terms for edamame flavor characteristics. Terms that appeared on panelists' lists most often included "mild", "beany", "sweet", "nutty", "starchy", and "texture". The texture component that panelists agreed on was "chewiness".

Panelists chose beaniness, sweetness, nuttiness, and chewiness as the four attributes that best differentiated various edamame samples. Subsequently, they tasted the beans and rated their intensities for these four characteristics. Panelists readily differentiated varieties along sweetness and chewiness dimensions; however, panelists found it difficult to differentiate varieties based on beaniness and nuttiness. Thus, beaniness and nuttiness were the focus of subsequent training sessions.

In the second training session, panelists focused on nuttiness and beaniness by tasting beans spiked with black walnut extract (The Spicery Shoppe, Donners Grove, IL) and green bean juice (Roundy's Inc., Milwaukee, WI). Subsequently, panelists tasted 6 samples numbered with random 3-digit codes and rated them from less to more, separately for beaniness and nuttiness, on labeled horizontal line scales. After these assessments, panelists discussed their difficulties differentiating between samples based on these characteristics and attempted to delineate further the nuttiness and beaniness characteristics. In the third training session, panelists were given samples of edamame, pecans, walnuts, cashews, peanuts, black-eyed peas, sweet peas, and green beans. Panelists were instructed to record their comments for each sample in writing and to compare flavors in edamame with those in the nuts and the other legumes to identify which most closely approximated the nuttiness and beaniness characteristics found in edamame. The consensus among panelists was that edamame nuttiness was best represented by the nut flavors in cashew and pecan. They also agreed that edamame beaniness was best represented by the bean flavor in lima bean and sweet pea. Therefore, cashew, pecan, lima bean, and sweet pea were used as standards in the sample evaluations.

Evaluation sessions were conducted on 12, 19, and 26 June, 2003 at the OARDC in Wooster, OH. Panelists were instructed on bean evaluation and consumption and were then given an 18 cm × 23 cm white Styrofoam® tray, pre-labeled with randomly selected three-digit codes for each of the six samples. Each sample consisted of two pods containing 2–3 beans each. Panelists

were given a new tray for each characteristic, with characteristics scored in the order sweetness, nuttiness, beaniness, and chewiness. Samples were presented in a randomized, counterbalanced order across subjects and within sessions. Panelists scored samples from less to more for each characteristic by placing a vertical line corresponding to their perception of the characteristic on a labeled, 9 cm horizontal line scale, with one scale per sample. The lines were then measured from the left side of the scale in centimeters with measurements corresponding to a nine-point scale (e.g., for sweetness, 1 = extremely not sweet, 2 = very not sweet, 3 = moderately not sweet, 4 = slightly not sweet, 5 = neither sweet nor not sweet, 6 = slightly sweet, 7 = moderately sweet, 8 = very sweet, and 9 = extremely sweet). Panelists completed evaluations in the individual booths described above. Since it is inappropriate to conduct consumer testing under colored lights, more natural lighting was used for that phase. Thus, in order to more easily compare data sets, during the descriptive analysis phase the room was illuminated in the same fashion. Panelists were instructed to cleanse their palates before they began the tasting and in between samples using the Dannon® bottled water and saltine crackers that were provided.

2.5. Statistical analysis

Liking scores and descriptive analysis ratings were subjected to analysis of variance using the General Linear Model procedure of SAS (Statistical Analysis System for Windows™, v.8, Cary, NC). Treatment means were compared using Fisher's protected least significant difference (LSD) test ($\alpha = 0.05$) in SAS.

3. Results

3.1. Affective tests

Although for the most part, average ratings for all attributes and varieties ranged from "Neither like nor dislike" to "Like slightly," the liking ratings for pod appearance and bean taste differed among varieties (Table 1). The pod appearance of 'Kenko', 'Sayamumume', and 'White Lion' were the most liked, while 'Early Hakucho' pod appearance was least liked. Bean taste scores for 'Sayamumume' were higher than for all other varieties except 'Kenko' and 'Sapporo Midori'.

Sorting liking test results by gender (Table 2) revealed that for 25 females, liking of bean taste varied significantly across samples (Fisher's $P < 0.05$), while for males it did not (Fisher's, $P < 0.05$). In contrast, for 29 males, liking of pod appearance varied significantly across samples (Fisher's, $P < 0.01$), while for females it did not (Fisher's, $P < 0.05$). As with unsorted ratings,

Table 1

Liking scores for 54 panelists rating six varieties of edamame grown organically at the Ohio Agricultural Research and Development Center (OARDC) in Wooster, OH in 2002

Variety	Pod appearance	Bean					Overall acceptability	Willingness to buy
		Appearance	Aroma	Taste	Texture	Aftertaste		
Early Hakucho	5.0d ^{y,z}	6.2	5.5	5.9bc	6.1	5.8	5.9	5.7
Kenko	6.0a	6.3	5.7	6.2ab	6.1	5.6	6.1	5.7
Misono Green	5.2cd	6.4	5.3	5.4 c	5.6	5.2	5.5	5.3
Sapporo Midori	5.3bcd	6.6	5.5	5.9abc	6.4	5.9	6.1	5.7
Sayamusume	5.6abc	6.7	5.7	6.5a	6.2	5.9	6.3	6.0
White Lion	5.9ab	6.6	5.7	5.8bc	5.9	5.6	6.1	5.7

^y Means within each column followed by different letters are significantly different according to Fisher's protected least significant difference test ($P \leq 0.01$).

^z For each sample, panelists scored their liking of these seven characteristics using the nine-point hedonic scale (where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely). Panelists also indicated their willingness to buy each sample using a nine-point scale (where 1 = extremely unwilling, 5 = neither willing nor unwilling, and 9 = extremely willing).

Table 2

Gender-dependent liking scores for 54 panelists judging six varieties of edamame grown organically at the Ohio Agricultural Research and Development Center (OARDC) in Wooster, OH in 2002

Gender	Variety	Pod appearance	Bean					Overall acceptability	Willingness to buy
			Appearance	Aroma	Taste	Texture	Aftertaste		
Female <i>N</i> = 25	Early Hakucho	5.4 ^y	6.9	5.9	6.5abc ^{*z}	6.8	6.2	6.6	6.4
	Kenko	6.2	6.9	6.2	6.8ab	6.8	5.9	6.6	6.2
	Misono Green	5.2	7.1	5.5	5.6c	6.0	5.6	5.8	5.5
	Sapporo Midori	5.5	7.3	6.0	6.2abc	6.7	6.1	6.4	6.0
	Sayamusume	5.4	7.2	6.0	6.9a	6.5	6.0	6.6	6.2
	White Lion	6.2	7.2	5.9	5.9bc	6.3	5.9	6.4	6.0
Male <i>N</i> = 29	Early Hakucho	4.6b ^{**}	5.6	5.2	5.3	5.6	5.4	5.3	5.1
	Kenko	5.8a	5.8	5.3	5.8	5.6	5.4	5.6	5.3
	Misono Green	5.2ab	5.8	5.1	5.2	5.2	4.9	5.2	5.1
	Sapporo Midori	5.2ab	6.0	5.0	5.7	6.0	5.6	5.8	5.4
	Sayamusume	5.8a	6.2	5.5	6.1	6.0	5.8	6.0	5.8
	White Lion	5.6a	6.0	5.4	5.8	5.6	5.4	5.8	5.5

^y For each sample, panelists scored their liking of these seven characteristics using the nine-point hedonic scale (where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely). Panelists also indicated their willingness to buy each sample using a nine-point scale (where 1 = extremely unwilling, 5 = neither willing nor unwilling, and 9 = extremely willing).

^z Means within each gender and column followed by different letters are significantly different according to Fisher's protected least significant difference test, $*P \leq 0.05$ and $**P \leq 0.01$, respectively.

females most liked the bean taste of 'Sayamusume' (mean = 6.9) and least liked the bean taste of 'Misono Green' (mean = 5.6). Among males, 'Kenko', 'Sayamusume', and 'White Lion' were the most liked (mean = 5.9) and 'Early Hakucho' (mean = 4.8) the least liked pod appearances, respectively.

In general, liking of pod appearance and bean taste varied among edamame varieties, with females also varying in their liking of bean flavor and males varying in their liking of pod appearance (Tables 1 and 2). 'Sayamusume' typically received higher scores across all categories, including overall acceptability than 'Misono Green'. Males tended to score these varieties similarly, while females also gave 'Early Hakucho' and 'Kenko' high scores. In general, females gave higher liking ratings than males for all characteristics.

3.2. Descriptive analysis

Panelists consistently and significantly (ANOVA, $P < 0.05$) differentiated varieties based on chewiness and sweetness (Table 3). 'White Lion' was less chewy than all other varieties (Fisher's, $P < 0.05$). 'Early Hakucho' received the highest rating for chewiness. 'Kenko' was rated higher in sweetness than all other varieties except for 'Sapporo Midori', while 'Misono Green' was rated lower in sweetness than all other varieties except 'Sayamusume'. There were no significant differences between varieties for the other two characteristics; however, 'Early Hakucho' and 'Misono Green' received the highest and lowest scores for beaniness, respectively. 'Sayamusume' and 'Early Hakucho' were rated the most and least nutty varieties, respectively.

Table 3

Intensity scores of 10 descriptive analysis panelists from an evaluation of edamame grown organically at the Ohio Agricultural Research and Development Center (OARDC) in Wooster, OH in 2002

Variety	Edamame descriptors			
	Beaniness	Chewiness	Nuttiness	Sweetness
Early Hakucho	5.08 ^y	5.22a ^z	3.88	3.33bc
Kenko	4.72	4.61a	3.95	4.54a
Misono Green	4.62	4.84a	4.29	2.82c
Sapporo Middori	5.01	4.78a	4.31	3.88ab
Sayamusume	4.64	4.88a	4.50	3.41bc
White Lion	4.88	3.66b	4.01	3.64b
LSD _{0.05}	0.91	0.69	0.90	0.72

^y Scores were measured corresponding to a nine-point scale (e.g., for beaniness, 1 = extremely unbeany, 5 = neither beany nor unbeany, and 9 = extremely beany).

^z Means within each column followed by different letters are significantly different according to Fisher's Protected Least Significant Difference test ($P \leq 0.05$).

Table 4

Interaction of evaluation day, panelist and variety on sensory descriptors for six varieties of edamame grown organically at the Ohio Agricultural Research and Development Center (OARDC) in Wooster, OH in 2002

	Edamame descriptors			
	Beaniness	Chewiness	Nuttiness	Sweetness
Evaluation	NS	NS	NS	NS
Panelist	***	***	***	***
Variety	NS	**	NS	***
Evaluation × Variety	NS	NS	NS	NS
Panelist × Variety	NS	NS	NS	NS

NS, **, *** = not significant or significant at $P \leq 0.01$ or $P \leq 0.001$, respectively.

Panelists varied significantly in their descriptor ratings ($P < 0.001$). Variety × evaluation and panelist × variety interactions were not significant for any descriptors ($P < 0.05$) (Table 4).

4. Discussion

Overall, the hedonic values given to the edamame varieties were rather low, with average values ranging from neutral to like slightly. This may reflect the newness of the product in the US, particularly if food neophobia is invoked (Raudenbush & Frank, 1999). Although liking scores may be similar between food neophobes and neophilics once samples are consumed, food neophobia is reported to influence food sampling and rating behavior and be only partially overcome with sensory information (Raudenbush & Frank, 1999). Regardless, if conducted in areas with high edamame consumption, such as Japan, this study may have resulted in higher and more diverse ratings among varieties. However, such a study would have identified

characteristics important to Japanese rather than US consumers. The information presented here is an early indication of potential consumer expectations with regard to fresh edamame, and it would be interesting to see how these expectations change as familiarity increases.

Affective test panelists had clear preferences for the pod appearance and bean taste of particular varieties. However, descriptive analysis panelists were less successful in distinguishing between edamame varieties for the flavor components beaniness and nuttiness. When sorted by gender, the liking of bean taste by females varied significantly across samples, while in contrast the liking of pod appearance by males varied significantly across samples. In addition, male panelists' ratings of taste and overall acceptability mirrored their ratings for pod appearance. The latter is likely due to the well-documented halo effect of color and appearance on subsequent assessments of food acceptability (Imram, 1999; Kostyla & Clydesdale, 1978). In contrast, female panelists' ratings of pod appearance did not strongly parallel their taste ratings, suggesting a gender difference in drivers of liking of edamame.

Gender differences in hedonic ratings of foods have been reported previously. In a survey of vegetable preferences among 100 Polish university students, a statistically significant influence of gender on hedonic preference was observed for 25 out of 32 vegetables, with women ranking 19 of the 25 vegetables higher than men (Babicz-Zielinska, 1999). Also, Chen, Weingartner, and Brewer (2002) examined factors impacting hedonic ratings of cookies made with various soy ingredients and found a significant interaction between degree of color liking and gender, with women giving higher ratings than men. Kandiah and Laird (2002) also found that for flavored soy nuts, female college students gave higher liking of appearance ratings than males. Together, results from this study on edamame and previous studies of other foods suggest that females tend to give higher ratings than men for liking of appearance. Such a gender difference may have contributed to the relatively small difference between the liking ratings of pod appearance by females for the edamame varieties. However, additional research would be necessary to substantiate this hypothesis.

In their sensory evaluation, Chung and Hwang (1996) found that preference scores were significantly associated with harvest stage. In the current study, as only one harvest date (based on horticultural maturity) was evaluated, it is possible that 'Sayamusume', which received the highest preference score, was at its optimum maturity, while 'Misono Green', which received the lowest score, was beyond its optimum maturity. Maturity was assessed using a combination of published days to harvest information for the varieties and visual examination of pods. Harvests were made when pods were

bright green and beans had reached a size where they were only just touching each other in the pod. This is consistent with Shono (1987), who suggested harvest periods of 30–36 days after anthesis, slightly before beans reach maximum size and sugar content. Thereafter, sugar, free amino acid, and ascorbic acid levels decrease rapidly with continued maturity. Eating quality indicators, such as sugar and vitamin content, are often difficult to measure in the field and impossible to measure without destructively sampling plants. Therefore, alternative maturity indicators, such as days to harvest and pod fill, must be used in the field. While these alternatives are generally reliable for predicting harvest time, they can under or over estimate crop maturity. For example, Mbuvi and Litchfield (1995) found that even slight delays (i.e., hours) in harvesting green peas may cause considerable losses in quality. Both 'Misono Green' and 'Sayamusume' in the current study were harvested 90 days after planting (DAP); however, on the California Central Coast, Gaskell (2001) found the days to harvest for 'Misono Green' and 'Sayamusume' to be 86–93 d and 91–93 d, respectively, with harvest occurring when plants had a maximum number of filled pods, and the first pods were turning yellow. Therefore, 'Misono Green' may have been four days past its optimum maturity, while 'Sayamusume' was at its harvest peak. This emphasizes the importance of employing multiple cues, including pod fullness, bean size, and days to harvest, in assessing maturity and selecting harvest dates in order to maximize eating quality (Chiba, 1991).

Regarding texture, 'Misono Green' tended to be the least preferred variety, based on mean liking scores. In a previous study, hedonic scores demonstrated that textural preference for green beans influenced likeability of several characteristics (Baron & Penfield, 1993). Textural preferences in the current study may have influenced taste preferences. Interestingly, descriptive analysis did not differentiate 'Misono Green' chewiness from that of four other varieties. This suggests that, like taste, edamame texture is composed of several components. 'White Lion' was rated second lowest in affective tests and less chewy than the other five varieties in descriptive analysis. Bourges, Camacho, and Banafunzi (1981) found that moisture steadily decreased as edamame pods increased in age, which could contribute to perceptions of chewiness. 'White Lion' was harvested 76 DAP, two weeks before four out of five other varieties. This could explain its lower chewiness rating. Data reported here suggest that chewiness is a desirable characteristic in edamame and that chewiness increases with pod and bean maturity.

Combining results from affective tests and descriptive analysis (e.g., with 'Sayamusume' and 'Kenko' liked best) suggests that panelists preferred a balance of sweetness, nuttiness and moderate chewiness. Beaniness was generally not a positive flavor characteristic, as

sweetness and beaniness may be negatively correlated (Chung & Hwang, 1996) and flavors most desired in beans are sweetness, nuttiness, and an absence of beany taste (Young et al., 2000). Nonetheless, in the current study, 'Sayamusume', which was the most preferred variety, was not significantly sweeter than 'Misono Green', which was the least preferred variety. This indicates that other characteristics may be involved in edamame flavor preference, in addition to those measured here.

Overall, edamame varieties appeared to have subtle flavor characteristics, yet panelists had clear variety preferences for taste and texture. 'Sayamusume' had the highest liking ratings for bean taste and the highest yield (kg ha^{-1}). 'Kenko', which also rated high in the sensory evaluations, tended to have a lower yield (data not shown). Therefore, for mid-western organic growing conditions 'Sayamusume' may be the most appropriate variety for consumers and growers, though all varieties tested were acceptable to the panelists.

The data presented here show preliminary evidence of varietal differences and consumer preference for edamame soybeans. Future studies under different environmental conditions and employing replicated harvests are required to further delineate consumer preference for edamame.

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