Reprinted from: Perspectives on new crops and new uses. 1999.
J. Janick (ed.), ASHS Press, Alexandria, VA.

Edamame: A Vegetable Soybean for Colorado

Duane Johnson, Shaoke Wang, and Akio Suzuki

Edamame, or vegetable soybean (Fig. 1), has a long history in many Asian cultures as a side dish or snack (Lumpkin et al. 1993). Japan has been consuming edamame for over 400 years. National consumption in Japan has averaged 110,000 tonnes (t) annually (Nakano 1991). These vegetable soybeans are generally sold in the pod as fresh or frozen beans (Fig. 2). Beans are harvested when bean pods are green and Brix readings (soluble solids) are generally between 8.5 and 12.0. For consumption, edamame is boiled for 5 to 7 minutes in highly salted water, drained and are served either hot or cold. Other vegetable soybean products are a shelled version of edamame called *mukimame* and a green bean paste, *zunda-mochi* (Masuda 1991).

Edamame quality is measured in Japan with three primary concerns: flavor, sweetness, and texture. To accomplish these concerns, breeders have based cultivar selection on five criteria: appearance, taste, texture, flavor, and nutritional value. Taste is determined by sucrose, glutamic acid, and alanine. Flavor is most desirable when it is "flower-like" and "beany" (Masuda 1991). The boiled beans are a good source of vitamin C (ascorbic acid), vitamin E (tocopherol), and dietary fiber. Trypsin inhibitors and other antinutrional factors do exist in edamame. To market, the pods should be bright green, have a light (white to grey) colored pubescence, be free of defects and contain a minimum of two beans per pod. Texture studies at Colorado State University indicate a preference for a "buttery" texture attainable by delaying harvest (J.A. Maga 1996, pers. commun.). The changes in texture preferred by US consumers will decrease the concentration of cis-jasmone and hexenyl-acetate responsible for the flowery flavor Masuda (1991). Boiling induces production of furans and ketones. In the lipid fraction, as the soybean mature, the fraction of linoleic fatty acids increases. Linolenic and palmitic fractions decreased. Monounsaturates tend to dominate in these immature soybeans. Nutritionally, edamame is very sound (Table 1).

Fig 1. Edamame soybean.

Fig 2. Edamame soybean plants ready for market.

Table 1. Proximate analysis of vegetable soybean in Japan (Masuda 1991) and Colorado.

Composition	Value/100 g	
	Japan	Colorado
Energy (Kcal)	582	573
Water (g)	71.1	71.1
Protein (g)	11.4	12.4
Lipids (g)	6.6	7.1
Carbohydrates g)	7.4	8.3
Fiber (g)	1.9	3.2
Dietary fiber (g)	15.6	13.8
Ash (g)	1.6	1.6
Calcium (mg)	70.0	72.0
Phosphorus (mg)	140	148
Iron (mg)	1.7	1.2
Sodium (mg)	1.0	1.5
Potassium (mg)	140	145
Carotene (mg)	100	89
Vitamin B1 (mg)	0.27	0.27
Vitamin B2 (mg)	0.14	0.14
Niacin (mg)	1.0	1.0
Ascorbic Acid (g)	27.0	17.0

THE COLORADO EDAMAME PROJECT

Colorado, due to elevation and latitude, is generally characterized as a Group 1-2 in the north and a Group 4 in the southern half of the state. Its extremes of climate, limited rainfall, and distance to market have restricted its introduction to the state. The dry climate and isolation, however, have also provided levels of yield and quality that stimulated interest in specialty markets for soybeans. Developing specialty soybeans required identifying the market. The developing immigrant and tourism industries for Asians on the West and East Coasts of the United States showed interest in purchases exceeding 2,200 t annually.

Edamame cultivars were obtained from Red Hen Corp. (Colorado Springs, Colorado) and Washington State University (Pullman, Washington) in 1992 and from Seedex, Inc. (Longmont, Colorado) in 1994. Initial results positive for yields and quality and additional yield trials were conducted from 1995 through 1998 utilizing Japanese cultivars of edamame provided by Seedex, Inc. Cultivar entries varied from year to year but five remained constant from 1994 through 1998. Cultivars were numbered as SE 1 through SE 5 and maintained under those designations throughout this timeframe. In 1995, a Colorado derived selection from SE 4 was relabeled as SE 7. SE 7 data were not significantly different from SE 4 and were not included in this analysis.

All entries were planted annually at Rocky Ford, Colorado from May 15 to June 1 and in Ft. Collins, Colorado from May 20 to June 10. All trials were planted in a randomized complete block design in four-row plots 7 m long and 1.6 m wide. Four replications were used at Rocky Ford and three replications at Fort Collins. Yields were divided into green bean and dry seed harvests using a split plot design. Green bean yields were based on harvests of two center rows, 2 m long and included total yield, salable yield (two or more beans/pod with no defects). Green harvest was based on physiological maturity of the beans (85–90% pod fill) and a Brix reading of parboiled beans in excess of 8.5. All plots were hand harvested. All green bean yields were adjusted to salable beans and analyzed using ANOVA protocols for Brix, texture, and salable beans. Texture was measured by sensory panel analyses in the Department of Food Sciences, Colorado State University. Dry bean harvests were conducted at the initiation of pod shatter (>10%). Dry bean plots harvested were two meters in length and were the two center rows in each plot. Dry beans were cut and tarped until dry and threshed using a modified Hege 125B combine. All dry bean yields were adjusted to 10% moisture and analyzed using ANOVA protocols.

Table 2. Yield results for edible beans at Rocky Ford and in Ft. Collins, Colorado, 1994–1998.

Cultivar	Whole yield (t/ha)	Salable yield (t/ha)	Brix (%)	Texture score[y] (1–10)
		Rocky Fork		
SE 4	10.2a[z]	6.8a	8.4b	8a
SE 2	8.4b	4.6b	8.4b	7b
SE 5	7.8b	5.2b	9.3a	9a
SE 1	5.9c	4.0c	9.1a	6b
SE 3	4.1c	2.1d	8.1c	4c
		Ft. Collins		
SE 4	8.1a	4.8a	8.3b	6a
SE 2	6.1b	3.9b	10.1a	7b
SE 5	6.9b	3.4b	10.5a	8a
SE 1	4.1c	2.8b	9.1a	8b
SE 3	2.2c	1.0c	7.1c	4c

[z]Mean separation by Duncans Multiple Range test, 5% level.
[y]1 = poor, 10 = execellent

Table 3. Yield of dry soybeans at Rocky Ford and Ft. Collins, Colorado, 1994–1997.

Cultivar	Whole yield (t/ha)	Salable yield (t/ha)	Germination (%)
		Rocky Fork	
SE 4	2.2a[z]	1.7a	82b
SE 2	1.5b	0.9a	85a
SE 5	1.3b	0.7a	85a
SE 1	0.9b	0.4b	76b
SE 3	0.4c	0.1c	78b
		Ft. Collins	
SE 4	1.6a	1.1a	78a
SE 2	0.9b	0.6a	75a
SE 5	0.6b	0.5a	65b
SE 1	0.3c	0.2b	62b
SE 3	0.1d	0.06c	72b

[z]Mean separation by Duncans Multiple Range test, 5% level.

Table 4. Brix quality of fresh green vegetable soybeans from Ft. Collins, Colorado, 1997.

	Brix (%)										
	Day										
Cultivar	0	2	4	6	8	10	12	14	16	18	20
SE 4	10a[z]	10a	10a	10a	10a	9a	9a	8a	6a	4a	3a
SE 2	11a	10a	10a	9a	9a	8a	8a	8a	6a	4a	3a
SE 5	11a	10a	10a	9a	8a	7b	7b	7a	6a	4a	3a
SE 1	9a	9a	9a	8b	8b	7b	7b	6b	6a	4a	3a
SE 3	6b	6b	6b	6b	5b	5c	5c	4c	4b	3a	3a

[z]Mean separation by Duncans Multiple Range test, 5% level.

Green Bean Yields

Green bean yields were significant for location effect and yield quality as measured by Brix. Results are summarized in Table 2. No location, year or cultivar interactions were noted. Data are summarized over years.

Yields of dry beans reflected similar variation with variance for cultivars, years, and locations being significant. Data are summarized in Table 3 for locations. Dry bean production was used to supplement potential green bean production and as an alternative seed market.

Processing Edamame

Edamame is marketed fresh or frozen. Fresh beans were harvested and selected for salable quality. Fresh beans of SE 4 from Ft. Collins were packaged in resealable plastic bags in lots of 2 kg/package. Plastic packs were flooded with air, 20:80 CO_2:N_2 gas and 40:60 CO_2: N_2. Replicated packs were refrigerated at 3°–5°C and sampled at 2 day intervals with subsamples of 0.10 kg/sample removed and prepared for consumption. Brix (%) were used as quality measures. Analysis of replicated trials are shown in Table 4. High sugar cultivars tended to have a shorter shelf life than the higher yielding lines. It appears for commercial edamame production, most cultivars are capable of 10 to 14 day storage without significant loss in quality.

Frozen soybeans were capable of long term storage and were commercially processed using IQF (Instant Quick Frozen) technology in Rocky Ford, Colorado. Frozen samples were distributed to commercial outlets for evaluation in 2 kg bags. Production and Instant Quick Freeze (IQF) processing technology utilized are illustrated in Fig. 1 and 2.

SUMMARY

Edible vegetable soybeans are feasible for production in Colorado. The dry climate and high altitude provide a low pathogen, high quality environment. Markets for this new crop exist within the United States and could conceivably require 13,000 ha to fill that market niche.

The crop can be processed either as fresh (chilled) product or as frozen product. New consumers in the United states appear to prefer a more mature bean which has a more “buttery” flavor and texture as opposed to traditional Japanese consumes who prefer a sweeter, more flowery flavor, and crisper texture.

REFERENCES

Lumpkin, T.A., J.C. Konovsky, K.J. Larson, and D.C. McClary. 1993. Potential new specialty crops from Asia: Azuki bean, edamame soybean, and astragalus. p. 45–51. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.

Masuda, R. 1991. Effect of holding time before freezing on the constituents and flavor of frozen green beans (edamame). In: R. MacIntyre and K. Lopez (eds.), Vegetable soybean: Research needs for production and quality improvement. Asian vegetable Research and Development Center. Taipei, Taiwan.

Nakano, H. 1991. Vegetable soybean area, production, demand, supply, domestic and foreign trade in Japan. In: R. MacIntyre and K. Lopez (eds.), Vegetable soybean: Research needs for production and quality improvement. Asian vegetable Research and Development Center. Taipei. Taiwan.