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Evaluation of Edamame Cultivars in New Jersey and Maryland

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Edible soybeans [*Glycine max* (L.) Merr., Fabaceae] are growing in popularity as a specialty vegetable crop. Soybeans can be processed into many types of protein rich foods. Asians consume fresh or salted edamame much as Americans consume peas and peanuts. The increase of soy products in the news, touting their health benefits, has increased the public's awareness of this traditional Asian vegetable (Sciarappa and Quinn 2004). In order to develop production information for growers of this new crop, organic cultivar trials were conducted in New Jersey and Maryland (2002–2005), to determine suitability in the Mid-Atlantic region.

Edamame has large seeds, a light colored hilum, green seed coat and high sugar content. It is traditionally cultivated in China, Japan, and other Asian countries because it provides an excellent substitute for animal based protein that avoids saturated fats and cholesterol. These beans contain from 30% to 40% protein and are rich in calcium, vitamin A, and phytoestrogens, which may reduce the incidence of menopausal symptoms (hot flashes, night sweats).

Conventional edamame yields can be variable, ranging from 6,840–11,400 kg/ha (Miles et al. 2000). However, commercial growing has its limitations, including inconsistent plant populations, lack of commercial harvesting options, seed size variability, and effects of geographic microclimates (Duppong and Hatterman-Valenti 2005).

MATERIAL & METHODS

New Jersey Trial

The New Jersey study site was located in Pittstown, New Jersey, at the Rutgers Snyder Research and Extension Farm. In both 2002 and 2003 seasons, the horticultural properties of 16 vegetable soybean cultivars were compared. Ten of these cultivars were received from the Asian Vegetable Research and Development Center in Taiwan and 6 were received from Evergreen Seeds, an Asian seed company based in Japan.

A trickle irrigated plasticulture system was utilized with 76-cm beds mounded 15–20 cm high (Sciarappa et. al. 2004) (Fig. 1). The Taiwanese cultivars were seeded on May 30, 2002, in a staggered double row pattern spaced 15 cm apart. The Japanese cultivars also were planted on May 30 but a single row system was used with 15-cm spacing between plants. The 2003 planting was made on July 11 due to excessive rainfall.

In the 2002 season, soil pH was 6.3 and all plots were fertilized with 91 kg of 5–10–10 NPK chicken manure before planting and 23 kg actual N/A six weeks after planting. All cultivars were pre-treated with *Rhizobium* inoculant before hand planting. Measurements were made on a daily basis as to time of first plant emergence, percent stand, first trifoliate leaf, first flower, plant height at flowering, number of days until maturity, plant height at maturity, number of nodes per plant, number of one-seed pods, number of two-seed pods, number of three-seed pods, length of pods, weight of pods, color of pods, plant stand at harvest, lodging, and total pod yield.

Fig. 1. Plasticulture system for edamame soybean in New Jersey.

Maryland Trials

From 2002–2005, cultivar trials were conducted in Salisbury, Maryland on an organically managed research farm—Lower Eastern Shore Research and Education Center (LESREC). The plot design was a Randomized Compete Block with 4 replications. The beans were planted using a

John Deere 71 Planter set at 0.61 bu/ha (16.5–19.8 seeds/m) at 2.5 cm seed planting depth following a spring poultry manure application at 2.25 kg/ha (population of 42,306).

The season length differs for edible soybeans compared to grain soybeans in that they are harvested while they are green. The season length is approximately 90 days from planting to harvest, with individual cultivars maturing at slightly different rates. In 2004: beans were planted on June 24 and harvested on Sept. 14 and in 2005, beans were planted on June 23 and harvested on Sept. 7.

Pods were harvested by hand, removing 5.3 m of a row from the field for yield assessment. The stems were counted, pods were removed and weighed. The number of pods per plant were counted on 10 stems from each plot. The yield data was analyzed using Statistix®. An Analysis of Variance was performed and means were separated using Tukey's HST.

Laboratory Methods

Harvest yield samples were brought to the laboratory for analysis of nutritional and health value. High-performance liquid chromatography coupled with ultraviolet and electrospray ionization mass spectrometry (HPCL/UV/ESI-MSD) was applied to the study of isoflavones in edamame (Wu et. al. 2004). Positive atmospheric pressure interface (API) MS and MS/MS were used to provide molecular mass information. To facilitate quantitative analysis, acid hydrolysis during extraction of soy samples was selected to convert the various phytoestrogen conjugates into their respective isoflavone aglycones, allowing accurate quantitation of total phytoestrogens as aglycones.

RESULTS AND DISCUSSION

New Jersey

The 16 edamame cultivars in New Jersey grew quite vigorously throughout the 2002 season on trickle irrigated plasticulture. In 2003, severe spring rains set back planting dates over six weeks such that the data were not typical and the results are not included here. Germination and emergence of the 16 cultivars in 2002 studies ranged from fair to very good. The horticultural traits of the 16 cultivars in the New Jersey study site showed considerable difference in bean size, shape, color, and weight. The average pod weights ranged from approximately 2 to 4 g/pod (Table 1).

Ten cultivars were harvestable in the normal 2002 growing season within 90 days. Total pod weight/plant at this 90 day harvest window showed that 'Early Hakucho' averaged 2,000 g/plant and 'Ryokkoh', 'Emerald', 'Shironoma' a little less at around 1,400 g/plant. The remaining 6 cultivars were harvested within 120 days in growing zone 6. Composite Fig. 2 compares the difference between 90 days harvest and 120 day harvests among the 16 cultivars as to the total yield of fresh weight pods. These results indicate significant differences in marketable yield between medium season length cultivars and long-season length cultivars.

These longer season types came to us from Taiwan and were not the erect types like the ones from Japan. Instead, these types were long vines up to 254 cm in length that was reflected in greater fresh weight biomass, longer plant length, increased total weight biomass, and higher percentage lodging (Table 1).

Table 1. Average pod weight of 16 edamame cultivars grown in New Jersey, 2002.

	Pod yield (g)	
Cultivar	90 day harvest	120 day harvest
Taisho Shiroge	215.0	215
Shironomai	148.0	148
Tzuzunoko	234.1	234
Emerald	137.9	300
Shirofumi	76.6	245
Neu Ta Pien	1.5	225
Ryokkoh	284.4	284
Neu Ta Pien Pi	57.4	158
Ryokkoh Pi	18.7	260
Ryokkoh Taisho	208.8	209
Lucky Lion	281.5	281
Early Hakucho	242.4	242
BeSweet	350.6	350
Green Legend	316.3	316
Late Giant	10.2	402
Taiwame	389.6	390

These longer season soybeans yielded a very large and sweet bean and were larger in seed size and weight than the short season beans and larger than a typical lima bean. They were oval in shape and green to yellow-green in color. Correspondingly, their individual pod weights averaged higher ranging from approximately 3–4 g/pod. These sweet tasting beans were also highly preferred by the insect populations; even when compared to a nearby study with tofu type soybeans which were hardly affected. Disease incidence was very low among all cultivars in this hot and dry season.

Maryland

'Dixie', which performed the best in terms of plant population and yield, did not have the highest pod number/plant (Table 2). This may be attributed to variation in bean seed size, which can result in skips during mechanical planting. 'Dixie', however, did not have a significantly different plant population from 'BeSweet 292' or '414F'. 'BeSweet 2020S', 'BeSweet 292', and '414F' also did not have significantly different plant populations. 'Mooncake', had the lowest population stand as well as the lowest yield. 'Mooncake', represented only in the 2005 study, is a USDA bred genotype (Comis 2003). It has the ability to grow 1.5–1.8 m tall, and significantly shade out weed competition. All cultivars, with the exception of 'Mooncake', yielded similarly, and were not significantly different. Pod number/plant, was highest in 'BeSweet 292', 'Dixie', '414F', and 'Mooncake', though 'BeSweet 2020S', 'Dixie', '414F', and 'Moooncake' were not significantly different.

Edamame cultivars differ significantly in terms of population, and pod number/ plant. Cultivar trials conducted throughout the US have determined that edamame cultivars respond differently to local environmental factors. Other factors that may affect yield parameters include seeding rates, age of seed, and supplemental irrigation (Miles 2002; Duppong and Hatterman-Valenti 2005). In this study beans were planted at a population of 42,306. An 80% or higher survival rate is considered ideal for edamame, resulting in a population of 33,845 for this study (Sanchez et al. 2005). This correlates well with the performance of 'Dixie', though 'BeSweet 292' and '414F' were within 13% and 20% respectively. Reported seeding rates have ranged from 24,281–28,328 plants/ha in the coastal areas of the US, and 16,187 in Missouri (Miles et al. 2000; Kratchovil 2002; Nelson et al. 2002).

LESREC rainfall records report 68.99 and 55.27 cm of rainfall during the growing season in 2004 and 2005, respectively (April–September). This excessive rainfall may have affected the yields in this study as recommended irrigation rates for edamame in Washington State are 30.48–40.64 cm of water for the growing season (Miles et al. 2000).

Phytochemical

In the phytochemical analysis of the 2003 New Jersey samples of 16 edamame cultivars, the key phytochemical compounds identified were 13 different isoflavones; including 3 aglycones, 3 glycosides, and 7 glycoside malonates. The major isoflavones in fresh soy were daidzein, genstein glycoside, and malonate conjugates (Fig. 2) (Wu, Sciarappa, and Simon 2003). No acetyl conjugate was detected in these original fresh soy samples.

In the phytochemical analysis of the 2006 Maryland samples of 5 edamame cultivars, the key phytochemical compounds were again daidzein, glycitein and genitol. These isoflavone levels per seed sample range from

Table 2. Performance of vegetable soybean varieties 2004–2005, Salisbury, Maryland.[z]

Cultivar	Plants/ha	Yield (kg/ha)	Pods/plant
Be Sweet 2020S	27,305 B	5,703 A	19.01 B
Be Sweet 292	29,946 AB	6,399 A	30.22 A
Dixie[y]	34,323 A	8,137 A	28.23 AB
414F	27,494 AB	6,295 A	26.20 AB
Mooncake[x]	13,860 C	2,138 B	29.51 AB

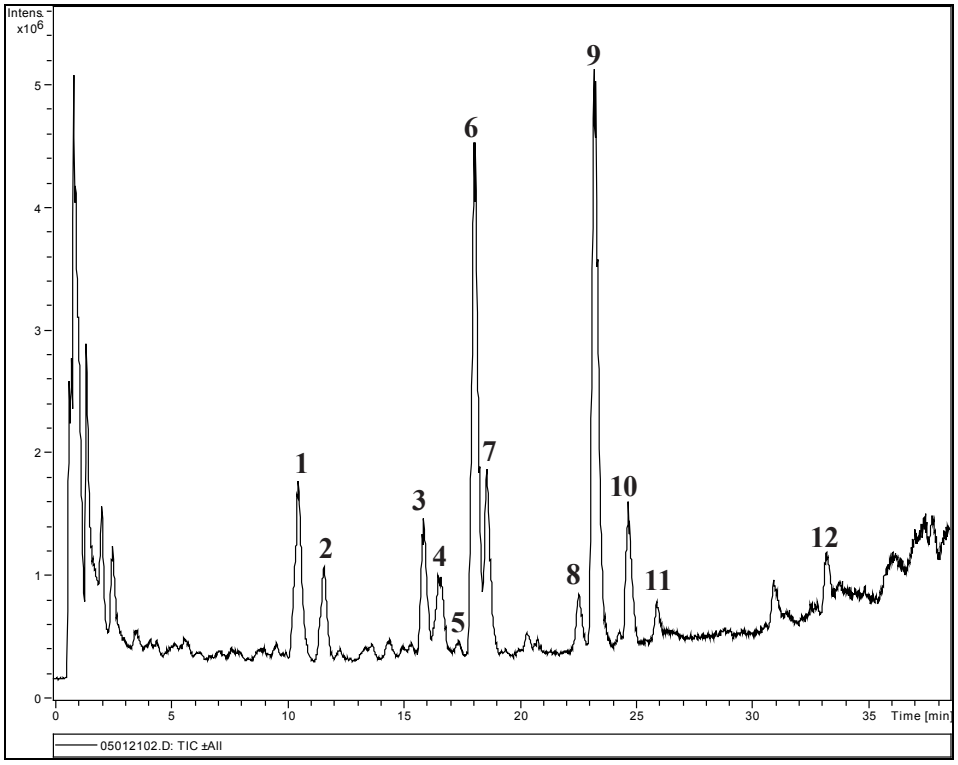
[z]Mean separation within column by Tukey's HSD Multiple Range Test (P=0.01).
[y]Dixie reported in 2004 only.
[x]Mooncake reported in 2005 only.

0.24% to 0.32%. The amounts of these isoflavones are compared on a cultivar basis in Table 3 to tofu soybeans grown in the same season (Sciarappa and Kluchinski 2004). There is a trend that these immature edamame cultivars are higher in percentage isoflavone concentration than some leading mature tofu type soybeans.

CONCLUSIONS AND FUTURE RESEARCH

Most edamame cultivars appear to have the horticultural properties for successful cultivation and marketing in the Mid-Atlantic region. There is evidence for high isoflavone content in many cultivars grown in both Maryland and New Jersey. These compounds are indicated in several trials as beneficial for human health and wellness. These important traits can serve as a selection factor in variety trials when coupled with laboratory analysis.

Both agronomic soybean growers and vegetable bean growers can conveniently transition to these higher value, human food soybeans. While animal feed processors could more easily adapt to tofu type beans with value added processing; vegetable growers could more easily crossover to many of the edamame soybean cultivars investigated in this study.



Peak no.	Identity
1	Daidzein-G
2	Glycitein-G
3	Genistein-G
4a	Daidzein-G-M
4b	Genistein-G-M
5a	Daidzein-G-M
5b	Glycitein-G-M
6	Daidzein-G-M
7	Glycitein-G-M
8	Genistein-G-M
9	Genistein-G-M
10	Daidzein
11	Glycitein
12	Genistein

Fig. 2. Total ion chromatogram of edamame soy seeds. G = glucosyl/galactosyl moiety; M = malonate.

Table 3. Total isoflavone concentrations from 5 edamame cultivars grown in Maryland and 5 tofu soybean cultivars grown in New Jersey 2006.

Edamame cultivar	Isoflavone concentration (% isoflavone)	Tofu cultivar	Isoflavone concentration (% isoflavone)
BeSweet 292	0.26	Iowa 1007	0.24
BeSweet 2020S	0.32	Iowa 2053	0.15
Dixie	0.13	HP 204	0.07
Mooncake	0.23	Roundup-Ready	0.18
414.F	0.24	Vinton 81	0.28

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