

# Agronomic and Seed Nutritional Quality Evaluation of Edamame Genotypes

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## Introduction and Methods

Edamame (pronounced “**eh-dah-MAH-meh**”) are large-seeded (seed dry wt. >250mg) soybean [*Glycine max* (L.) Merrill] harvested for fresh pods when the seeds are approximately 80% matured. Edamame cultivation could help farmers benefit from lucrative niche markets. The objective of this study was to evaluate eight edamame cultivars of Japanese origin, four large-seeded plant introductions along with two adapted US cultivars for production potential in southeastern USA. Planting was done May/June during 1995 through 1998 in a randomized complete block with four replications at the Fort Valley State Univ. Farm, Georgia.

Each year, growing degree days (GDD) from emergence to flowering and R6 stage (Fehr et al. 1971) were calculated as the  $\sum \{[(\text{Max} + \text{Min})/2] - 10\}$  air temperatures. At the R6 stage, plants from half-meter row were sampled from the middle rows of each plot for determining the fresh pod and seed yield, yield components, and seed compositional traits. The yield data and seed nutritional traits are expressed on fresh weight basis. Seed nutritional traits were determined from a sample of fresh green seeds as per the procedures described in Mohamed et al., (1986, 1995). The data were subject to statistical analysis using General Linear Model procedures of SAS [SAS, 1996]. PROC MIXED analysis was carried out using Year and Year by Cultivar as random effects. Year by Cultivar was used to test differences among cultivars.

## Results

The growing degree days (GDD) required to flowering and R6 stage ranged from 492 (Mian Yan) to 905 (Shangrao Wan Gingsi) and from 1352 (Mian Yan) to 1912 (Tanbagura), respectively (Table 1). The genotypes flowered within a mean GDD of 717 and reached R6 stage within a mean 1731 GDD.

The fresh pod yield varied between 14.6 Mg/ha (Ware) and 22.0 Mg/ha (Tanbagura). The average fresh pod yield across genotypes was 18.5 Mg/ha. The pod yield of Tanbagura, PI 181565, Tomahamare, and Shangrao Wan Gingsi was in excess of 20 Mg/ha. The pod yield of the vegetable soybean genotypes tested in this study were higher than those reported for vegetable soybean breeding lines in Taiwan (Shanmugasundaram et al., 1991) and Washington (Konovsky et al., 1996). Higher potential pod yields of upto 24 Mg/ha have been reported for some Taiwanese genotypes (Shanmugasundaram and Yan, 1999). Although Hutcheson also produced a similar number of pods as the higher yielding genotypes, its pod yield was considerably lower perhaps due to its smaller seeds. On the other hand, Tanbagura, because of its heavier seed, produced high pod yield, even though it had significantly fewer pods than PI 181565, Shangrao Wan Gingsi, Hutcheson, and Tomahamare.

The number of seeds per pod is one of the important quality characteristics that determines the marketability and profitability of fresh green pods of edamame. Pods with two or more seeds are generally preferred by consumers (Shanmugasundaram et al., 1991). In this study, the number of seeds per pod ranged from 1.3 to 2.2. Only Hutcheson had more than 2 seeds/Pod. Tanbagura had the lowest number of seeds per pod, whereas Hutcheson with smaller seeds had significantly more seeds per pod than all other genotypes. A similar number of seeds per pod was reported for several vegetable soybean genotypes grown in Virginia (Mebrahtu et al., 1997) and Washington (Konovsky et al., 1996).

The mean 100-seed fresh weight ranged from 31.5 g for Hutcheson to 94.8 g for Tanbagura. Tanbagura, Tomahamare, Akiyoshi, Shangrao Wan Gingsi, Guanun Da Kei Dun, PI 200506, and Houjaku had a mean 100-seed fresh weight above 50.0 g. The seed weight was positively correlated with days to R6 stage. The longer duration to attain R6 stage in Tanbagura, Shangrao Wan Gingsi, Akiyoshi, PI 181565, and PI 200506 resulted in heavier seeds.

All genotypes produced high fresh green seed yield, which ranged from 7.3 for Ware to 11.6 Mg/ha for Tomahamare. Ware produced a significantly lower seed yield than Tomahamare, Shangrao Wan Gingsi, PI 181565, and Tanbagura, but was similar to the rest of the genotypes. Tomahamare, PI 181565, Tanbagura, Shangrao Wan Gingsi, and Hutcheson had a mean seed yield of above 10 Mg/ha.

Variations in the mean seed yield between genotypes could be attributed to variation among yield components. Hutcheson produced greater number of pods and seeds per m<sup>2</sup> (data not shown), which contributed to its high fresh seed yield. In Tanbagura, it was mainly the seed fresh weight that resulted in higher pod and seed yields. In Guanun Da Kei Dun, Tomahamare, and Shangrao Wan Gingsi a combination of number of pods and seeds per m<sup>2</sup>, and seed weight was responsible for higher seed yield than that of other genotypes. Ware, Tousan-122, and Mian Yan, which had relatively fewer pods and seeds, and lighter seeds also had lower seed yields. Fresh pod weight was the major yield determinant with an R<sup>2</sup> value of 0.88 followed by number of seeds m<sup>-2</sup>, 100-seed fresh weight and seeds per pod in the order of importance.

### **Nutritional Quality Parameters:**

The oil content ranged from 5.0 to 6.9 % on fresh weight basis (Table 1). Hutcheson had a significantly greater oil content than Houjaku, Mian Yan, Ware, Tousan - 122, Shangrao Wan Gingsi, and PI 181565. The seed oil content (on fresh weight basis) of the genotypes tested in this study was only one-third that (18-20%) found in mature dry soybean seed (Rao et al., 1998).

The seed protein content varied between 33.3 and 38.6%. The protein content of Akiyoshi was significantly higher than Tousan-122 and Houjaku. The Japanese cultivars tended to have a slightly higher protein and lower oil content than the American cultivars and some of the PI lines. The combination of low oil and the relatively higher protein content of green seeds makes them particularly desirable to the health conscious people seeking low fat snacks.

The percent sugar varied between 6.03 and 7.4. Hutcheson had a significantly higher sugar content than Guanun Da Kei Dun, PI 181565, Akiyoshi, PI 417427, Tomahamare, and Mian Yan. Higher temperatures during seed filling may have been the reason for lower sucrose content.

Phytate, the main source of phosphorus in soybean seed and a calcium-magnesium-potassium salt of inositol hexaphosphoric acid (Liu, 1999) ranged from 1.08 to 1.39%. Tanbagura and Houjaku had lower phytate than Akiyoshi, PI 200506, Guanun Da Kei Dun, Tomahamare, and Mian Yan. The phytate content of the genotypes studied here were lower than those reported for several vegetable soybean genotypes in Virginia (Mebrahtu et al., 1997).

The seed oil, glucose, and phytate contents were positively correlated with seed weight ( $r = 0.99^{***}$ ,  $0.93^{***}$ ,  $0.92^{***}$ , respectively), whereas protein content was negatively correlated ( $r = -0.84^{***}$ ). Protein was also negatively correlated with seed oil ( $r = -0.83^{***}$ ), and glucose ( $r = -0.90^{***}$ ). Seed yield was positively correlated with oil content but negatively with protein.

## Conclusions

All Japanese cultivars, except Mian Yan, appeared to belong to maturity groups VI thru VIII and gave pod and seed yields similar to or better than Hutcheson, an elite high yielding cultivar belonging to MG V. PI 181565, Tanbagura, Shangrao Wan Gingsi, and PI 200506 with pod and seed yields in excess of 20 and 10 Mg/ha, respectively offer potential for commercial production in Georgia. Serial planting of early and late maturing cultivars may extend the duration of harvesting marketable fresh produce and offers the farmer the choice to market the fresh pods on the stem to health food stores.

Research aimed at improving the rate of germination and resistance to stink bugs, combined with identification and elimination or minimization of off-flavor causing chemicals through conventional and/or molecular marker assisted breeding should help improve farm gate profit margin and develop nutritious, high yielding vegetable soybean cultivars with taste and flavor acceptable to the American consumer.

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Table 1. Growing Degree Days (GDD) to Flowering and R6 Stage, Fresh Seed Yield and Yield Components, and Seed Nutritional Traits at R6 Stage of Vegetable Soybean Genotypes. Fort Valley, GA, 1995-1998.

Genotype	Flowering	R6	Pod	Seeds	Seed	Oil	Protei	Glucos	Phyat	
	g	Stage	Yield	No./Po	Fresh	wt.	n	e	e	
	----- GDD	-----	Mg/ha	d	g/100	Mg/ha	-----	-----	-----	
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Tanbagura	811	1912	22.0	1.3	94.8	11.1	6.0	35.9	7.18	1.08
PI 181565	768	1905	21.7	1.8	42.0	11.1	5.6	35.4	6.46	1.14
PI 417427	719	1746	21.5	1.5	58.2	11.6	6.1	35.5	6.48	1.28
Shangrao Wan Gingsi	905	1871	21.2	1.6	51.3	11.5	5.5	36.4	7.00	1.26
Akiyoshi	816	1817	19.7	1.6	56.6	9.9	6.2	38.6	6.47	1.33
Mian Yan	492	1352	18.7	1.6	47.1	9.0	5.3	36.6	6.44	1.35
PI 200506	852	1880	18.2	1.6	50.8	9.5	5.8	37.1	6.59	1.38
Hutcheson	719	1675	17.9	2.2	31.5	10.0	6.9	37.0	7.40	1.25
Houjaku	765	1786	17.6	1.6	50.4	8.7	5.0	34.8	6.54	1.08
Guanun Da Kei Dun	696	1610	17.3	1.5	57.5	8.9	5.9	36.3	6.03	1.39
Tousan - 122	657	1690	16.3	1.8	49.8	8.6	5.6	33.3	7.00	1.19
Tomahamare	635	1794	16.0	1.6	49.4	8.9	5.9	36.1	6.40	1.32
PI 416981	694	1716	16.0	1.8	44.1	8.6	5.8	35.4	6.95	1.23
Ware	514	1475	14.6	1.7	39.6	7.3	5.6	36.2	7.03	1.29
<b>LSD (P = 0.05)</b>	<b>70</b>	<b>113</b>	<b>5.8</b>	<b>0.3</b>	<b>9.5</b>	<b>3.0</b>	<b>1.1</b>	<b>3.5</b>	<b>0.91</b>	<b>0.24</b>

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<b>Mean</b>	<b>717</b>	<b>1731</b>	<b>18.5</b>	<b>1.7</b>	<b>51.7</b>	<b>9.6</b>	<b>5.8</b>	<b>36.0</b>	<b>6.71</b>	<b>1.26</b>
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