**Evaluation of cooking properties of vegetable soybean (*Glycine max* (L.) Merrill) genotypes**

**Abstract:**

Nowadays, there is an increased demand for the less expensive plant-based protein sources. Due to its high protein content, legumes are considered as poor mans meat. Vegetable soybean belongs to the same species as grain soybean but it is harvested at R6 growth stage (full pod) when the seeds are still immature and green but are fully developed inside the pods (80-90% of the pod cavity) in contrast to the dry mature harvest (R8 stage) of grain soybean. In the present study, cooking properties of 11 vegetable soybean genotypes and one check variety (DSB34-Contrl) at R6 and R8 stage were analysed. The results of the study found significant variation (p<0.01) among all the selected genotypes at both the stages. Among the R6 stage samples, AGS447 genotypes found the highest swelling capacity, swelling index, cooked L/Bratio and cooked 100 seed weight. The cooking time of R6 stage samples were ranged between 35.33-38.75min. The large seed genotype AGS447 observed the highest sweeling capacity and index, hydration capacity and index, cooked L/B ratio and elongation ratio. Cooking time and water uptake ratio of grain types soybean (DSB34) was significantly higher than vegetable soybean genotype at R8 stage. The solid gruel loss of AVSB2001 and AVSB2004 were high and Karune found the lowest value. Soaking and cooking are fundamental preparation steps of beans consumption, which increases the digestibility of protein, maximum retention of nutrients, reduces the antinutrients and improves the sensorial attributes.\

**Key words:** Genotypes, cooking property, Vegetable soybean

**Introduction:**

Due to their low production costs, adaptability to a variety of climatic conditions, and abundance of macro and micronutrients, legumes are a staple food in most parts of the world. Among the legumes, soybean has grown the greatest during the last thirty years (Agyenim-Boateng *et al*., 2023). Soybean (*Glycine max* L. Merrill) is one of the important and oldest world crops belongs to Fabaceae family (Zewudie and Gemede, 2024). It serves as a major oilseed crop and also provides more than a quarter of the total protein for the world’s food (Tian *et al*., 2025). As one of the most significant crops, soybeans have the potential to significantly improve the nutritional status of people all over the world. As a functional ingredient, soybean reduces the risk of various diseases such as atheroscelerosis, osteoporosis and different types of cancers. Though, India is one of the largest producers of the soybean, utilization of soybean in food use is less than 1% of the total production because of beany flavour do not suit the Indian palate (Kumar *et al*., 2006).

Soybeans can be eaten as a vegetable crop or processed into a variety of goods. Vegetable soybeans, also referred to as "edamame" in Japan, "maodou" in China, and "poot kong" in Korea, are members of the same species as grain type soybean. But beans are eaten when they are still immature or unripe; in other words, the pods are picked at the R6 stage Mozzonia and Chen, 2018; Jiang *et al*., 2022; Ribera *et al*., 2022; Nair *et al*., 2022; Djanta *et al*., 2020). During crop rotation, vegetable soybean can fit into small windows due to its short growing period. Vegetable soybean can be cooked just like sweet pea, chickpeas or lima beans, their green seeds can be added to stews and soups, boiled in salt water, or roasted like peanut seeds. Immature vegetable soybean genotypes are potential source of nutrients like vitamins (B1 and B2), minerals (iron, calcium, phosphorus), and protein content compared to green seeds of other legumes (Williams et al., 2022; Mozzonia and Chen, 2018; Ribera *et al*., 2022). Antioxidant’s content of vegetable soybeans can strengthen the body's immune system and reduce the risk of cancer, and presence of isoflavones that reduce cancer risk, prevent heart disease, lower blood pressure, and reduce disorders during menopause (Amilia *et al*., 2021).

Though many studies are available on the cooking properties of different types legumes (Chuwa *et al*., 2023; Wani *et al*., 2015; Huma *et al*., 2008), cooking properties data on the selected vegetable soybean genotypes harvested at two stages (R6 and R8 stage) is not widely reported. Therefore, the present study was designed to analyse the cooking properties of recently developed (<https://avrdc.org/seed/improved-lines/vegetable-soybea>n/) vegetable soybean genotypes and compared the coking properties of vegetable soybean genotypes with the grain type soybean.

**Materials and methods**

The present study was conducted at Post Graduate and Research Center, PJTAU, Hyderabad, Telangana, Inda. Vegetable soybean genotypes (n=11) namely AVSB2001, AVSB2002, AVSB2004, AVSB2006, AVSB2007, AVSB2009, AVSB2012, AVSB2013, Swarna Vasundhara, Karune and AGS447, along with grain soybean (DSB34) were selected for the study. All the samples were harvested at R6 stage (Growth stage when the seeds are still immature and green but are fully developed inside the pods) and R8 stage (full maturity of the seed) for further evaluation. The cooking properties such as swelling capacity, swelling index, cooking time, L/B ratio and Cooked 100 beans weight of vegetable soybean genotypes at R6 stage were determined after boiling the fresh sample. While cooking properties of R8 stage vegetable soybean genotypes were analysed by the standard methods of Wani *et al*. (2015).

**Results and discussion**

**Cooking quality of vegetable soybean genotypes at R6 stage:** Cooking includes starch gelatinization, protein denaturation, polysaccharide solubilization and collapse, and softening of the structural materials in the cotyledon (Hamid *et al*., 2016). From consumers point of view, the cooking quality is also judged to some extent on increase in volume after cooking, duration of cooking, amount of water absorbed and the time required to attain desired softness (Sethi *et al*., 2011). Cooking time is a very important quality criteria in terms of consumer. Excess cooking decreases the nutritive value of protein, essential amino acid content (Karayel and Bozoglu, 2015). The cooking time of vegetable soybean genotypes at R6 stage were ranged between 35.33-38.75min. The genotype AVSB2013 reported lowest cooking time and DSB34 found highest cooking time. Cooking time of vegetable soybean genotypes was significantly lower than the grain type soybean. The swelling capacity of cooked vegetable soybean genotypes at R6 stage were ranged between 0.023 (Karune)-0.048 (AGS447). The swelling index of AGS447 significantly higher than the other genotypes. The cooked length-width ratio of AGS447 (1.35) genotypes and Karune (1.23) was significantly higher than other genotypes. The amount of increase in weight of 100 beans was ranged between 63.99-81.30gm/100beans. Among the genotypes, 100 beans cooked weigh was found highest in AGS447 and lowest in DSB34.

**Cooking quality of vegetable soybean genotypes at R8 stage:** The cooking quality properties like seed volume, swelling capacity and cooking time are important traits for consumers, particularly when whole grains are consumed after soaking and cooking. Cooking is the fundamental preparation step of beans for consumption, which increases the digestibility of protein, maximum retention of nutrients, reduces the antinutrients and improves the sensorial attributes. The cooking properties of vegetable soybean genotypes at R8 stage were analysed and the results were presented in Table-2. Hydration capacity determines the extent to which seeds absorb water on soaking. Chemical composition of seed coat and cotyledons influences the hydration capacity of the seeds (Bewley *et al*., 2006). The hydration capacity of AGS447 (0.40g/ seed) was significantly higher than other genotypes. The hydration index was varied significantly (p<0.01) among the genotypes. Differences in seed size, seed coat thickness and water absorption characteristics of seeds influences the differences in both hydration capacity and hydration index of vegetable soybean genotypes (Kimothi *et al*., 2020). Swelling capacity and swelling index also displayed significant differences among the genotypes. The sweeling capacity of genotypes ranged between 0.17 (DSB34)-0.49 (AGS447). The swelling index of AGS447 was significantly higher than other genotypes. Various factors such as seed size, seed density and weigh of the grain had great influence on the swelling capacity and swelling index of the seeds (Kimothi *et al*., 2020). It was reported that the legumes having the higher hydration and swelling coefficients require less cooking time (Nciri *et al*., 2014; Thapa and Shrestha, 2017).

Water absorption of legumes is a measure of gross water uptake by seeds during soaking (Urga *et al*. 2006). Water uptake or water absorption capacity of seeds depends on the cell wall structure, composition of seed and compactness of the cells (Sethi *et al.,* 2011). A significant difference was observed in the water uptake ratio of vegetable soybean genotypes. Among the genotypes highest water uptake ratio was observed in Karune (2.47) and lowest in DSB34 (2.22).

For both consumers and food processors, cooking time is an important quality attribute because longer cooking time is inconvenient, require pre-soaking and is more costly, as it requires more electricity or fuel (Wood, 2017). The amount of time required for beans to reach the cooked texture considered acceptable to consumers is called as cooking time. It is a more ideal parameter, as it is very close to the texture preferred by the consumer (Moscoso *et al*., 1984). The cooking time of pre-soaked vegetable soybean genotypes at R8 stage were ranged between 76.33-104min. Various factors like genetics, environment, postharvest storage, pre-processing and cooking conditions influences the cooking time of the beans (Wainaina *et al*., 2021). Solid gruel loss(%) of genotypes varied significantly at 1% level of significance. The percentage of solid gruel loss was found highest in AVSB2004 (14.16%) and lowest was seen in Karune (8.52%). Cooked length breadth ratio showed significant differences among the genotypes and were in the range of 1.36 (AVSB2007)-1.69 (Swarna Vasundhara). Elongation of vegetable soybean genotypes were varied significantly at 1% level of significance. Various factors such as cultivar, seed characteristics, composition of seeds, growing location and environment influences the cooking quality of the genotypes calculated (Wani *et al*., 2015).

**Table-1 Cooking quality of vegetable soybean genotypes at R6 stage**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Genotype** | **Sweeling capacity** | **Swelling index** | **Cooking time** | **L/B ratio** | **Cooked weight/100beans** |
| **AVSB2001** | 0.035±0.00b | 0.057±0.00c | 35.83±0.76ab | 1.13±0.00ab | 64.76±0.87b |
| **AVSB2002** | 0.038±0.00bc | 0.069±0.01cd | 36.42±1.23abc | 1.07±0.02a | 64.42±0.37b |
| **AVSB2004** | 0.037±0.00bc | 0.064±0.00cd | 36.50±0.50abc | 1.09±0.02a | 69.37±0.83b |
| **AVSB2006** | 0.038±0.00bc | 0.067±0.00cd | 37.70±0.61cde | 1.10±0.03a | 66.41±0.19b |
| **AVSB2007** | 0.039±0.01c | 0.073±0.00d | 38.17±0.57de | 1.15±0.05ab | 69.00±0.45b |
| **AVSB2009** | 0.039±0.00c | 0.070±0.01cd | 36.92±0.87abcd | 1.12±0.01a | 63.99±0.06b |
| **AVSB2012** | 0.037±0.00bc | 0.063±0.08cd | 35.48±0.50a | 1.11±0.02a | 64.00±0.05b |
| **AVSB2013** | 0.047±0.00d | 0.106±0.01e | 35.33±0.57a | 1.14±0.05ab | 64.65±0.25b |
| **Swarna Vasundhara** | 0.025±0.00a | 0.030±0.02c | 37.44±0.38bcde | 1.13±0.01ab | 69.17±0.74b |
| **Karune** | 0.023±0.00a | 0.025±0.01ab | 38.38±0.23de | 1.23±0.01b | 70.64±0.17b |
| **AGS447** | 0.048±0.00e | 0.107 ±0.01f | 38.55±0.17de | 1.35±0.09c | 81.30±0.36c |
| **DSB34** | 0.024±0.00a | 0.015±0.00a | 38.75±0.66e | 1.11±0.02a | 57.73±0.68a |
| **F value** | 187.32 | 158.46 | 10.47 | 11.34 | 8.56 |
| **p value** | 0.00\*\* | 0.00\*\* | 0.00\*\* | 0.00\*\* | 0.00\*\* |

**Note:** The values are presented as the mean±SD of (n=3) replications. NS-non-significant, \*Significant at 5%, \*\*Significant at 1%. Values with a different superscript in the same column are significantly different (p≤0.05)

**Table-2 Cooking quality of vegetable soybean genotypes at R8 stage**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Genotype** | **Swelling capacity** (ml/seed) | **Swelling index** | **Hydration capacity** (g/seed) | **Hydration index** | **Water uptake ratio** | **Cooking time** (min) | **Solid gruel loss**(%) | **L/B ratio** | **Elongation ratio** |
| **AVSB2001** | 0.23±0.01b | 1.35±0.12bcd | 0.25±0.00ab | 0.91±0.07a | 2.24±0.04ab | 82.00±2.00abc | 15.83±0.16g | 1.42±0.03 ab | 1.39±0.07a |
| **AVSB2002** | 0.25±0.02bc | 1.43±0.27bcd | 0.26±0.01ab | 1.28±0.14ab | 2.24±0.04ab | 87.33±2.51cde | 12.83±0.57cde | 1.38±0.04ab | 1.59±0.08b |
| **AVSB2004** | 0.26±0.03bc | 1.32±0.14abc | 0.25±0.02ab | 1.18±0.09ab | 2.29±0.08abcd | 87.00±3.60bcde | 14.16±0.64f | 1.48±0.03abc | 1.58±0.05b |
| **AVSB2006** | 0.35±0.00ef | 1.62±0.07cd | 0.28±0.04abc | 1.07±0.18ab | 2.34±0.04d | 87.67±0.10cde | 11.88±0.42c | 1.44±0.05ab | 1.62±0.03bc |
| **AVSB2007** | 0.29±0.00cd | 1.19±0.01ab | 0.28±0.05abc | 1.19±0.13ab | 2.30±0.03bcd | 89.00±1.00cde | 12.13±0.31cd | 1.36±0.03a | 1.68±0.01bcd |
| **AVSB2009** | 0.26±0.02bc | 1.45±0.21bcd | 0.27±0.02abc | 1.19±0.09ab | 2.26±0.01abc | 84.33±0.30bcd | 12.23±0.52cd | 1.49±0.08bc | 1.63±0.09bc |
| **AVSB2012** | 0.32±0.00de | 1.56±0.03cd | 0.26±0.01ab | 1.12±0.08ab | 2.35±0.02d | 80.00±0.43ab | 13.04±0.00de | 1.59±0.04cd | 1.79±0.09d |
| **AVSB2013** | 0.27±0.03bc | 1.04±0.17a | 0.26±0.03ab | 0.94±0.06a | 2.36±0.06d | 76.33±1.52a | 13.72±0.88ef | 1.50±0.03bc | 1.55±0.03b |
| **Swarna Vasundhara** | 0.38±0.01f | 1.63±0.23d | 0.35±0.08bcd | 1.01±0.23ab | 2.31±0.03bcd | 92.00±0.20e | 9.10±0.38ab | 1.69±0.02d | 1.63±0.02bc |
| **Karun** | 0.37±0.01f | 1.61±0.03cd | 0.39±0.04cd | 1.38±0.26ab | 2.47±0.05e | 85.67±0.20bcde | 8.52±0.37a | 1.60±0.11cd | 1.68±0.14bcd |
| **AGS447** | 0.49±0.03g | 2.98±0.22e | 0.40±0.16d | 1.43±0.52b | 2.32±0.02cd | 91.33±0.15de | 9.66±0.14b | 1.68±0.15d | 1.77±0.16cd |
| **DSB34** | 0.17±0.02a | 1.21±0.08ab | 0.20±0.07a | 1.14±0.47ab | 2.22±0.00a | 104.00±0.36f | 9.50±0.26ab | 1.44±0.03ab | 1.64±0.04bcd |
| **F value** | 44.36 | 29.12 | 2.68 | 1.26 | 8.54 | 9.81 | 41.77 | 8.26 | 4.69 |
| **p value** | 0.00\*\* | 0.00\*\* | 0.02\* | 0.30 | 0.00\*\* | 0.00\*\* | 0.00\*\* | 0.00\*\* | 0.00\*\* |

**Note:** The values are presented as the mean±SD of (n=3) replications. NS-non-significant, \*Significant at 5%, \*\*Significant at 1%. Values with a different superscript in the same column are significantly different (p≤0.05)

**Conclusion**

From the present study, it can be concluded that vegetable soybean genotypes varied with respect to cooking characteristics both at R6 and R8 stages. The cooking time and cooked L/B ratio of R6 stage samples ranged between 35.33-38.75min and 1.07 to 1.35, respectively. AGS447 genotypes observed the highest cooked 100 beans weight at R6 stage. The cooking quality properties of R8 stage samples such as Swelling capacity, swelling index, hydration capacity, hydration index, cooked L/B ratio and elongation ratio of AGS447 was significantly higher than other selected genotypes. Cooking time of grain type soybean significantly higher than vegetable soybean genotypes.

**References**

Agyenim-Boateng, K.G., Zhang, S., Zhang, S., Khattak, A.N., Shaibu, A., Abdelghany, A.M., Qi, J., Azam, M., Caiyou Ma, Feng, Y., Feng, H., Liu, Y., Li, J., Li, B and Sun, J. 2023. The nutritional composition of the vegetable soybean (maodou) and its potential in combatting malnutrition. Frontiers in Nutrition. 9(1034115): 1-21.

Amilia, W., Wiyono, A.E., Ferzia, D., Rusdianto, A.S., Suryaningrat, I.B., Mahardika, N.S and Suryadarma, B. 2021. Physical, Chemical, and Sensory Characteristics of Frozen Salted Edamame During Storage at Room Temperature. International Journal on Food, Agriculture, and Natural Resources. 2(1): 9-17.

Djanta, M.K.A., Agoyi, E.E., Agbahoungba, S., Quenum, F.J., Chadare, F.J., Assogbadjo, A.E., Agbangla, C and Sinsin, B. 2020. Vegetable soybean, edamame: Research, production, utilization and analysis of its adoption in Sub-Saharan Africa. Journal of Horticulture and Forestry. 12(1): 1-12.

Erbersdobler, H.F., Barth, C.A and Jahreis, G. 2017. Legumes in human nutrition. Science and Research. 64(9): 134–139.

Hamid, S., Muzaffar, S., Wani, I. A., Masoodi, F. A., & Bhat, M. M. (2016). Physical and cooking characteristics of two cowpea cultivars grown in temperate Indian climate. Journal of the Saudi Society of Agricultural Sciences, 15(2), 127-134.

Huma, N., Anjum, F.M., Sehar, S., Khan, M and Hussain, S. 2008. Effect of soaking and cooking on nutritional quality and safety of legumes. Nutrition and Food Science. 38(6): 570-577.

Jiang, G., Townsend, W., Sismour, E and Xu, Y. 2022. A Study of Application and Comparison of Thermal Drying and Freeze Drying of Fresh Edamame Seeds in the Analysis of Seed Composition. Agronomy. 12(1993): 1-13.

Karayel, R and Bozoglu, H. 2015. The change of some physicochemical properties depending on the sowing times in local pea genotypes. Bulgarian Journal of Agricultural Science. 21(1): 109-117.

Kimothi, S., Dhaliwal, Y.S and Sharma, V. 2020. Functional properties and cooking quality of Kidney beans (Phaseolus vulgaris L.) grown in different regions of Himachal Pradesh. Himachal Journal of Agricultural Research 46 (2): 181-187.

Kumar, V., Rani, A., Billore, S.D and Chauhan, G.S. 2006. Physico-chemical properties of immature pods of Japanese soybean cultivars. International Journal of Food Properties. 9: 51–59.

Moscoso, W., Bourne, M. C., and Hood L. F., (1984). Relationship between the hard-to cook phenomenon in red kidney beans and water absorption, puncture force, pectin, phytic acid, and minerals. Journal of Food Science, 49: 1577-1583.

Mozzonia, L and Chen, P. 2018. Correlations of yield and quality traits between immature and mature seed stages of edamame soybean. Journal of Crop Improvement. 1-16.

Mozzonia, L and Chen, P. 2018. Correlations of yield and quality traits between immature and mature seed stages of edamame soybean. Journal of Crop Improvement. 1-16.

Nair, R.M., Yan, M., Vemula, A.K., Rathore, A., Zonneveld, M.V and Schafleitner, R. 2022. Development of core collections in soybean on the basis of seed size. Legume Science. 1-6.

Ribera, L.M., Aires, E.S., Neves, C.S., Fernandes, G.C., Bonfim, F.P.G., Rockenbach, R.I., Rodrigues, J.D and Ono, E.O. 2022. Assessment of the Physiological Response and Productive Performance of Vegetable vs. Conventional Soybean Cultivars for Edamame Production. Agronomy. 12 (1478): 1-14.

Sethi, S., Samuel, D. V. K and Khan, I. 2011. Development and quality evaluation of quick cooking dhal- A convenience product. Journal of Food Science Technology. DOI 10.1007/s13197-011-0534-6.

Thapa, B and Shrestha, A. 2017. Effects of different processing methods on chemical composition and phytochemicals present in chickpea (*Cicerareitinum* L.). GoldenGate Journal of Science & Technology. 3: 52-58.

Tian, Z., Nepomuceno, A.L., Song, Q., Stupar, R.M., Liu, B., Kong, F., Ma, J., Lee, S and Jackson, S.A. 2025. Soybean2035: A decadal vision for soybean functional genomics and breeding. Molecular Plant Perspective. 18**:** 245–271.

Urga, K., Fufa, H., Biratu, E and Gebretsadik, M. (2006) Effect of blanching and soaking on some physical characteristics of grass pea (Lathyrus sativus) African Journal of Food Agriculture Nutrition and Development, 6(1); DOI:10.4314/ajfand.v6i1.19174.

Wainaina, I., Wafula, E., Sila, D., Kyomugasho, C., Grauwet, T., Loey, A.V and Hendrickx, M. 2021. Thermal treatment of common beans (Phaseolus vulgaris L.): Factors determining cooking time and its consequences for sensory and nutritional quality. Comprehensive Review in Food Science and Food Safety. 1-29.

Wani, I.A., Sogi, D.S., Wani, A.A and Gill, B.S. 2015. Physical and cooking characteristics of some Indian kidney bean (Phaseolus vulgaris L.) cultivars. Journal of the Saudi Society of Agricultural Sciences. 1-9.

Williams, M.M., Zhang, B., Fu, X and Ross, J. 2022. Everything Edamame: Biology, production, nutrition, sensory and economic. Frontiers in Plant Science. 5-7.

Wood, J.A. 2017. Evaluation of Cooking Time in Pulses: A Review. Cereal Chemistry. 94(1):32–48.

Zewudie, K.G and Gemede, H.F. 2024. Assessment of nutritional, antinutritional, antioxidant and functional properties of different soybean varieties: implications for soy milk development. Food Science and Technology. 10(1): 1-19.