

# Association Between Protein, Oil and Sugar in Vegetable Soybean

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## Introduction

Vegetable soybeans are characterized by their large seed size, pleasing aroma and sweet taste (Masuda, 1991; Tsou and Hong, 1991). There are several taste related compounds in vegetable soybean seed, such as sugars, amino acids, organic acids, inorganic salts, flavonoids and saponins. The younger generation in Japan prefers high sucrose type of vegetable soybeans (Konovsky, 1990). The sucrose content in soybean varies from 3.97 g/100 g to 15.00 g/100 g (Masuda and Harada, 2000; Tsou and Hong, 1991). Using a simple correlation analysis Hymowitz et al. (1972) reported that sucrose is positively correlated with oil content. The objectives of this study were to determine the relationship of oil and protein content with sucrose content of vegetable soybean and to determine if protein or oil content could be used as predictors of sucrose content.

## Materials and Methods

Two hundred F<sub>4</sub> and F<sub>5</sub> lines each from 32 crosses were selected at random. Single F<sub>6</sub> and F<sub>7</sub> plants were selected and the lines derived from them were evaluated in pedigree rows. Varying numbers of lines from each cross were evaluated in spring, summer and autumn seasons from a total of 20 trials during 1996-1999. All the experiments were conducted at the AVRDC experimental farm in Shanhua, Tainan, Taiwan. The trials were conducted using a RCBD with two replications. AVRDC's suggested cultural practices were used in growing the crops (Shanmugasundaram and Yan, 2001). For each replication, a 250 g sample of graded pods was taken at random from instant quick freeze and thawed at room temperature for one hour and then oven dried at 45°C for 2 days. Each sample was ground to obtain dry powder. Protein, oil and sugar contents were measured using a pre-calibrated near infrared reflectance spectroscopy (NIRS). The broad sense heritability was estimated by  $\sigma^2(G)/\sigma^2(A)$  (Johnson et al. 1955).

## Results and Discussion

The pooled ANOVA of vegetable soybean data on sugar content over seasons showed that the genotypic variance and the variance due to seasons were highly significant. In 1996, 1997 and 1999, the percent total sum of squares of genotype for sugar content was fairly high (about

50%) but in other years, the variation was predominantly due to season. The estimates of broad sense heritability for sugar content were 0.68, 0.56, 0.45, 0.86, 0.49, 0.24 and 0.83 for the 7 trials. Since the heritability estimates for sugar content were fairly high, there is good scope for making progress in selection for high sugar content.

In the present study, the correlation between sugar and oil content, sugar and protein content, and between sugar content and protein plus oil content were determined (Table 1). The correlation between sugar content and oil was significant and negative in 15 out of 20 trials. In contrast, Openshaw and Hadley (1981) found significant positive correlation between oil content and percent sugar. As shown by Masuda and Harada (2000), the sucrose levels vary during seed development in soybeans. At the vegetable soybean stage, the sucrose levels are high and the oil content is low, but at later stages, sucrose level decreases and oil content increases. In addition, the correlation between sugar content and protein was largely negative but significant only in 6 out of 20 cases (Table 1). An analysis of the pooled data from all the trials confirmed the correlation between sugar content and oil was  $-0.50$  (0.0001) and that of sugar content and protein was  $-0.15$  (0.0005). In both cases the population was  $N = 514$ . A highly significant negative correlation between sugar content and protein plus oil was also observed [ $-0.52$  (0.0001)  $N = 514$ ]. Akazawa et al., in 1997 reported that vegetable soybeans contain a higher amount of water-soluble nitrogen than grain soybeans. Whether this higher amount of water-soluble nitrogen is also associated with higher sugar content needs further investigation.

Table 1. Phenotypic correlations between protein, oil and sugar content in different seasons and different years in vegetable soybean, AVRDC, Taiwan.

Trial	Year	Season	Protein and sugar	Oil and sugar content
1	1996	SP	-0.33	-0.86 (0.0001)
2		SU	-0.19	-0.63 (0.0001)
3		AU	-0.28	-0.45 (0.002)
4	1997	SP	-0.50 (0.02) <sup>1/</sup>	-0.82 (0.0001)
5		SP	-0.51 (0.02)	-0.47 (0.03)
6		SP	0.24	-0.86 (0.0001)
7		SU	0.008	-0.23
8		SU	0.30	-0.21
9		SU	0.05	-0.68 (0.001)
10		AU	-0.38	-0.69 (0.0008)
11	1998	AU	-0.45 (0.04)	-0.48 (0.04)
12		AU	-0.33	-0.50 (0.02)
13		SP	-0.35	-0.65 (0.001)
14		SP	-0.43 (0.04)	-0.69 (0.004)
15		SU	-0.20	-0.80 (0.0001)
16		SU	0.02	-0.46 (0.02)
17		AU	0.13	-0.30
18	1999	AU	-0.31	0.34
19		SP	-0.74 (0.0001)	-0.66 (0.0005)
20		AU	-0.60 (0.002)	-0.32
Pooled data (N = 514)			-0.15 (0.0005)	-0.50 (0.0001)

<sup>1/</sup>Values in parenthesis refer to significance at probability level.

## Conclusions

Vegetable soybeans have large seed size and sweet taste. Direct selection for sweet taste was rather cumbersome. Therefore, the objective of this study was to understand the relationship between sugar content and oil or protein, and to determine whether oil or protein content can be used as an indirect selection criteria. The results showed that sugar content in vegetable soybean is negatively correlated with oil content and protein + oil content. Therefore, oil content can be used as an indirect selection criterion to select for high sugar content. Since the heritability of sugar content is fairly high indirect selection should be effective. It is to be noted that the sugar content in mature seed is positively correlated with oil content. Results have also shown that higher sugar content lines with large seed size and higher graded pod yield can be obtained.

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### **Acknowledgement**

The authors gratefully acknowledge the generous financial support provided by the Council of Agriculture (COA), Taiwan and continued encouragement by Dr. Shui-Ho Cheng of COA, Taiwan.