Nutritional and Health Benefits of Vegetable Soybean: Beyond Protein and Oil

A. Mohamed
Virginia State University, Department of Life Sciences, P.O. Box 9064, Petersburg, VA 23806, e-mail: amohamed@vsu.edu

M.S.S. Rao
Fort valley State University, Fort Valley, GA 31030, E-mail: raom@mail.fvsu.edu

T. Mebrahtu., Virginia State University, Agricultural Research Station, P.O. Box 9061, Petersburg, VA 23806, e-mail: tmebraht@vsu.edu

Introduction

There is an increasing demand for vegetable soybean as fresh, canned or frozen vegetable or as roasted soynuts. Such specialty soybean varieties with value-added traits are essential for the diversification of soybean for food uses and benefit from lucrative niche markets. During the past decade, significant breakthroughs have been made in genetic alteration of soybean and soybean oil composition (Wilson, 1991). In addition to unsaturated fatty acids, soybean oil contains some other components in small quantities, such as phytosterols, tocopherols and others. that have significant health benefits.

Soybeans are rich source of tocopherols which are known as Vitamin E. Tocopherols are well known for their antioxidant effects and their health benefits are well documented. Most American diets do not provide adequate amounts of Vitamin E and vegetable soybean could improve Vit E status for many Americans.

Phytosterols are plant steroid-like compounds similar to cholesterol in appearance. Among legumes, soybeans contain the highest phytosterol content with exception of peanuts. One cup of soybeans provides about 150 mg of phytosterols whereas a cup of tofu provides about 50-60 mg (Messina 1999). Phytosterols comprise number of compounds structurally related to cholesterol. β-Sitosterol, campesterol and stigmasterol are three major phytosterols in soybeans (Fig. 2). The soy sterols, are not physiologically active, are not highly absorbed and precipitate bile acids thus reducing enterohepatic recycling of colon tumor-promoting biliary components which may result in oxidative damage to crypt cells and micro-nuclei accumulation (Wang and Wixon, 1999). The total phytosterol content of soybeans is 0.3 to 0.6 mg/g as reported in our previous reports (Mohamed and Rangappa, 1992). In the early 1950s, the hypocholesterolemic effect of phytosterols in chicks had been demonstrated and was confirmed by a number of human studies.

Phytic acid (PA) [inositol hexaphosphate] occurs widely in legumes. Current literature suggests that PA occurs primarily as calcium and potassium salts in soybeans. The ability of PA to complex with protein and minerals has been a subject of many investigations. The binding of proteins by PA leads to decreased solubility of protein [DeRham and Jost, 1979]. Calcium interacts with protein and PA to further decrease the solubility of protein. Phytic acid can also complex with essential dietary minerals such as calcium, zinc, iron, and magnesium and make them unavailable for absorption [DeRham and Jost, 1979]. Several studies have indicated that phytate reduces colon cancer.

The main objective of this study was to determine the variability in tocopherols, phytosterols and phytic acid in selected vegetable soybean genotypes.

Materials and Methods

Several vegetable-type soybean genotypes from maturity groups (MGs) IV -VI were selected based on seed size (small < 10 g/100 or large >20 g/100 seeds) and seed availability. These genotypes were planted at Virginia State University and Fort Valley State University Research Farms. Three replications of each genotype were planted in four-row plots in a randomized complete block design. Details of the agronomic practices can be found in our previous reports (Mebrahtu et al., 1997 and Rao et al., 1998). Pods were harvested at R6 stage. Beans were removed from the pods by hand and then freeze dried. Oil was extracted at room temperature as described by Mohamed and Rangappa (1992) and oil samples were saponified, then tocopherols and phytosterols were extracted with ether and dried under N_2. The unsaponfiable matters were dissolved in known volume of hexane and directly analyzed without derivatization using Gas Chromatography (GC). Extraction and determination of phytate were done according to the procedure of Mohamed et al. (1986). The data were analyzed by Statistical Analysis System [SAS, 1994]

Results and Discussion

Twenty vegetable soybean genotypes were analyzed for tocopherol and sterol contents. The three types of tocopherol (δ, γ and α) and sterols (β-sitosterol, campesterol, and stigmasterol) were measured. Wide variations in tocopherol contents were observed among tested vegetable soybean genotypes. The mean δ, γ and α-tocopherol contents were 127.6, 84.1 and 97.5 µg/g dried seed respectively (Table 1). Genotypes with the highest total tocopherol were PI 379-621 (379 µg/g), PI V81-370055 (355 µg/g) and 399-055 (223 µg/g). Comparing the growing seasons, 1996 and 1997, there was a significant increase in γ-tocopherol (75 versus 93 µg/g) and a significant decrease in α-tocopherol (130 versus 65 µg/g). However, no significant difference was found when means of the two years were compared for the δ-tocopherol levels among the genotypes (Table 2).

Measurement of sterol concentrations (Table 1) showed that mean β-sitosterol (234.8µg/g) was the highest in tested vegetable soybean genotypes and campesterol and stigmasterol levels were significantly lower (45.6 and 44.6 µg/g respectively). Genotypes Ware, Pella and PI 417-440 had the highest concentrations of β-sitosterol (520 mg/g), campesterol (60 mg/g) and stigmasterol (58 mg/g), respectively. Comparison by growing seasons showed no significant difference for any of the sterols. These results are in agreement with reported data on mature vegetable and grain-type soybean genotypes (Mohamed and Rangappa, 1992 and Ibrahim et al. 1990). There were significant and positive correlations between (and α-tocopherol and campesterol, and negative with stigmasterol table (3). There was significant and positive correlation between stigmasterol and β-sitosterol.

The mean phytate content was 1.26%. Tanbagura and Haujaku had relatively low phytate content compared to Akiyoshi, PI 200506, Guanun Da Kei Dun, Tomahamare, and Mian Yan. The rest of the genotypes did not differ significantly. The phytate content of the genotypes studied here were considerably lower than those reported for several vegetable soybean genotypes harvested at R6 stage in Virginia (Mebrahtu et al., 1997) and for Amsoy and Vinton/Vinton 81 soybeans (Schaefer and Love, 1992). Significant varietal differences in the accumulation of phytic acid in soybean seed have been reported (Raboy et al., 1984; Mebrahtu et al., 1997).

Given that tocopherols, phytosterols, and phytate have significant health effect through controlling serum cholesterol level and reducing risk of cancer, a higher amount of these compounds in vegetable soybean is desirable.

Table 1. Tocopherol and sterol contents of selected immature vegetable soybean genotypes

Component	Overall Mean :g/g Dried Seeds	LSD(P>0.05)
Campsterols	45.6	12.01
Stigmasterol	44.6	13.76
β-Sitosterol	234.8	208.43
Total	**325**	
α-Tocopherol	97.5	60.53
γ-Tocopherol	84.1	33.54
δ-Tocopherol	127.6	60.71
Total	**309.2**	

Table 2. Year effects on tocopherol and sterol contents of selected immature vegetable soybean genotypes

Component, :g/g Dried Seeds	1996	1997
Campsterols	44	47
Stigmasterol	44	46
β-Sitosterol	223	247
Total	311	340
α-Tocopherol	130	65*
γ-Tocopherol	75	93*
δ-Tocopherol	135	120
Total	309.2	278*

*Significantly different from zero, P=0.05

Table 3. Simple Linear correlation coefficients among chemical parameters of selected immature Soybeans.

Component :g/g Dried Seeds	Stigmasterol	β-Sitosterol	δ-Tocopherol	γ-Tocopherol	α-Tocopherol
Campsterols	-0.123	0.130	0.059	0.210*	0.275*
Stigma sterol	-	0.204*	0.089	-0.320*	-0.264*
β-Sitosterol	-	-	0.045	-0.144	0.017
δ-Tocopherol	-	-	-	0.069	0.133
γ-Tocopherol	-	-	-	-	0.153

*Significantly different from zero, P=0.05

Summary

Immature vegetable-type soybean is nutritious food and its incorporation into American diets could reduce the risk of coronary heart diseases and cancer. There are wide genetic variabilities among the genotypes tested that could be used in breeding program to improve tocopherol, sterol, and phytate contents of immature soybean.

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