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Color, texture, nutrient contents, and sensory values of vegetable soybeans [*Glycine max* (L.) Merrill] as affected by blanching

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Abstract

Vegetable soybeans (VSB) are harvested over a short period of the year as they are in the immature state outside that period. Freezing and storing, after blanching, constitute a possible method to commercialize vegetable soybeans. In this study, blanching conditions of vegetable soybeans [*Glycine max* (L.) Merrill] were determined, based on colour, texture, nutrient content, and sensory value. The sensory values (a seven-point scale) for the overall qualities of VSB blanched at 80 °C for 30 min, 90 °C for 20 min, and 100 °C for 10 min were 4.6, 5.0 and 5.2, respectively. These three conditions gave the highest sensory values at each temperature, and were used for further examination. The levels of greenness degradation at the three blanching conditions were similar. The loss of nutritive components including sugars, vitamins B_1, B_2, and C, were minimal at 100 °C for 10 min. Seed hardness values (g_f), after blanching, were 469, 392, and 284, respectively, whereas that of the control was 576. Conclusively, blanching at a high temperature and short time is recommended.

Keywords: Blanching; Chlorophyll; Greenness; Texture; Vegetable soybean

1. Introduction

Vegetable soybeans (VSB) are generally harvested as they reach approximately 80% of maturity. VSB are popularly consumed after blanching in far east areas, including Korea, Japan, and China. In western markets, frozen or canned VSB have appeared, for example Sweet Beans, SunRich, Inc., Hope, MN, USA (Liu, 1997). VSB offer several benefits over yellow mature soybeans: strong appeal as a vegetable because of the green colour and soft texture (Liu, 1997); less bitter and beany flavour (Rackis, Honig, Sessa, & Moser, 1972); high content of ascorbic acid and β-carotene (Bates & Matthews, 1975; Simonne et al., 2000), and low amounts of antinutritional factors, including trypsin inhibitors and phytates (Liu, 1997).

For all of these benefits, VSB can be harvested and stored for 2 weeks in a year. To be commercially consumed, large quantities of VSB should be harvested, processed, and stored in a short period. Restaurants require precooked or blanched VSB because they want a minimal cooking process, i.e. heating with microwave or hot water. Therefore, this study aimed to set the blanching conditions to produce consumable VSB without further cooking.

Heat-processing is applied to vegetables to decrease deterioration and to increase nutritive value (Lund, 1977). The blanching of legumes, however, degrades and leaches nutritive components, for example, sugars, minerals and vitamins (Cumming, Stark, & Sanford, 1981; Rincon, Ros, & Collins, 1993; Vidal-Valverde & Valverde, 1993). It also changes colour and texture of soybeans (Anzaldua-Morales, Quintero, & Balandran, 1996; Stanley, Bourne, Stone, & Wismer, 1995). In this study, we measured the changes in colour, texture, nutrient content, and sensory value of blanched VSB to determine the optimal blanching conditions.

2. Materials and methods

2.1. Preparation of vegetable soybeans

Seokryang variety of *Glycine max* (L.) Merrill, which is one of the most popular VSB varieties currently

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grown in Korea, was used. The VSB were harvested in 1997 in Kyunggi Province, Korea. They were blanched at 80, 90, and 100 °C and immersed in cold water (4 °C) for 1 min immediately after blanching. The blanched samples were stored at −20 °C for analyses.

2.2. Analytical methods

The contents of moisture, protein (Nitrogen×6.25), carbohydrate, lipid, and ash in soybeans were determined by the AOAC methods (1995). For the analysis of mineral content, an induced coupled plasma–atomic emission spectrometer (JY 138 Ultrace, Jobin, Yvon, Lonjumeau, France) was used by the method of AOAC (1995).

L, *a*, and *b* values were determined by a colorimeter (CR-200, Minolta, Osaka, Japan). Chlorophylls of VSB were extracted by the method of AOAC (1995). The following formulae were used to calculate the chlorophyll concentrations: $C_t = 7.12A_{660} + 16.8A_{642.5}$; $C_a = 9.93A_{660} - 0.777A_{642.5}$; and $C_b = 17.6A_{642.5} - 2.81A_{660}$; where C_t, C_a and C_b are concentrations (mg/l) of total chlorophyll, chlorophyll *a* and chlorophyll *b*, and A_{660} and $A_{642.5}$ are absorbances at 660 and 642.5 nm, respectively.

For the analysis of free sugars, an HPLC (Waters 474, Waters, MA, USA) system was used. The samples was defatted with hexane, and suspended in 80% (v/v) ethanol solution. After centrifugation, the supernatant was concentrated and used for the analysis.

Content of amino acids was analyzed with an amino acid analyzer (SYKAM, Muchen, Germany). Soybean proteins were hydrolyzed by suspending samples in 6 N HCl solution. After drying, samples were dissolved in 0.1 N HCl solution. Amino acids were identified from retention times, using amino acid standards. The separated amino acids from the column were derivatives on a post-column reaction system.

An HPLC system (Waters 474, Waters, MA, USA) with the column, μ-bondapak C_{18}, was used for the analyses of vitamins B_1, B_2, and C (AOAC, 1995). Vitamins B_1 and B_2 were detected by a fluorescence detector and vitamin C was detected by an UV-light detector. For all analyses, samples were processed in triplicate.

2.3. Texture

Hardness was determined by the puncture test of a texture analyzer (TA-HD, Stable Micro Systems, Haslemere, UK). The values were measured when an iron probe (diameter, 1.62 mm) passed through a seed of VSB. The test speed was 1.0 mm/s and the full-scale load was 50 kg. The maximum peak height of the force–deformation curve was recorded to measure the breaking force as g/force (g_f) of the sample. Hardness measurements were determined with six replications.

2.4. Sensory evaluation

Untrained female panellists (graduate students, Food and Nutrition Department, Sookmyung Women's University, Seoul, Korea) aged 25–42 ($n = 60$) performed sensory evaluation. The sample presentation was random, by using a compilation of random numbers. Panellists rinsed their mouths with water provided. They evaluated blanched VSB on disposable white plates labelled with three-digit random numbers in private booths (temperature 22.5±0.5 °C and humidity 52.0±0.5%). Panellists rated acceptability of overall quality on a seven-point scale anchored with 1 = not accept and 7 = fully accept.

2.5. Statistics

Statistical analysis was conducted by analysis of variance using the general linear model (SAS Institute, Inc., 1985). The data were analyzed using ANOVA and Duncan's multiple-range test to detect the differences among the samples. Pearson correlation coefficients were calculated among evaluative factors.

3. Results and discussion

3.1. Composition of VSB

The components and contents of the VSB used in this study are listed in Table 1. Previous studies reported that VSB contained moisture (68–75%), protein (11–13%), carbohydrate (7–13%), lipid (5–7%) and ash (1–2%) (Pennington & Church, 1980; Wang et al., 1979; Watanabe, Ebine, & Ohda, 1991). The VSB used in this study contained lower amounts of moisture and lipid, and higher amounts of protein than the previously reported VSB.

3.2. Changes in colour of VSB by blanching

In a pre-experiment, VSB blanched at a temperature lower than 80 °C were not accepted in consumer panels because of the raw bean taste (data not shown). For the blanching of VSB, the temperatures of 80, 90, and 100 °C were used. The −*a* values of pods and seeds were decreased during blanching. The blanching at a high temperature degraded greenness faster than that at a low temperature (Fig. 1). The degradation of greenness (the −*a* values) of pods during the first 10 min of blanching was less severe than that of seeds. Since the pods were directly exposed to hot water, the greenness of the pods was significantly degraded at an early stage of blanching, compared to the seeds (Fig. 1). Other colorimetric values (*b*, *L*) were not affected as significantly as −*a* values (data not shown).

Table 1
Composition of vegetable soybeans

Components	Content (g/100 g)	Mineral components	Content (mg/100 g)
Moisture	65.50±0.75	Ca	59.7±0.39
Protein	15.3±0.49	Fe	3.95±0.04
Carbohydrate	12.7±0.78	P	0.35±0.04
Lipid	4.49±0.20	Na	1.94±0.01
Ash	2.01±0.08	K	572±3.39
		Mg	103±1.45

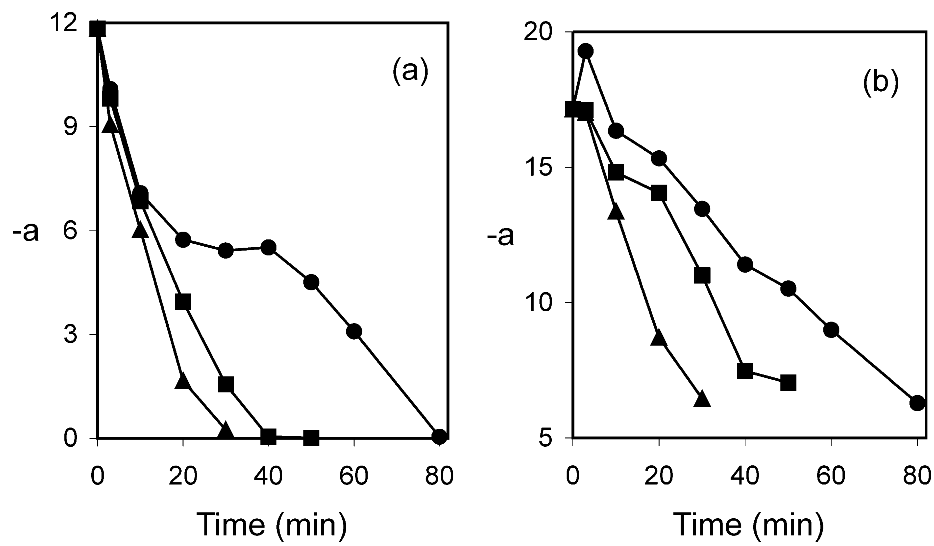

Fig. 1. Changes in greenness ($-a$) of vegetable soybeans during blanching of (a) pods and (b) seeds. Symbols: ●, 80 °C ; ■, 90 °C ; and ▲, 100 °C.

To compare the effect of temperature on the loss of greenness, the reaction rate constants of greenness were measured. The reaction rate constants of greenness correlated with the blanching temperature. An increase in temperature by 10 °C increased the reaction rate constant by a factor of two, and this indicated an Arrhenius relationship (Table 2).

Table 2
Reaction rate constants for thermal degradation of greenness

Temperature (°C)	Rate constant[a] (min^{-1}) of greenness ($-a$)	
	Pod	Seed
80	0.018	0.022
90	0.073	0.043
100	0.110	0.087

[a] Values were calculated from the normalized concentration curves of $\ln(1-f)=-kt$ (Steet & Tong, 1996a, 1996b) where k is the rate constant; t is time; and $f=\frac{(-a_0-[-a])}{(-a_0-[-a_\infty])}$. The $-a$ values at t_0 were $-a_0=11.8$ for pods and 17.15 for seeds. The $-a$ values of completely degraded greenness were $a_\infty=0.26$ for pods and 5.3 for seeds. $R^2>0.91$.

3.3. Sensory evaluations

The sensory values (a seven-point scale) of VSB blanched for 10, 20, and 30 min at 100, 90, and 80 °C, respectively, varied (Table 3). Therefore, the three conditions, 80 °C–30 min, 90 °C–20 min, and 100 °C–10 min, were mainly used in this study. The sensory values at 80 °C–30 min, 90 °C–20 min, and 100 °C–10 min were 4.6, 5.0 and 5.2, respectively. These data indicated that a higher temperature and a shorter time for blanching produced preferable VSB. However, the sensory values were not significantly different at the probability of 95%.

The sensory values at 100 °C significantly decreased as the heating process was prolonged (Table 3), probably due to the loss of greenness (see Fig. 1). In contrast, the sensory values at 80 °C increased as the heating process was prolonged (Table 3). Since VSB was hardly cooked at 80 °C, the prolonged heating might compensate the low cooking temperature. In addition, Savage, Wei, Sutherland, and Schmidt (1995) reported that the acceptable inactivation times of soybeans were 18.2 and 12.0 min for trypsin inhibitor, and 13.7 and 7.4 min for urease at 90 and 100 °C, respectively. Colour and texture were thus further analyzed.

Table 3
Acceptability of vegetable soybeans after blanching

Temperature (°C)	Overall acceptability[a,b]		
	Time (min)		
	10	20	30
80	4.0±1.2c	4.4±0.9c	4.6±1.1c
90	3.8±0.8c	5.0±1.2c	4.4±1.5c
100	5.2±1.9c	3.6±1.1c,d	2.4±0.5d

[a] Acceptability values for 60 panelists ($n=60$).
[b] Mean±S.E. values; not accept=1, fully accept=7; values followed by unlike letters differ at $P<0.05$.

Table 4
Acceptability of vegetable soybeans after blanching

Blanching condition	Colour[ab]		Flavour		Texture	Overall
	Pod	Seed	Sweetness	Body taste		
80 °C–30 min	3.25±1.39	4.88±1.25	4.25±0.71	4.25±0.46	4.63±0.92	3.75±1.39
90 °C–20 min	4.13±1.13	4.63±1.60	4.00±1.07	4.75±1.16	4.75±0.89	4.88±0.99
100 °C–10 min	3.88±1.64	5.00±0.93	3.88±1.25	4.00±1.41	5.13±1.13	5.13±1.46

[a] Acceptability values for 60 panelists ($n=60$).
[b] Mean±S.E. values; not accept=1, fully accept=7.

The second sensory evaluation was performed with the samples prepared at 80 °C–30 min, 90 °C–20 min, and 100 °C–10 min. The sensory values of overall quality (Table 4) were similar to the values obtained in the first sensory evaluation (Table 3).

3.4. Changes in texture of VSB by blanching

The sensory values for the texture were closely correlated with those for the overall quality (Table 4). The texture (hardness) of VSB was measured by a texture analyzer. The higher the blanching temperature, the softer were the seeds of VSB (Table 5). In a 60-member sensory evaluation, there was a negative correlation between the hardness and the texture acceptability. The correlation coefficient was −0.482 ($P<0.05$). Therefore, a soft texture can give a high consumer preference for the blanched VSB. The hardness of VSB is due to starch and pectin (Snyder & Kwon, 1987). By blanching, starch granules are gelatinized and pectic substances become soluble (Snyder & Kwon, 1987). VSB contained large quantities of carbohydrates (12.7%, w/w) (Table 1). The gelatinization of starch granules and the formation of soluble pectic substances, by blanching, might cause the softness of VSB.

3.5. Changes in chlorophyll contents of VSB by blanching

The sensory values for the overall quality were closely correlated with those for the texture but the value for the overall quality at 80 °C–30 min was significantly low, compared with that for the texture (Table 4). At 80 °C–30 min, the sensory value of the pod colour was significantly low and thus, the contents of chlorophyll were measured. The contents of chlorophylls *a* and *b* decreased after blanching (Table 6). This result is coincident with the decreases in greenness of VSB after blanching (Fig. 1). The content of total chlorophyll at 80 °C–30 min was higher than those at 90 °C–20 min and 100 °C–10 min (Table 6). The strong greenness (chlorophyll content) of the pods might give an impression of uncooked VSB and cause the low sensory values.

3.6. Changes in nutrient contents of VSB by blanching

The sugars and amino acids of seeds are important, not only for the nutritional availability but also for the flavour of VSB. Blanching significantly decreased the contents of glucose, fructose, and sucrose (Table 7). The tri- and tetra-saccharides (raffinose and stachyose) were not decreased, differently from mono- and disaccharides (glucose, fructose, and sucrose). The longer the blanch-

Table 5
Seed hardness of vegetable soybeans after blanching

Blanching condition	Force (g_f)
Raw	575.6±41.8
80 °C–30 min	468.9±20.5
90 °C–20 min	391.7±51.5
100 °C–10 min	283.8±41.2

Table 6
Changes in chlorophyll contents by blanching of vegetable soybeans

Blanching condition	Content (mg/gfw)[a]			
	Raw	80 °C–30 min	90 °C–20 min	100 °C–10 min
Pod				
Chlorophyll *a*	1.67	1.37	0.90	1.12
Chlorophyll *b*	1.06	0.95	0.75	0.87
Total chlorophyll	2.72	2.32	1.65	1.99
Seed				
Chlorophyll *a*	1.01	0.76	0.82	0.59
Chlorophyll *b*	0.91	0.80	0.75	0.70
Total chlorophyll	1.92	1.56	1.58	1.30

[a] gfw = grams fresh weight.

Table 7
Effect of blanching on contents of free sugars, amino acids, vitamins in seeds of vegetable soybeans

Blanching condition	Raw	80 °C–30 min	90 °C–20 min	100 °C–10 min
Sugar (mg/gfw[a])				
Glucose	2.05	0.99	0.74	1.56
Fructose	1.73	0.35	0.88	1.31
Sucrose	28.3	0.78	3.10	14.6
Raffinose	2.32	2.18	2.47	2.53
Stachyose	2.60	2.30	2.89	2.86
Amino acid (mg/gfw)				
Aspartate	20.5	16.2	18.6	19.1
Threonine	4.24	4.43	5.88	5.73
Serine	8.46	7.12	7.79	8.40
Glutamate	33.4	24.7	28.2	28.8
Glycine	7.17	5.68	6.58	6.76
Alanine	7.97	5.78	6.55	7.07
Valine	8.27	6.33	7.04	7.79
Isoleucine	6.07	6.30	6.88	6.15
Leucine	13.2	10.5	11.9	12.6
Tyrosine	6.34	5.40	5.87	6.27
Phenylalanine	8.78	7.40	7.79	7.95
Lysine	12.3	9.68	11.1	11.9
Histidine	4.15	3.54	4.12	4.16
Total of 20 amino acids	150	121	134	143
Vitamin (μg/gfw)				
Vitamin B_1	7.96	4.56	7.20	8.54
Vitamin B_2	3.41	1.50	2.41	2.97
Vitamin C	170	58.2	84.7	121

[a] Moisture content of the samples after blanching was 66–69%.

ing, the more was the loss of mono- and disaccharides (Table 7). The molecular size of sugars and the duration of blanching affected the contents of sugars. These data suggested that the loss of the mono- and disaccharides was due to leaching during blanching.

Blanching did not significantly affect the composition of amino acids (Table 7). The content of glutamic acid was highest among the amino acids determined (Table 7), which is similar to a previous report (Tsou & Hong, 1991). The total content of the amino acids in VSB at 80 °C–30 min was 81% of that of the control. This result suggested that 19% of the amino acids in VSB were present as soluble forms and leached during the blanching of VSB at 80 °C–30 min. Above 50 °C, the solubility of proteins becomes less than that of native proteins because of denaturation (Cheftel, Cuq, & Lorient, 1985). Therefore, proteins might become less soluble at 90 and 100 °C than 80 °C and this might also affect the loss of amino acids during blanching.

Tannenbaum, Young, and Archer (1985) reported that water-soluble vitamins could be leached and degraded by blanching. Therefore, the levels of the water-soluble vitamins B_1, B_2, and C, were also examined. Under all blanching conditions, the vitamins decreased, except vitamin B_1 (Table 7). The decreases in the vitamins were least at 100 °C–10 min. The loss of nutrients tested was minimal at 100 °C–10 min. Therefore, blanching for a short period at a high temperature is beneficial for keeping nutritional values.

4. Conclusion

Blanching degraded greenness (the $-a$ values) and chlorophylls *a* and *b*. The degradation levels of greenness and chlorophylls at 80 °C–30 min, 90 °C–20 min, and 100 °C–10 min, were similar. In the sensory evaluation, though not statistically meaningful, the overall quality of blanched vegetable soybeans at 100 °C–10 min was highest. The loss of nutrients, including sugars, amino acids (and proteins), and vitamins was minimal at 100 °C–10 min. At 100 °C–10 min, blanching caused the softest texture and it gave the highest acceptability for the texture in the sensory evaluation. Based on the factors tested, blanching at 100 °C–10 min gave more preferable results than those at 90 °C–20 min and 80 °C–30 min. The blanching process at a high temperature and short time, for VSB, is recommended.

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