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A N I N T E R N A T I O N A L J O U R N A L

Effects of Storage Time and Temperature on the Characteristics of Vegetable-type Soybean Grain Minimally Processed

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ABSTRACT

The objective of this study was to evaluate the effects of storage time and temperature on the characteristics of vegetable-type soybean grain (cultivar BRS 267) minimally processed and to define the best conditions for its storage. The evaluation was performed by measurement of vitamin C levels, weight loss and color parameters (L, a*, and b*). The time of storage of vegetable-type soybean grains minimally processed and storage in Styrofoam trays and wrapped with PVC film, caused a decreased in vitamin C levels and color parameters and increased weight loss. This process was intensified with higher temperature at 25 °C than 5°C. To maintain appropriate levels of vitamin C, weight and color of vegetable-type soybean grains minimally processed and storage in trays wrapped in plastic wrap, recommended storage for 3 days at 5°C.*

Key words: vegetable-type soybean, quality, edamame

INTRODUCTION

Vegetable-type soybeans are harvested at the R6 growth stage, where beans are green and immature but developed. At this stage, the grain size is considered to be large, weight of 100 grains above 250 mg, color is bright green and the hilum may be gray or pale yellow. The pods also have a bright green color, good shape and no surface staining (Masuda 1991; Yokomizo and Vello 2003). The food type soybean is popular in Asia and consumed with or without the pods, but only the beans are edible (Tsay and Sheu 1991).

In Japan, vegetable-type soybeans are called edamame. The pods are boiled in salted water and served as appetizers when the beans are still easily removed from the pod. As a product of vegetable-type contain considerable amounts of protein, vitamins A, C, B1, and B2, minerals such as K, P and Ca and dietary fiber (USDA 2008).

The quality characteristics for the marketing of vegetable-type soybean grains include appearance, flavor, taste, texture and nutritional composition. The flavor of vegetable-type soybean grains is considered milder and sweeter than conventional soybeans. The sweetness of the vegetable-type soybean raw grains is mainly due to higher levels of sucrose and of the amino acids glutamic acid and alanine. After cooking edamame, maltose and fructose also contribute to the sweet and

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distinctive taste (Silva et al. 2009; Silva et al. 2010).

Vegetable-type soybeans are usually marketed in the form of grains or beans *in natura*; their high respiration rate causes a rapid decrease in quality (Liu 2004). The minimal processing of vegetable-type soybean grains may contribute to the maintenance of characteristics similar to fresh product, without the loss of nutritional and sensory qualities. This processing can ensure that the grains are ready for consumption and with enough shelf-life for their distribution, marketing and consumption (Pereira et al. 2003; Moretti 2007).

Minimally processed vegetables are metabolically active and therefore more susceptible to physiological, biochemical and microbiological changes that can cause degradation of color, texture and flavor which give the largest perishable products as compared to the intact product (Moretti 2007). Thus, according Moretti (2007) and Chiba (1991) it is important to establish the appropriate storage time and temperature to maintain the quality of vegetable-type soybean grains.

The quality attributes of vegetable-type soybean grains include appearance, flavor and nutritional value. Soybeans must be minimally processed to avoid the loss of green color, which reflects the decline of the freshness of the beans and the degradation of sugars, amino acids and ascorbic acid. The degradation of ascorbic acid can be used as an indicator of deterioration of color and freshness (Konovsky et al. 1994; Masuda 1991; Damodaran et al. 2010).

The BRS 267 soybean cultivar was developed at Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), National Center for Soybean Research (CNPSo) for commercial cultivation and use as vegetable-type or soyfood. When harvested at maturity stage R6 show grain size, mild flavor, little pubescence and a pod yield that is suitable for the production of food-type soybean. It is also harvested at stage R8 as a raw material for the preparation of tofu and soluble soy extract (Carrão-Panizzi 2006). The vegetable-type soybean is widely investigated in Japan and Taiwan due tradition and high consumption. In Brazil, research about this vegetable is still incipient and needs further investigations, because this vegetable show high nutritional value that may become a new alternative to supply the consumer needs for some nutrients and make a food significant global.

Santana (2009) investigated the effects of time and storage temperature on chemical and physical characteristics of pods and concluded that storage at 7 °C for 6 days maintained the starch content and color.

The research related to evaluating the quality of vegetable-type soybean is still precarious in the literature and being a perishable product is need to know the optimal storage conditions to ensure a product marketed for longer time.

The objective of this study was to evaluate the effects of storage time and temperature on the characteristics of vegetable-type soybean grains, cultivar BRS 267, and to define better storage conditions for these grains.

MATERIALS AND METHODS

Materials

The pods of vegetable-type soybean cultivar BRS 267 were supplied at Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), National Center for Soybean Research (CNPSo), Londrina, PR. After harvesting, the pods were manually harvested from the branches and bleached in boiling water for 3 minutes. After bleaching, the grains were removed manually and immediately processed.

Minimal processing

The vegetable-type soybean grains were selected, sanitized for 30 min in a solution of approximately 100 ppm chlorine, and prepared according to the method outlined in Krolow (2006). The grains were rinsed in running, potable water, dried with paper towels, and packed in portions of 60 g in Styrofoam trays that were then wrapped with PVC film. These were stored for 4 days in one of two temperature-controlled chambers, one cooled to 5°C (refrigeration temperature) and the other set at 25°C (room temperature).

Analytical procedures

Vitamin C levels, expressed in g 100 g^{-1}, were determined by the method of Tillmans, according Instituto Adolfo Lutz (2008), with the modifications described by Benassi and Antunes (1988).

Assessment of the weight loss of samples, expressed as percentage, was performed by daily semi-analytical weighing (Marconi, model AL500C), as described by Chiba (1991).

The color parameters of the vegetable-type grains, namely lightness (L*), red-green component (a*) and yellow-blue component (b*), were determined using a colorimeter (Minolta model CR-400, Japan) with standard illuminant D65 as well as the CIE system.

Experimental design and statistical analysis

The experimental design was a completely randomized block with four replications. All analytical procedures were performed in triplicate. To evaluate the effect of storage temperature on the characteristics of vegetable-type soybean grains minimally processed, the results were subjected to analysis of variance (ANOVA) and means were compared using the Tukey test at the 5% significance level. To determine the effect of storage time on the characteristics of vegetable-type soybean grains minimally processed, were performed regression analysis. Statistical analysis was conducted using STATISTICA version 7.0 (2004).

RESULTS AND DISCUSSION

Vegetable-type soybean grains cultivar BRS 267 processed minimally and stored at temperatures of 5°C or 25°C, showed varied levels of vitamin C (Table 1) from the 1st day to the last day of storage. Vitamin C content decreased by 91.52% and 19.61% by the 4th day of storage at 25°C and 5°C, respectively. At regression parameters β (-6.52 /-1.40), vitamin C content decreased by 4.66-fold at room temperature than at refrigeration temperature. These results confirmed that the vitamin C level decreased in greater proportion when the grains were stored at room temperature. The vitamin C degradation is dependent on temperature, as described by Damodaran et al. (2010). According to analyses of variance, p values indicated that the linear regression was significant at both temperatures, and the coefficient values R^2 (0.88 and 0.89) determined that the variation in vitamin C content showed a good fit to time of storage of vegetable-type soybean grains.

Table 1 - Vitamin C content of vegetable-type soybean grains cultivar BRS 267 minimally processed and stored at 5°C and 25°C for 4 days [1].

Storage days	Storage temperature	
	5°C	25°C
0	$29.94^a \pm 1.02$	$29.94^a \pm 1.02$
1	$28.75^a \pm 0.72$	$15.60^b \pm 0.26$
2	$27.56^a \pm 0.43$	$9.39^b \pm 1.73$
3	$26.49^a \pm 0.73$	$5.13^b \pm 1.14$
4	$24.07^a \pm 0.60$	$2.54^b \pm 0.36$
	Linear regression (parameters) [2]	
β	-1.40	-6.52
p	0.0000	0.0000
R^2	0.88	0.89

[1] Results expressed in g 100 g^{-1} (dry weight); means within a column followed by the same letters, do not differ by Tukey's test, at 5% probability; [2] Significant at 5% by F test.

Vegetable-type soybean grains cultivar BRS 267 minimally processed and stored at either 5°C or 25°C, showed weight loss (Table 2) that varied from the 1st day to the last day of storage. The weight loss was 58.76% and 17.52% by the 4th day of storage at 25°C and 5°C, respectively. The main factor responsible for weight loss is transpiration, which leads to elimination of water and is associated with the respiration process during dry matter intake. The loss of water through the process of respiration does not represent loss of nutritional value, but conditions that promote high water loss can damage the appearance and acceptability of the product (Chitarra and Chitarra 1990). The weight loss of vegetable-type soybean grains at room temperature was 19.95% on the 1st day and 13.14% at refrigeration temperature on the 3rd day. Considering weight loss only, it is recommended that minimally processed soybeans should not be stored at room temperature and then refrigerated for up to three days. Chitarra and Chitarra (1990) found that weight losses of around 3-6% are sufficient to cause a decline in quality, but some products are still marketable after 10% weight loss. One must consider that the vegetable-type soybean grains are perishable and were storage in Styrofoam trays wrapped in plastic wrap. Further studies are recommended to evaluate the permeability of the packaging materials to prevent these losses.

For the regression parameters β (12.91 / 4.66), it was observed 2.77-fold greater weight loss at room temperature than at refrigeration temperature (Table 2). The differences observed were probably due to the processes of transpiration and respiration, which are catalyzed by the storage temperature of grains, as described by Chitarra and Chitarra (1990) and Liu (2004). According to the analysis of variance, p values indicate that at both temperatures the linear regression was significant, and the coefficient values R^2 (0.96 and 0.96) determined that variation of weight loss presented a great setting the storage time of vegetable type soybeans.

Table 2 - Weight loss of vegetable-type soybean grains cultivar BRS 267 minimally processed and stored at 5°C and 25°C for 4 days[1].

Storage days	Storage temperature	
	5°C	25°C
0	0[a]	0[a]
1	2.92[a]	19.95[b]
2	7.53[a]	34.9[b]
3	13.14[a]	47.97[b]
4	17.52[a]	58.76[b]
	Linear regression (parameters)[2]	
β	4.66	12.91
p	0.0000	0.0000
R^2	0.96	0.96

[1]Results expressed in percentage (%); means in the same columns that are followed by the same letters do not differ by Tukey's test at 5% probability; [2]Significant at 5% by F test.

The L* parameter, which measures the luminosity of vegetable-type soybean grains, was different at 5°C and 25°C on the 4th day of storage (Table 3). For the regression parameters β (-2.98 / -0.87), it was observed a 3.43-fold greater decrease in the L* parameter at room temperature than at refrigeration temperature, indicating that browning occurred during storage. According to variance analyses, p values indicated that at both temperatures the linear regression was significant; however, the value of R^2=0.39 at 5°C indicated that these results cannot be explained by the model, and the value of R^2=0.77 at 25°C determined that the variation of the parameter L* showed a regular setting time storage of vegetable-type soybean grains. The low R^2 value obtained was possibly due to the use of a colorimeter that had some limitations with respect to the uniformity of the surface evaluated and also considered the empty spaces between the grains. Therefore, to measure the L*, a*, and b* of surfaces such as soybean grains, it is recommended that these measures are performed using digital images, as described by Oliveira et al. (2003).

The a* and b* parameters of the vegetable-type soybean grains minimally processed, showed differences between storage at 5°C and 25°C on the 1st day of storage (Table 3). The a* parameter (red-green component) showed a positive linear variation, indicating that there was a decrease in green color of the vegetable-type soybean grains during storage. For the regression parameters β (4.09 / 1.24), we observed a 3.3-fold increase in the a* parameter at room temperature compared to refrigeration temperature. According to analyses of variance, p values indicated that at both temperatures the linear regression was significant. The coefficient values R^2 (0.83 and 0.91) determined that the variation of parameter a* correlated with the time of storage. The color parameter b* (yellow-blue component) showed a negative linear variation, indicating that there was a decrease in yellow color of the grains during storage. For the regression parameters β (-3.80 / -1.24), it was observed a decrease in the b* parameter 3.06-fold greater increase at room temperature than at refrigeration temperature. According to analyses of variance, p values indicated that at both temperatures the linear regression was significant. The coefficient values R^2 (0.81 and 0.94) determined that the variation of color parameter b* correlated with storage time.

Table 3 - Color parameters of vegetable-type soybean grains cultivar BRS 267 minimally processed and stored at 5°C and 25°C for 4 days[1].

Storage days	L*		a*		b*	
	5°C	25°C	5°C	25°C	5°C	25°C
0	68.81[a]	67.65[a]	-27.81[a]	-27.81[a]	51.96[a]	51.96[a]
1	66.72[a]	66.37[a]	-26.78[a]	-18.99[b]	51.25[a]	46.05[b]
2	65.82[a]	65.12[a]	-24.91[a]	-15.38[b]	48.86[a]	43.75[b]
3	63.95[a]	61.36[a]	-23.86[a]	-13.02[b]	48.02[a]	40.82[b]
4	65.84[a]	55.26[b]	-23.05[a]	-10.32[b]	47.35[a]	35.56[b]
Linear regression (parameters)[2]						
β	-0.87	-2.98	1.24	4.09	-1.24	-3.80
p	0.0033[(1)]	0.0000	0.0000	0.0000	0.0000	0.0000
R^2	0.39	0.77	0.83	0.91	0.81	0.94

[1]Means followed by the same letters in the same columns do not differ by Tukey's test at 5% probability; [2]Significant at 5% by F test. (average values of four replicates). L* value indicates white (100) or black (0), a* value indicates red (+) or green (-) and b* value indicates yellow (+) or blue (-). Maximum values for a* and b* are between 100 and -100, respectively.

During the storage of soybean grains, it was observed that those kept at 5°C may be consumed until the 3rd day without a noticeable loss of sensory quality. The grains stored at room temperature become unsuitable for consumption within 24 hours because of their unpleasant appearance and odor. An alternative method to increase the shelf-life of vegetable-type soybeans grains would be canning. Santana et al. (2011) observed that to preserve the quality of vegetable-type soybean grains, pods should be stored at 30ºC and consumed within 24 hours or stored in closed plastic bags at 7ºC and consumed within 3 days; these conditions guarantee the maintenance of protein content, sweetness and color.

CONCLUSION

At room temperature, the vegetable-type soybean grains cultivar BRS 267 minimally processed and storage in trays wrapped in plastic wrap cause a greater decrease in vitamin C content, more weight loss and larger changes in color parameters (L*, a*, b*) than at refrigeration temperature (5°C). Therefore, for maintenance of appropriate vitamin C levels, weight and color parameters of vegetable-type soybean grains cultivar BRS 267 minimally processed and storage in Styrofoam trays wrapped with PVC film, it was recommend storage at 5°C for 3 days.

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