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Effects of Variety and Cultivating Region on the Color of Soymilk and Other Soybean Processing Foods in Brazil

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Abstract
Color (L*a*b* values) of 10 Brazilian soybean varieties was determined. The color depended on the varieties, and generally the red color was stronger than Japanese soybeans. A boiled bean paste made from one Brazilian variety (BRS 213) was yellow, and this color seemed to be preferable as a food base. It was shown that soil of the cultivating region affected the color of the beans, but the effect was less than that of soybean varieties. Washing twice during soaking caused no significant change in color. Using acetic acid at a concentration of 0.1% for soaking slightly decreased the red tone of soymilk. However, when the concentration of acetic acid was higher than 0.5%, it caused deterioration in the smell of soymilk and boiled soybean, and the boiled soybean became harder at the same time. The color of soybeans was shown to be dominated by varieties and soil types of the cultivating region, and it was difficult to improve the color by a washing procedure during soaking.

Discipline: Food
Additional key words: L*a*b* system, soil, washing

Introduction

Soybean is an excellent source of proteins and oils, and its inclusion in the diet is therefore of great benefit[2]. Soybean also contains many kinds of functional compounds which can help to keep good health conditions of the population[3,7]. In Brazil, however, soybean is mainly used to produce oil and meal for animal feedstuff, and consumption of soybean as human food is limited at present.

To increase soybean consumption as food, we need to develop cooking methods suitable for preparing tasty and easy-to-eat dishes. To do this, we first have to evaluate the quality and functionality of soybeans and then use these properties as efficiently as possible.

Soybean qualities that must be assessed for food processing include gel strength of tofu, soybean flavor and color. It is important to evaluate those qualities of soybean samples and investigate the effects of the variety, cultivation conditions, storage conditions and processing on the quality of soyfoods.

Color is one of the most important qualities of food materials[4,12], and if the color of soybean is brown or red, it is not proper for preparing soymilk or tofu. Color of Japanese soybean varieties from various districts was reported[5,8–11]. It was shown that the variation coefficient of the color was small in Japanese soybean varieties[8]. It was also reported that the color of soybeans in Brazil had strong red tones and the boiled soybeans were not suitable for food materials because of their color[13]. However, the effect of varieties or cultivation conditions of Brazil-

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ian soybeans on their color is not clear yet.

In this study, several soybean varieties produced in Brazil were used as experimental materials, and samples of one variety were collected in different cultivating regions. The main objective was to make it clear which factors affect the color, as well as controlling the color with simple methods, e.g. washing or pH control of soaking water. Through this investigation, we would possibly find good varieties and more adequate preparatory methods for preferable color materials from soybean.

Materials and methods

1. Materials

Soybean varieties were developed by the breeding program of the National Center for Soybean Research (Embrapa Soja) located in Londorina, Brazil. The varieties provided were BR 36, BRS 212, BRS 213, BRS 214, BRS 215, BRS 216, BRS 230, BRS 231, BRS 232, and BRS 233. Some of the characteristics of each variety are summarized in Table 1. Three samples of BR 36 were collected from two different cultivating regions of Parana State (PR): one from Pirai, PR, and two from Castro, PR, Brazil. All soybean samples were harvested in 2003.

2. Preparation of soymilk and okara (tofu residue)

Soybeans (100 g) were soaked in water for 18 h at room temperature. After soaking, water was added to a total weight of 600 g. The mixture was homogenized with a home use mixer (Arno Inc., Kaleo Magibox) for 2 min, and then soymilk was squeezed out through a nylon cloth. The residue was used as okara.

3. Preparation of boiled soybean paste

Soybeans (100 g) were soaked in water for 18 h at room temperature. Then 600 mL of water was added to the soaked soybeans and the mixture was boiled for 1 h. After boiling, the soybeans were ground with a mortar and a pestle for 10 min, and the color was measured immediately after completion of grinding.

4. Washing conditions

Normal washing procedure was carried out by washing lightly with water and then soaking. For further washing, the soybean grains were washed again and soaking water was changed after 1 h and 2 h of soaking. Acetic acid solution (0.1, 0.5, or 1% v/v) was used as soaking media to change the pH during the soaking process.

5. Color analysis

Color was analyzed with a handy color reader (Minolta CR-13). The color of the sample was expressed by the L*a*b* system.

Results and discussion

1. Effect of soybean varieties

The L*, a*, and b* values of soymilk, okara, and boiled bean paste of 10 soybean varieties are shown in Fig. 1. Each value of L*, a*, and b* is indicated as follows[4]; L* value indicated white or black, a* value indicated red(+) or green(–), and b* value indicated yellow(+) or blue(–). Maximum and minimum values for L* were 100 and 0, respectively. Theoretical maximum and minimum values for a* or b* were about 100 and –100, respectively.

Table 1. Characteristics of soybean varieties in Brazil

Variety	Genealogy	Weight of 100 seeds (g)	Protein content (%)	Oil content (%)	Color of hilum
BR 36	IAS 4(2) × BR78-22043	n/a	41.5	21.8	Bright brown
BRS 230	BR85-18565(5) × (Embrapa 4 × Tracy-M)	17.4	40.6	21.4	Bright brown
BRS 231	Sharkey × (Hartwig × BR92-31814)	15.6	n/a	n/a	Bright brown
BRS 232	BR85-18565(3) × [Embrapa 4(3) × Tracy-M]	18.5	40.9	19.5	Bright brown
BRS 233	Bragg(2) × BR93-32091	15.6	40.6	20.7	Brown
BRS 212	IAS 5*3 × BR89-11983	17.8	38.0	19.9	Bright brown
BRS 213	BR94-23354 × BR94-23321	16.5	39.7	19.0	Yellow
BRS 214	Sharkey × (Hartwig × BR92-31814)	15.3	39.0	20.6	Bright brown
BRS 215	BR92-31879 × Sharkey	15.4	39.5	20.0	Brown
BRS 216	(BR79-15807 × Embrapa 4) × IAC 13	10.4	43.6	17.6	Yellow

All the data was quoted from document of EMBRAPA[1] .
n/a: not available.

There was a general tendency for soymilk to have a higher L* value and lower a* and b* values than okara, and okara showed a higher L* value and lower a* and b* values than boiled bean paste. Color of tofu was not measured in this study, but it is thought that the color of soymilk is the most important factor which decides color of tofu.

Soymilk obtained from BR 36 and BRS 231 showed relatively high L* values, which meant that the color was very white. However, the L* value of boiled bean paste made with BR 36 was low. We assumed that when soymilk contained high amounts of surfactants, such as saponins, the dispersion conditions of soymilk became better and in consequence, the L* value increased.

Boiled bean paste made with BRS 215 and BRS 233 showed the lowest L* values. Those two varieties have dark brown hilum (Table 1), which affected the color of boiled bean paste but did not affect the color of soymilk.

Boiled bean paste from BRS 213 showed yellow color, probably because this variety has a light yellow hilum (Table 1). This color seemed to be preferable as a food base, but further investigation on this preference should be carried out by sensory testing.

The color of cows' milk purchased at a local market in Londrina was L*= 89.5, a*= –2.5 and b*= 9.6. There were considerable differences between the color of cows' milk and soymilk; cows' milk was much more white and less red and yellow.

As an example, the colors of soymilk made with Japanese soybean (enrei) and green soybean were L*= 83.4, a*= –2.6, b*= 11.3, and L*= 76.9, a*= –7.6, b*= 23.6, respectively. Generally, soybean in Brazil had higher L* and a* values than those of in Japan.

2. Effect of cultivating region

The L*, a*, and b* values of BR 36 cultivated in different regions are shown in Fig. 2. The sample from Londrina was a stronger red, which may have been caused by the red soil at the location. The sample cultivated in the area with sandy soil, such as in Pirai, showed a lower a* value. It was shown that the soil of the cultivating region affected the color of the soybean, but this effect was smaller than that of soybean varieties.

Although soybean varieties and cultivation regions have been shown to affect the color of soybean, there are other factors that might affect color such as drying and storage conditions of soybeans. Further investigations will be necessary to clarify this point.

Two of the samples (Nos. 2 & 3 in Fig. 2) were organic soybeans. The effects of organic cultivating conditions on color and other qualities are not clear. Further investigations are also needed on this point as well.

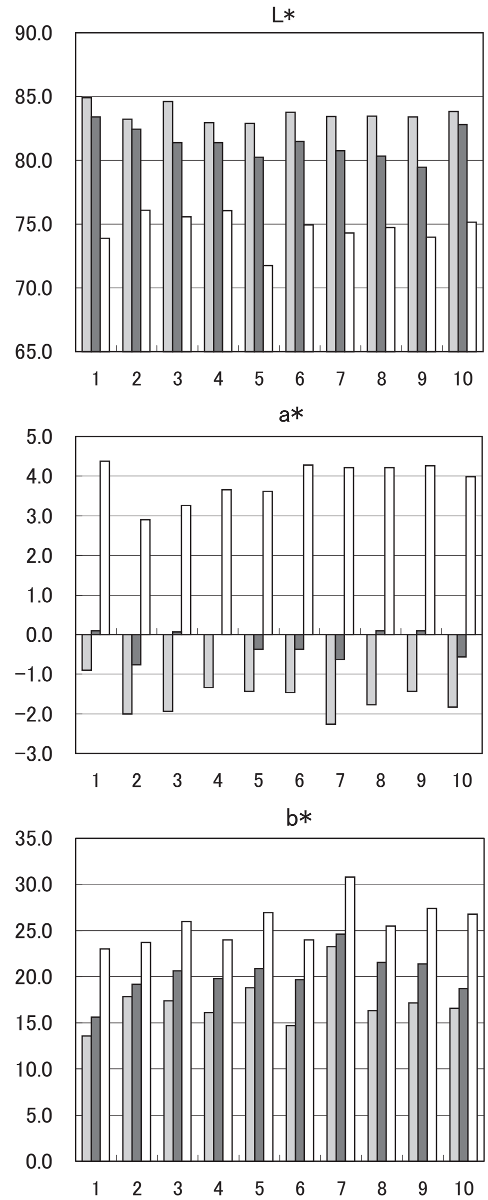

Fig. 1. L*, a*, and b* values of soybean samples of various varieties in Brazil

: soymilk, : okara (residue),
: boiled bean paste.

1: BR 36, 2: BRS 230, 3: BRS 231, 4: BRS 232, 5: BRS 233, 6: BRS212, 7: BRS 213, 8: BRS 214, 9: BRS 215, 10: BRS 216.

3. Effects of washing

The L*, a*, and b* values for variety BR 36 (sample No. 4 in Fig. 2) treated with different washing and soaking conditions are shown in Fig. 3. Table 2 shows 6 treatments of different washing and soaking conditions and their effect on the pH of soymilk.

Washing twice during soaking caused no significant change in the color of soybeans. When acetic acid solu-

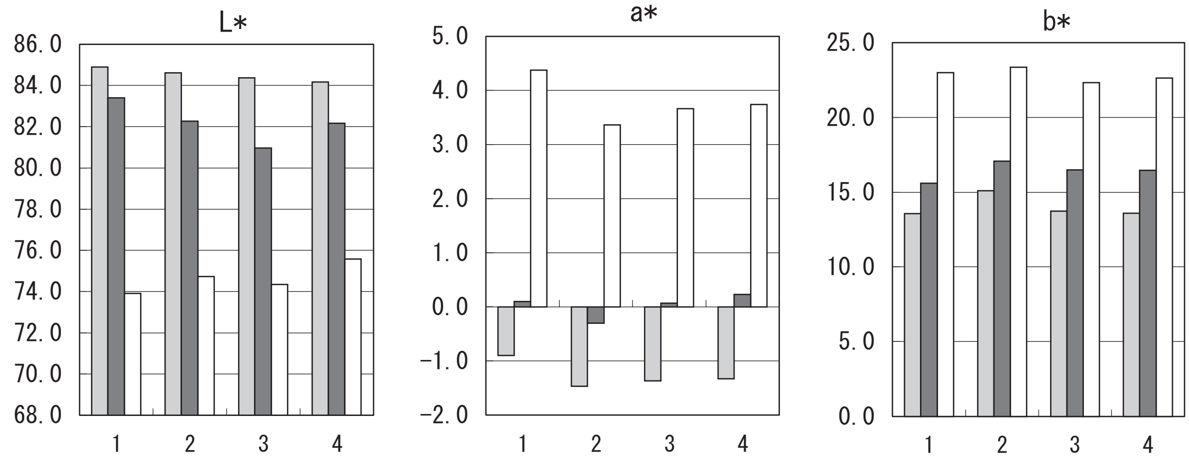

Fig. 2. L*, a*, and b* values of soybean samples (BR36) from various locations

: soymilk, : okara (residue), : boiled bean paste.

1: Londrina (EMBRAPA), PR; 2: Pirai, PR; 3: Castro, PR (farm D), 4: Castro, PR (farm K).

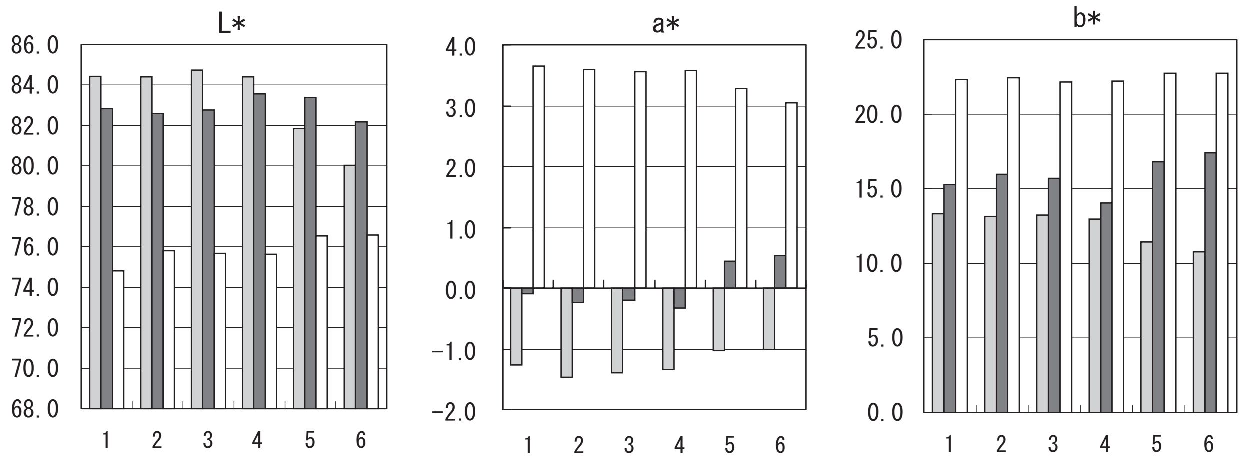

Fig. 3. L*, a*, and b* values of soybean samples (BR36) treated under various washing and soaking conditions

: soymilk, : okara (residue), : boiled bean paste.

1: unwashed, 2: washed once, 3: washed twice, 4: soaked in 0.1% acetic acid, 5: soaked in 0.5% acetic acid, 6: soaked in 1% acetic acid.

Table 2. pH of soaking water and soymilk

Conditions	pH of initial soaking water	pH of final soaking water	pH of soymilk
Unwashed	6.5	6.4	6.5
Washed once	6.5	6.4	6.5
Washed twice	6.5	6.4	6.5
Soaked in 0.1% acetic acid	3.5	3.6	6.3
Soaked in 0.5% acetic acid	3.0	3.2	5.4
Soaked in 1% acetic acid	2.8	2.9	4.9

tion (0.1% v/v) was used as soaking media, it had a slight effect on improving the color of soymilk, and it caused little change in pH and the quality of soymilk. When acetic acid concentration was higher than 0.5%, it caused decreases in the L* and b* values and an increase in the a* value of soymilk. At the same time, it caused a decrease in pH of soymilk and deterioration in the flavor of soymilk and boiled soybeans. Texture of boiled soybeans became hard at the same time. These changes were not desired, so when acetic acid is used for washing or soaking of soybeans, the concentration should be around 0.1%.

In conclusion, color of soybeans was shown to be determined by the variety and soil of the cultivating regions, but it was also assumed that contamination of the soybean seed coat with soil affected the color. Although washing and/or soaking procedures were not very efficient for improving soybean color, they may still be recommended for soybean grains with significant soil contamination.

Main coloring compounds in soybeans are reported to be polyphenols and carotenoids[4,9]. Carotenoid components are different for the various soybean genotypes[6], and carotenoids are thought to be one of the major factors determining color of soybeans. Soybean also contains many types of minerals, which can affect the color. In this study, we indicated the effects of soybean varieties, cultivating region and washing procedures on the color. However, to determine the change in the color, we have to analyze the coloring compounds and try to elucidate the color changes from the point of plant physiology.

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