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Soybean Curd Residue (Biji) as a Dietary Fiber Source in Cake

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Abstract

The content of total dietary fiber in biji dried by hot air was 65.40%, and the percent of insoluble fiber and soluble fiber in total dietary fiber was 63.60% and 1.80%, respectively. In testing the feasibility of biji as a fiber source in cake, cakes were prepared with flour substituted with biji powder at the level of 0%, 5%, 10%, 15% and 20%. The Hunter values showed that the crumb colors of the cakes with 10%, 15% and 20% biji powder were significantly different from the control. The specific volume of the cake with 20% biji powder was significantly lower than the other cakes. Cakes with 5%, 10% and 15% biji powder were less hard than the control after 10 days storage at 20°C. Sensory evaluations showed that their characteristics - crumb color, crumb texture, moistness, softness and overall preference - were significantly influenced by the replacement of flour with 10%, 15% and 20% biji powder. However, there was no difference in softness and overall preference of the cake prepared with 5% replacement compared to the control.

Key words: hot air dried biji, dietary fiber, cake staling

INTRODUCTION

Soybean and its products such as tofu and soy milk have served as important protein sources in oriental countries for many centuries. Biji, a by-product from the manufacture of tofu or soy milk, has been used as animal feed or discarded as a waste since it decomposes easily due to its high moisture content. In an attempt to extend storage life, Chung et al. (1) reduced the moisture content of soybean curd residue from 593% to 378% by pressing it mechanically. The partially dehydrated soybean curd residue was formed into a thin layer of pellets and then hot air was applied to them to reduce the moisture content further to 10%. Problems with hot air drying, such as surface hardening, brown color, and rancidity, tried to be counteracted by solvent treatment. Kim et al. (2,3) reported that washing soymilk residue with acetone or alcohol not only shortened the drying time but also enhanced the protein content, oil and water absorption properties, and color. Several studies were done to use biji as a growth medium for microorganisms or as a food ingredient in order to make use of natural food resources and reduce contamination of the environment. Lee (4) reported that the contents, specifically, glucose, amino acids, and fatty acids were improved by the pre-treatment of hydrolysis enzymes and following natural fermentation. Also Lee et al. (5) identified the microorganisms in fermenting soybean curd residue and reported the changes in contents of free amino acids, nucleotides, reducing sugars, and oligosaccharides during fermentation. Both studies indicated that fermentation of soybean curd residue enhanced the utilization of soybean curd residue as a substitute for soybean in meju preparation. Sohn and Kim (6) reported that the replacement of soybean with dried soy milk residue by 10% did not bring significant unfavorable change in the quality of soybean curd. Recently the possibility of retort biji product was investigated to improve its storage condition and to utilize biji as a product which consumers can access easily in the market (7). Besides this, biji is an excellent fiber source. Soybean has 35% carbohydrate content on a dry weight basis, and most of it consists of insoluble fiber. The insoluble fiber stays in biji when the biji and soy milk are separated during tofu manufacture.

Fiber has been added back to foods such as bread, cakes, or biscuits in an effort to increase daily consumption of dietary fiber after the lack of fiber in the diet was regarded as a contributing factor in a number of diseases (8-10), and their functional properties as well as sensory characteristics as a food ingredient were investigated (11-15). The texture of cake becomes hard and brittle during storage which is largely due to the retrogradation of starch. Fiber has been investigated as an ingredient to retard the retrogradation rate due to its high water holding capacity. Kang et al. (16) reported that the addition of apple powder, pectin, and dietary fiber enhanced the water holding capacity of cake. Also gums which form hydrophilic colloidal solutions increased the viscosity of starch solution and slowed the retrogradation rate (17). This study was done to investigate the feasibility of the use of biji powder cake as a dietary fiber source. Biji cakes were stored at 20°C for 10 days and the change in hardness was measured to investigate the effect of the substitution of flour with biji powder on the staling of cake.

MATERIALS AND METHODS

Materials

Biji was obtained from a tofu factory in Nonsan and spread

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uniformly 1.5 cm height on a stainless steel tray, and then dried for 5 hours under a hot air dryer (JBS-DO200, JBS International Corp.) which was preheated to 80°C. The dried biji was ground in an homogenizer (AM-7, Nihonseiki Kaisha LTD, Japan) and sieved through a 40 mesh sieve. A soft wheat flour (Daehan flour co.) was used to prepare the cakes.

Cake preparation

Guy's formula (18) was adapted (Table 1) and cakes were prepared according to Brockmole and Zabik (12). Flour was substituted with biji powder at levels of 0%, 5%, 10%, 15%, 20% and they were well mixed. Prior to preparation of the cakes, a premix was prepared containing all ingredients except water, shortening, and egg. The preweighed ingredients were mixed to insure uniform distribution, sealed in polyethylene bags, and held at 4°C until used. The premix was warmed to 20°C before being mixed in a Kenwood table mixer (Kenwood Ltd., Hanpshire, UK) with shortening and 60% water at low speed for 30 seconds. Then the bowl was scraped and the batter was mixed at medium speed for 4 minutes. The egg and half of the remaining water were added, and the batter was mixed for 30 seconds at low speed. Again the bowl was scraped, and the batter was mixed for 2 min at medium speed. The remaining water was added and the batter was mixed for 30 seconds at low speed, the bowl was scraped, and the batter was mixed for 2 min at medium speed. The batter was placed into a cake pan, and baked on the middle shelf of the oven preheated to 190°C, for 35 min. Cakes were cooled in the pan for 30 min and for an additional 20 min after being removed from the pan at room temperature.

Proximate composition of biji

The moisture, protein, fat, and ash content of biji powder were determined by the AOAC method (19). The protein content was determined by the macro-Kjeldahl method using 5.7 as a converting factor from nitrogen to protein (20). Both soluble and insoluble dietary fiber were measured according to the enzymatic gravimetric method of Prosky et al. (21), except that the protein correction was based on N×5.7 rather than N×6.25. Total fiber content was calculated by adding the amounts of both soluble and insoluble dietary fiber.

Table 1. Cake formula

Ingredients	Amount	
	g	% (Flour basis)
Cake flour	200.0	100.0
Sugar	200.0	100.0
Shortening	80.0	40.0
Whole egg	110.0	55.0
Nonfat dry milk	20.0	10.0
Salt	5.0	2.5
Baking soda	0.8	0.4
Baking powder	1.2	0.6
Water	120.0	60.0

Color

The crumb color of biji powder and biji cake was measured by colorimeter (Color and color difference meter, TC-3600, Denshoku Technical Center, Tokyo, Japan), and represented as Hunter L, a, b values. The total color difference, expressed as ΔE, between biji cake and control, was calculated using the Hunter values of control (L, a, b) and biji cakes (L′, a′, b′) in the following equation:

$$\Delta E=\sqrt{(L-L')^2+(a-a')^2+(b-b')^2}$$

Volume

Cake volume was measured by the seed replacement method (22). Cake volume was divided by cake weight to obtain the specific volume (cm^3/g) of cake.

Hardness

Hardness was measured with a rheometer (Sun Scientific Co. Ltd., CR-200 D. Japan). The cake was cut into 20×25×20 mm (L×W×H) squares, and the force applied to the cake when a plunger compressed the center portion of cake to 50% of its original thickness was measured as hardness. A plunger headed with a 15 mm circular disc was used. A 1 kg load cell was used and the table and chart speed were set as 60 mm/min.

Sensory evaluation

The 10 sensory panels were chosen from Konyang University students who took a sensory evaluation course. Training sessions were held prior to the sensory evaluation to acquaint the panels with the score card and the characteristics of cake. A 15 cm horizontal line with a short vertical line at 1.5 cm from each end was used as a score card. The word describing a weak taste or color was written below the left end mark, while the word describing a strong taste or color was written below the right end mark. For the overall preference, the word describing strong preference was written below the left end mark, while the word describing weak preference was written down below the right end mark. Panel members were asked to indicate their responses by marking a short vertical line across the horizontal line. The distance between the left end and the vertical line was measured in cm and used as a score for each of the cake characteristics. The visual appearance of the crust color and crumb color ('light brown' to 'dark brown'), crumb texture ('very fine' to 'very coarse'), mouth-feel of crumb including dryness ('very dry' to 'very moist'), softness ('very smooth' to 'very gritty'), and overall preference ('like a lot' to 'dislike a lot') were measured. The data was analyzed for variance and a Tukey's test was used to sort out differences revealed by the analysis of variance. The SPSS (Statistical Product and Service Solution) system was used for the data analysis.

RESULTS AND DISCUSSION

Proximate composition

The general composition of dried biji powder is expressed

on a dry weight basis in Table 2. The contents of protein, fat, and ash were 17.86%, 6.26%, 3.20%, respectively. The total dietary fiber content was 65.4% which consisted of 63.6% insoluble and 1.8% soluble dietary fiber. Lee et al. (23) reported that the average contents of protein, lipid and ash in biji prepared in the laboratory as 20%, 11.5%, 3.6%, and the total dietary fiber content as 57% which contained only 2.5% soluble fiber. Additionally, he reported that the average content of protein, lipid and ash in commercial biji as 17.3%, 9.8%, 3.4%, and the total dietary fiber content as 59.1%, indicating that the contents vary depending on the soybeans and methods used to produce the tofu.

Color of cake

Crumb colors of the cakes with replacement of 0%, 5%, 10%, 15%, 20% of flour weight with biji powder were measured by colorimeter, and the total color difference in crumb color was expressed by ΔE (Table 3). The Hunter values of a and b changed but not as significantly as the L value. Since a higher L value indicates a lighter crumb color, our study showed that the crumb color tended to be darker as the amount of biji powder increased. The increased ΔE value also indicated that the total color difference in biji cake was greater as the amount of biji powder in cake increased.

Specific volume

One of the deleterious effects of fiber on cake is volume decrease, and it is more evident in bread baking than cake. Pomeranz et al. (24) reported that at levels above 7%, fiber decreased loaf volume much more than would be expected by dilution of gluten. However, Shafer and Zabik (11) reported that no significant difference in volume between the control and cakes prepared with 30% of the flour substituted with any type of bran. Nevertheless, the volume was reported as being adversely affected when 50% of the flour was substituted with bran. In this study, no significant decrease in the specific volume of cake was observed by adding biji powder up to 15%, and a substantial decrease was observed at the level of 20% (Table 4).

Hardness

Cake becomes harder during storage mainly due to the moisture migration from inside towards the surface, and starch retrogradation. One way to prevent the staling of cake is to increase the retention time of moisture inside the cake by adding material with high water holding capacity such as fiber. Kang et al. (16) observed the hardness of cakes prepared with 2% apple powder or pectin during 12 days of storage at 21°C, and reported that the hardness of fiber bread was similar to the control for up to 8 days, but stayed much lower than the control after 12 days.

Since biji is an excellent fiber source, the hardness of crumb was measured to investigate the effect of biji on the quality of cake during storage. The hardness of cakes stored at 20°C for 10 days was measured every 2 days (Fig. 1). The hardness of cakes were similar on the first day with the exception of the cake containing 20% biji powder. The hardness of the cake containing the 20% biji powder stayed higher throughout the storage period. The hardness of the 5%, 10%, and 15% biji cakes was lower than the control during storage indicating the effect of biji powder on the hardness rate of cake. The 5% biji cake showed the least hardness at the end of storage followed by 10%, 15%, control, and 20%. Evidently, even though biji powder can be added as the fiber source to retard the rate of staling of cake up to 15%, 5% addition seems like the optimal level which does not affect the cake texture. Chen et al. (25) reported that cake tends to be more brittle as the amount of fiber increases and the quality of cake is interfered with when more than 10% fiber is added;

Table 2. Proximate composition[1)] of dried biji powder (unit: %, dry weight basis)

Material	Protein	Fat	Ash	Total dietary fiber	
				Insoluble	Soluble
Dried biji	17.86 ±0.78	6.26 ±0.06	3.20 ±0.18	63.60 ±1.03	1.80 ±0.02

[1)]Mean ± standard deviation of two replicates

Table 4. Specific volumes[1)] of cakes prepared with the flour substituted with biji powder at various levels

Flour substituted	Specific volume (cm^3/g)
Control	2.27 ± 0.02
5%	2.25 ± 0.02
10%	2.24 ± 0.05
15%	2.20 ± 0.04
20%	2.06 ± 0.05*

[1)]Mean ± standard deviation of three replicates
*Specific volume is significantly different from control at p=0.05.

Table 3. Crumb color values[1)] of cakes with the flour substituted with dried biji powder at various levels

Flour substituted	Hunter color values			
	L	a	b	ΔE
Control	79.1 ± 1.97	-1.07 ± 1.00	20.9 ± 0.57	0.00 ± 0.00
5%	77.1 ± 0.72	-0.87 ± 0.21	21.3 ± 0.25	2.36 ± 1.33
10%	72.8 ± 2.00*	0.93 ± 0.31*	21.7 ± 0.40	6.69 ± 4.06
15%	69.3 ± 1.60*	1.20 ± 0.10*	22.1 ± 0.60*	10.2 ± 1.45
20%	68.8 ± 2.00*	1.20 ± 0.10*	22.9 ± 0.40*	10.8 ± 1.83

[1)]Mean ± standard deviation of three replicates
*L, a, b values which are significantly different from control at p=0.05.

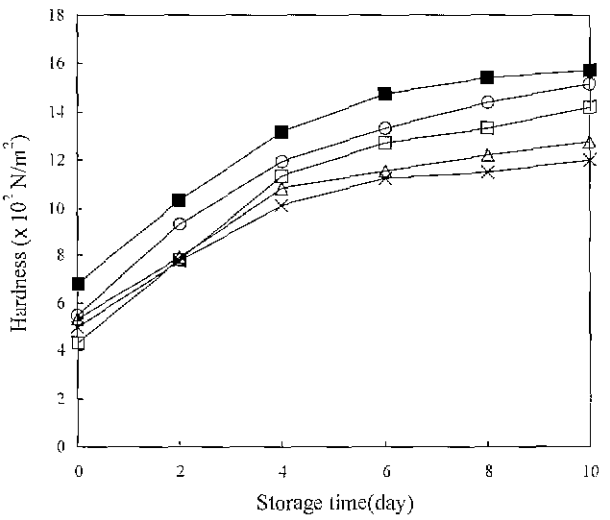

Fig. 1. Changes in hardness of cakes, prepared with the flour substituted with biji powder at various levels during storage at 20°C for 10 days. ○: Control, ×: 5%, △: 10%, □: 15%, ■: 20%

also, the cakes prepared with more than 10% biji powder were observed as more brittle compared to the control in this study.

Sensory evaluation

The results of the sensory evaluation of cakes prepared with the replacement of 0%, 5%, 10%, 15%, 20% of flour with biji powder are shown in Table 5. The crumb color of biji cake was darker than the control, while the crust color of 15% and 20% biji cake showed a lighter brown than the control. The biji cakes were scored as coarse, dry and rough apart from the 5% cake which was accepted as smooth as the control. The overall preference of biji cake was lower than the control with the exception of the 5% biji cake.

CONCLUSION

Total dietary fiber content of the hot air dried biji powder was 65.40% which consisted of 63.60% insoluble and 1.80% soluble fiber. The hardness of 5%, 10%, 15% biji cake on the first day was similar to the control, while it stayed lower than the control through the 10 days storage. Total color difference measured by colorimeter showed that crumb color was affected when more than 10% biji powder was added. In the sensory evaluation, the characteristics of cakes including crumb color, crust color, texture, and mouthfeel were significantly influenced by the substitution of flour with biji powder. Only the cake containing 5% biji powder showed no difference from the control except for crust color. But overall preference indicated there was no significant difference among cakes indicating that the biji powder could be added as a fiber source to cakes.

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Table 5. Sensory properties[1)] of the cakes prepared with the flour substituted with dried biji powder at various levels

Flour substituted	Crust color	Crumb color	Crumb texture	Mouth-feel		Overall preference
				Moistness	Softness	
Control	9.544±1.504	2.944±1.029	3.231±1.034	11.688±0.951	2.981±0.663	3.675±1.169
5%	9.988±1.248	4.406±1.049*	4.963±1.210*	9.419±1.202*	4.350±1.325	4.569±0.665
10%	8.262±1.398	5.200±1.236*	7.613±1.630*	8.875±0.946*	5.719±1.575*	5.869±1.174*
15%	7.056±2.082*	6.444±1.539	7.831±1.741*	6.719±1.544*	7.200±1.805*	7.363±1.300*
20%	7.500±1.949*	7.319±1.831*	9.481±1.800*	5.119±1.492*	8.475±2.200*	8.831±1.248*

[1)]Mean±standard deviation of three replicates
*Sensory value is significantly different from control at p=0.05.

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