【Article】

Utilization of Bean-curd refuse (Okara) in Fiber-bread processing

Toshie TSUDA*, Tomoko HASUMI*, and Tazuko WATANABE*

Many papers have been published on the significance of dietary fiber for human nutrition. The beneficial influence of dietary fiber is its function on colon. An increased cereal fiber intake is desirable and this can best be achieved by means of bread. We studied on the processing of bread, in which some parts of the white wheat flour were replaced by fiber-rich material, Okara.

White wheat flour and Okara were blended and baked, and the effect of this Okara blending on functional properties in bread making was investigated. Loaf volume was measured by repassed displacement. Firmness and cohesiveness were analyzed using a rheolometer. And we made a sensory survey of the Okara-bread on sixteen 20-year old women who were students of Kyoritsu Women's University. The characteristics, like as loaf volume, crumb grain, and texture, of Okara-bread differed substantially from conventional bread. The deleterious effects of Okara could be counteracted by the additon of sodium stearoyl-2-lactylate (SSL), whey, and whole egg together.

Keywords: Okara, Dietary fiber, Bread, Loaf volume, Rheology, Sensory evaluation

INTRODUCTION

Many papers have been published on the significance of dietary fiber for human nutrition. Several diseases, such as appendicitis, cancer of colon and diabetes, are believed to be associated with the consumption of refined carbohydrate-rich foods[1]. Dietary fiber is believed to have a beneficial influence on colonic function[2)3)]. An increased cereal fiber intake is desirable which can best be done by means of bread. The nutritional benefits of incorporating fiber into baked products have been the subjects of numerous investigations[4)5)]. However, there is little information available about the influence of dietary fiber in breadmaking.

We report on the measures that can be used to produce a conventional type of bread in which the white flour is replaced by fiber-rich material, okara. Characteristics of Okara-bread are compared with white bread. Showing that addition of okara has effects on loaf volume and grain quality. Firmness and cohesiveness were analyzed using a rheolometer.

* *Kyouritsu Women's Junior College*

MATERIALS AND METHODS

1. Materials

The flour used is a commercial product, which has a protein content of 12%. Flour was obtained from Nisshin seifun Co. Tokyo Japan. Okara, the residuum left after tofu is produced from soy beans, was used as a source of fiberirl bread. It was frozen, dried and ground on a mill to a fineness so that it could pass through a 80 or 100-mesh screen. It had a fiber contents of 57.64%. The analysis was performed using AOAC method[6]. It had water contents of 4.0%.

2. Measurement methods

An automatic bread baker "Bread Bakery SD-BT 56 P" (Panasonic Co.) was used to bake the bread. This baker is designed to sense the temperature and automatically control the heating system during the entire process of baking. All the steps, from mixing to baking, were automatic. The baking process is shown in Fig. 1. Table 1 provides the formula of basic white bread. Okara (42g) was added as a basic ingredient to white bread dough, mixed, and then baked into bread.

The rheological properties of crumb were mea-

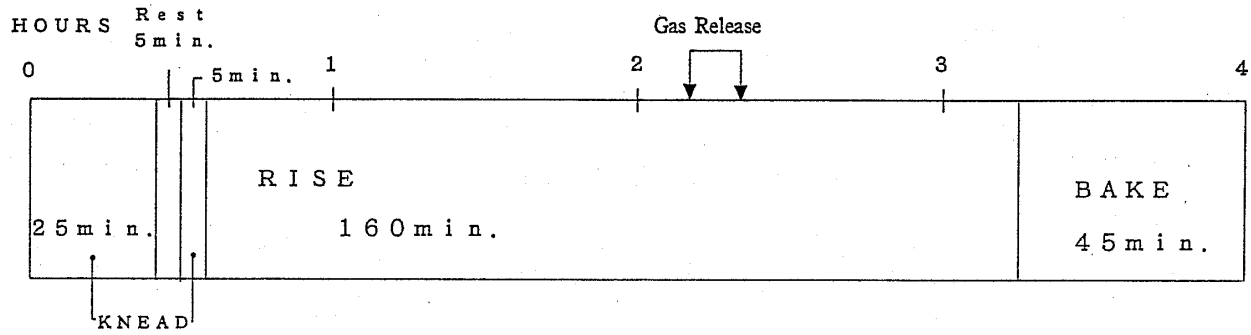


Fig. 1 Baking process with Bread Bakery, above steps from mixing to baking are automatic for bake mode.

Table 1. Basic White Bread and Okara-Bread Formula

	Basic White Wheat Bread		Okara-Bread	
	amount (g)	ratio (%)	amount (g)	ratio (%)
Wheat flour	280	100	226	100
Sugar	17	6.1	24	10.6
Butter	11	3.9	15.5	6.8
Non-fat dry milk	6	2.1	4	1.8
Salt	5	1.8	3.5	1.5
Water	210	75	226	100
Dry yeast	3	1.1	3	1.3
Okara	—	—	30	13.3

sured with the RHEONER RE 3305 (YAMADEN Co.) 1 hr. after baking. The bread was cut to 3×3×3cm by cutter of ultorasonic wave (YAMADEN Co.).

The weight required to depress the plunger (5mm in diameter) 35mm into the bread, after the crust was removed, was taken as the compressibility measurement. Bread color was determined with a Hunterlab color different meter. To standardize, we used Hunterlab Tile Standard No. 95 H. Whiteness 93.19 (Y=93.74, X=91.77, Z=109.97). Bread color differences were calculated as total color differences ;

$$\Delta E=\sqrt{(\Delta L^2+(\Delta a^2)+(\Delta B^2)}$$

Loaf volume was measured by repassed displacement.

Okara-bread was baked using different amounts of water and white wheat flour in the recipe in order to determine how much of these ingredients produced the best product. Other factors investigated were altered the time of mixing and rest and varying the size of Okara grain used.

Gluten formation was measured.

A survey of sensory characteristics was conducted using sixteen women aged 20 of Kyouritsu Women's University. A factor analysis was conducted for the bread using the results of sensory evaluation. A semantic differential (SD) method[7)8)9)], using 8 items for appearance, flavor and texure was employed.

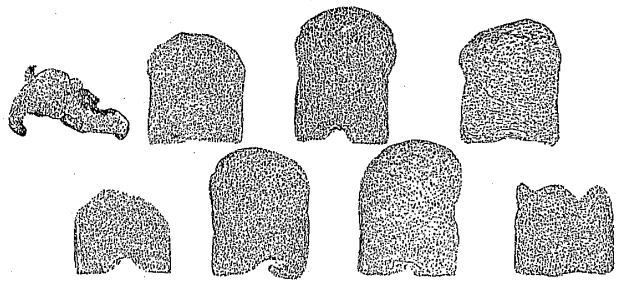
RESULTS AND DISCUSSION

1. Effects using Okara in breadmaking

Fiber content of 9.71g/100g (baked bread) was found in okara bread the standard white bread included 5.34g/100g (baked bread). The analysis was preformed using AOAC method[6)]. Okara was found to be a good food additive to provide dietary fiber.

1) The effect of the amount of water added to the Okara bread recipe

Characteristics of Okara-bread were compared with the basic white wheat flour bread using different amount of water in the Okara-bread recipe. Loaf volumes of the white bread and the Okara-bread using different water levels are given in Fig. 2. Okara was used at the level 15% of white wheat flour. When Okara-bread was baked with the same



Water level (ml)	Loaf volume (ml/100g of Wheat flour)
210	—
235	298
260	505
285	593
310	630
320	591
335	514
360	420

Fig. 2 Loaf volumes of bread baked from a blend of 280g wheat flour and 42g of Okara plus with different water levels

amount of water as in the the control bread (210ml, 75.0% of wheat flour), the Bread Bakery Machine could not make bread. As water was increased from 235 to 310ml, loaf volume incresed, the water levels between 235 to 285ml the bread had a poor appearance and poor crumb grain. With more than 320ml water, the loaf volume decreased. Crumb grains were satisfactory with 310ml added water. Crumb-color changed in Okara-Bread, becoming more orange than white bread. However loaf color changed only slightly, the orange interior colors of the Okara-bread was not necessarily undesirable. Hence, adding 310ml of water was the best recipe for making Okara-bread.

2) **The effect of the amount of flour added to the Okara bread recipe**

The amount of flour was varied and loaf volume determined. The amount of flour was varied ingredients between 280g and 340g. The other ingredient contents were as same as basic white wheat bread formula in Table 1. An increase in loaf volume occurred as in the amount of flour increased from 280g to 340g. The loaf volume per 100g flour was calculated, differences were not found. No differences were found in cohesiveness and firmness when less than 310g of flour was added. As 320g or more flour was used, firmness incresed with, cohesiveness decreasing only slightly. The recipe for the Okara-bread which used 320g flour (13% of wheat flour) had better flavor and texture than other Okara-breads.

The okara-bread formula shown in Table 1. The Bread Bakery requires a specific weight of ingredients in order to work well. When the total weight was adjusted using the optimal ratio of major ingredients, good cohesiveness was maintained. Sugar and butter were increased in the Okara-bread recipe in order to mask the Okara-flavor. Table 2 represents for this recipe.

3) **Adjusting time levels of mixing and rest**

The quality of Okara-bread was investigated by measuring loaf volume as the times for mixing and rest were adjusted. An increase in the time of mixing resulted in decreased loaf volume. (See Fig. 3) The firmness of the crumb as measured by rheolometer increased with according to increasing in the mixing time, and while the cohesiveness decreased. When the time of rest was varied between 5 and 40min., no changes were found for loaf volume and crumb grain. Optimal values for Okara-bread are the same as normally used by the Bread Bakery appliance.

4) **Adjusting the size of the Okara grain**

Freeze-dried Okara was ground on mill to a fineness to pass through a 30, 80, 100, or 150-mesh screen. These Okara samples were used as ingredients in the bread. The Okara ground to pass through a 100-mesh sieve was found to be the optimal size when measured by loaf volume.

2. Improvement of dough condition

Gluten in dough is related to gas retention, as described by Baker and Mize[10]. Okara-bread was rested for amount of gluten. In the standard white bread mixture of flour and water, the amount of gluten made was 13.13g/100 flour(dry). During process of baking, basic white wheat bread had the gluten content was 9.43g/100g flour, and Okara-bread had 8.95g/100g flour. (a decrease of 5.1%)

1) **Effects of emulsifier**

Okara-bread was improved by addition to emulsifier. Dough condition was stabilized by SSL (sodium stearoyl-2-lactylates), which is a surfactant[11]. SSL, a surface active agent, had been found to improve stability of dough condition, mixing property, and gas retention in which the

	Time (min)	Loaf Volume ml/100g of flour	Color		Crumb rheology	
			Interior	Exterior	Firmness N/m^2	Cohesiveness
The time of kneading	25	554	a 15.27 b 15.72 E 60.53	a 14.88 b 15.83 E 60.14	5.2350×10^{4}	8.7519×10^{-1}
	35	529	a 13.46 b 14.86 E 60.38	a 14.44 b 17.86 E 56.36	9.8705×10^{4}	7.5923×10^{-1}
	55	391	a 11.82 b 14.29 E 65.3	a 12.91 b 14.45 E 59.74	17.8855×10^{4}	6.5234×10^{-1}
The time of rest of further fermentation	5	603	a 14.62 b 13.75 E 63.82	a 14.92 b 15.34 E 60.79	5.1435×10^{4}	7.8381×10^{-1}
	15	595	a 12.48 b 16.35 E 66.38	a 14.42 b 19.81 E 61.28	5.6678×10^{4}	8.4340×10^{-1}
	25	590	a 14.74 b 14.41 E 63.0	a 14.96 b 14.97 E 62.03	6.8163×10^{4}	7.7980×10^{-1}
	40	554	a 15.27 b 15.72 E 60.53	a 14.88 b 15.83 E 60.14	5.235×10^{4}	8.7520×10^{-1}

Fig. 3 Characteristics of Bread Baked from Blends of 280g Wheat Flour and 42g of Okara with Levels of Kneading Time and Rest Time

white wheat bread was replaced by an experimental corn and rice, as described by Tsen and Medina[11]. SSL also has been reported to increase loaf volume and firmness of crumb in fiber-enriched bread.[12] In this study, the volume on addition of SSL was assessed by measuring loaf volume and crumb grain of bread in which 15% of the white wheat flour was replaced by okara. SSL at the level of 0.5, 1.0, 1.5, 2.0, 2.5% of flour was added to a Okara-bread formula in Table 1. Fig. 4 shows the impact of various levels of SSL on Okara-bread. As SSL was increased, loaf volume increased linearly. SSL improved for softness of the crumb, as also described by Tenny.[13] Loaf volume increased the most at 1.5 % level of SSL, and the crumb firmness also varied with the addition of SSL as presented in Fig. 4.

2) **Effects of whey and egg**

Reactions triggered by addition include whey rapid development and maturation of the dough system independently of yeast fermentation, as described by Henika and Rodgers[14]. Whey at the level of 7% of flour was added to a Okara-bread formula (Table 1), mixed and baked. A commercial whey was used. Addition of whey did not change the loaf volume. The grain quality was not satisfactory, however, the addition of whey tempered the improving effect of SSL.

Egg is an important material breadmaking due to emulsification by the yolk. Lecithin in egg is the active ingredient. Egg together with SSL and whey were used in baking Okara-bread. Dough made with egg expanded with heat and fixed. Bread quality was improved more when SSL, whey, and egg were used together than when used individually.

3. Sensory evaluation

Sensory attributes and palatability of Okara-bread were compared with standard white wheat bread. The recipe used for Okara-bread is shown in Table 2. The survey using sixteen 20-year old women profiled the sensory attributes by SD method [7)8)9)], using eight items, falling under the categories of texture (smoothness, softness, tenderness), taste (overall taste, smell, flavor) and appearance (color, and crumbs).

Improvers	Loaf volume ml/100g flour	Crumb Rheology Firmness N/m²	Cohesieveness
None	604.0	5.1435×10^{4}	7.8381×10^{-1}
SSL* 0.5%**	632.7	4.3195×10^{4}	7.9528×10^{-1}
SSL 1.0%	663.7	9.8375×10^{4}	6.1204×10^{-1}
SSL 1.5%	691.7	7.0910×10^{4}	6.1970×10^{-1}
SSL 2.0%	530.9	8.0231×10^{4}	6.1911×10^{-1}
SSL 2.5%	663.7	5.7760×10^{4}	1.8332×10^{-1}
Whey 5.0%**	599.5	4.9936×10^{4}	7.8694×10^{-1}
Whey 7.0%	628.3	5.0353×10^{4}	7.9848×10^{-1}
Whey 9.0%	531.0	6.2730×10^{4}	8.0264×10^{-1}
SSL-Whey-Egg	716.8	6.4002×10^{4}	5.6196×10^{-1}

* SSL=Sodium stearoyl-2-laclylate
** ratio of white wheat flour

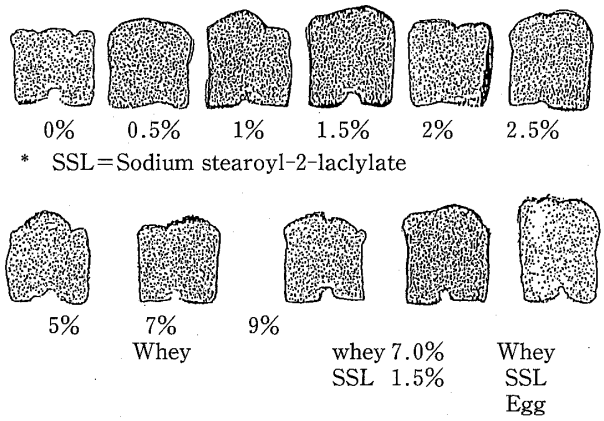


Fig. 4 Characteristics of Okara-bread with or without Improvers

Table 2. Formula Okara-bread with SSL, Whey, and Egg

	amount (g)	ratio (%)
Wheat flour	226	100
Sugar	24	10.6
Butter	15.5	6.8
Non-fat dry milk	4	1.8
Salt	3.5	1.5
Water	226	100
Dry yeast	3	1.3
Okara	30	13.3
SSL	3.4	1.5
Whey	15.8	7
Egg	30	13.3

SSL=Sodium stearoyl-2-lactylate

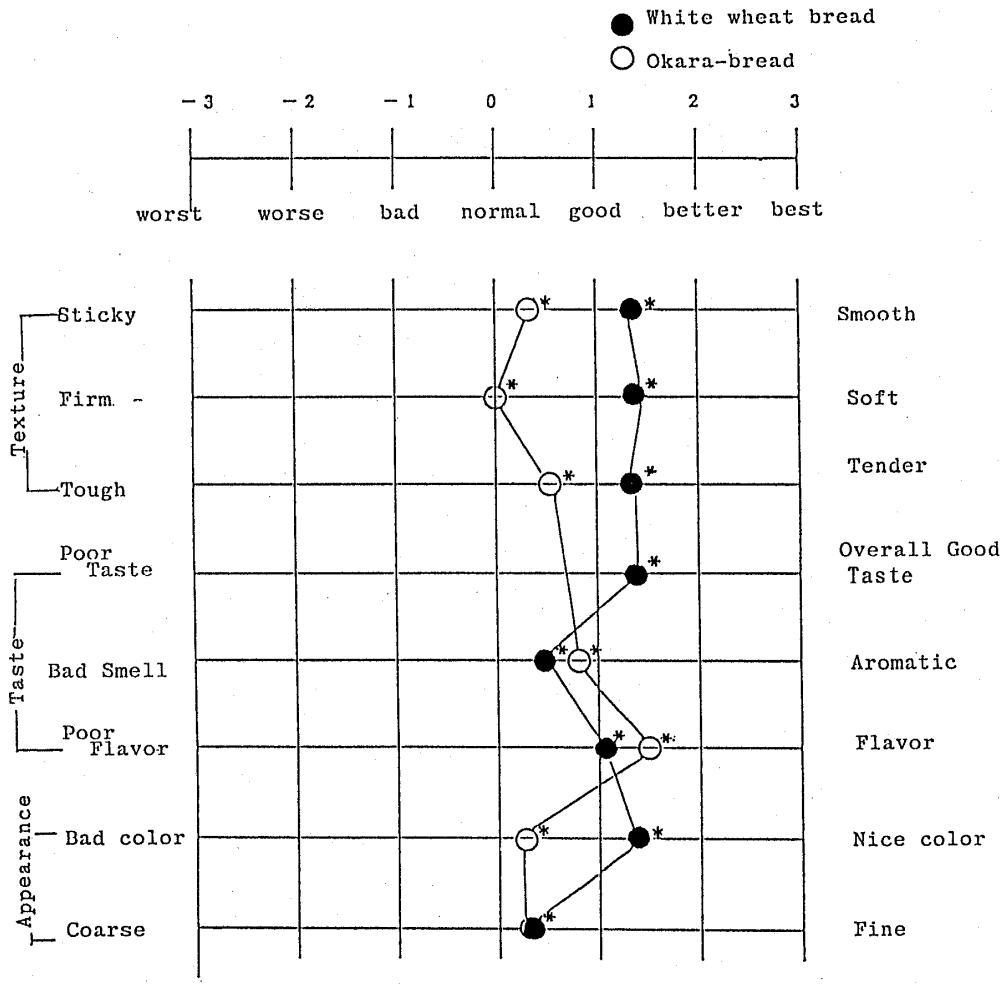
Factor analysis completed on sensory judgments about Okara-Bread indicated test. Judgments about flavor and color loaded on the first factor, and judgments about softness loaded on the second factor. The rate of total variance explained by these factors was 35.4%. For standard whitebread the first factor was tenderness and second was overall taste. The rate of total variance explained by these factors was 28.3%. (Table 3). Fig. 5 shows the average grade of each sensory attributes for the two kinds of bread. Okara-bread got a high score on savory, the difference between Okara-bread and white wheat bread on this factor is significant at the 1% probability level. Okara-bread, in which white wheat flour was replaced by fiber-rich material, Okara was found to be at "normal" or above in all sensory aspects measured.

REFERENCE

1) Trowel, H.; *American J. of Clinical Nutrition.* **29,**

Table 3. The Factor loading of Appraised items on the Preference of Okara-bread

Appraised items		First factor		Second factor	
		White bread	Okara bread	White bread	Okara bread
Texture	Thick	−0.1218	−0.4159	0.4258	0.1982
	Softness	0.1886	−0.0679	−0.3714	0.8191
	Tender	0.9263	0.4650	−0.1625	0.4669
Taste	Tasty	0.7047	0.4661	0.1782	0.3647
	Aromatic	0.5352	0.5254	0.6868	−0.3224
	Savory	0.5369	0.8719	0.1709	0.2887
Appearance	Color	0.5213	0.7483	−0.5893	0.0981
	Fine	−0.1027	−0.4157	0.0518	−0.2295
Variance explained by component		2.2618	2.8358	1.2283	1.3109
% of total variance explained		28.30%	35.40%	15.40%	16.40%



* Significant at $P<0.1$ (n=16)

Fig. 5 Average Grade of desirability obtained by Sensory Evaluation

417-427 (1976)
2) Commings, J. H., Hill, M.J., Jenkins, D. J. A., Pearson, J. R. and Wiggins, H. S.; *American J. of Clinical Nutrition.* **29**, 1468-1473 (1976)
3) Michell, W. D. and Eastwood, M. A.; Fiber in Human Nutrition (G. A. Spiller and R. J. Amen,

editors) New Yok: Plenum Press 185-206 (1976)
4) Pommeranz, Y., Shogren, M. D., Finney, K. K., and Bechel, D. B.; *Cereal Chem.* **54**, 25 (1977)
5) Prentic, N., and D'appolonia, B. L.; *Cereal Chem.* **54**, 1084 (1977)
6) Prosky, L., Asp, N. G., Furda, I., Devries, J. W., Schiveizer, T. F. and Harland, B. F.; *J. Assoc. of. Anal. Chem.*, **68**, 677 (1985)
7) Osgood, C. E.; *Am. Psycho.*, **17**, 10 (1960)
8) H. Toyokawa, E. Marui, H. Onoda, N. Kimura, S. Yoshida, S. Kaneko, M. Yamagami, I. Nagayama, M. Akabane, Y. Nishioka, S. Ishii, and S. Moriguchi,; *J. Japan Society Nutrition Food Science*; **34**, 6, 531 (1981)
9) S. Akusawa, S. Sawayama, and A. Kawabata; *J. Home Economic* (Japan); **42**, 5, 411 (1991)
10) J. C. Baker and M. D. Mize,; *Cereal Chem.*, **18**, 18 (1941)
11) Tsen, C. C., Medina, G.,: Proc. *Int Congress Food Sci. and Technol.*, **5**, 333 (1974)
12) M. D Shogen, Y. Pomeranz, and K. F. Finney; *Cereal Chem.*, **58**, 142 (1981)
13) Tenny, R. J.; *Bakers Digest*, **52**, 8, 24 (1978)
14) R. G. Henika and N. E. Rodgers; *Cereal Chem.* **42**, 397 (1965)

(Received February 17, 1995)

ファイバーブレッドへのおからの利用

津田淑江*, 蓮見知子*, 渡辺多津子*

食物繊維の栄養的価値に対する報告は多くある。食物繊維は，結腸機能に効果的に作用する。穀類からの食物繊維摂取量の増加が望まれ，そのためにはパンからの摂取が最も効果を高めることができる。著者らは，精白小麦粉の一部を食物繊維豊富な材料のオカラに置き換えることによるパンの製造過程への影響の検討を行った。

小麦粉とおからを混合させ，パンを焼き，おからをパンに添加することの影響について検討を行った。焼上がり体積は菜種法で測定した。パンの内相の硬さ，凝集性はレオロメーターを用いて測定した。出来上がったパンについては，共立女子短期大学学生16名を対象に官能検査を行った。その結果，おからを加えることにより，パンの膨化，パン生地の性質，テクスチャーに影響がでた。しかしSSL，ホエイ，全卵を同時に添加することにより，おからパンの品質を改良することができた。

キーワード：おから，食物繊維，パン，膨化体積，物性，官能検査

(平成7年2月17日受理)

* 共立女子短期大学