Dietary Fiber Breads Containing Gobo Residue, Gobo Holocellulose, and Konjac Powder

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ABSTRACT

Bread was made from mixtures (95:5, 90:10, and 85:15) of hard wheat flour and one of three fibrous materials: gobo residue, gobo holocellulose, and konjac powder. In the dough, the gobo residue caused a slight increase in water absorption. The gobo holocellulose increased absorption markedly at the 10 and 15% replacements, and the konjac powder caused the greatest increase in absorption. The bread containing 5% gobo residue or konjac powder did not differ significantly in loaf volume from the control, but reductions in loaf volume were observed at the 10 and 15% levels. The gobo holocellulose at the 5% level severely reduced loaf volume. At all the replacement levels, konjac powder gave the softest bread, gobo holocellulose the hardest, and gobo residue the coarsest. The konjac powder had the least effect on color, and the gobo residue had the greatest. Bread containing 5% gobo residue or konjac powder did not differ significantly from a control bread in loaf volume, crumb texture, and taste.

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In recent years we have reported that dietary fibers such as vegetable residues and konjac mannan may help to prevent toxicity caused by food additives (Nagai et al 1978). On the other hand, researchers in the West have suggested that low intake of fibers in the diet could cause such diseases as diverticulitis, atherosclerosis, and colonic cancer (Burkitt 1975, Painter and Burkitt 1971, Robertson 1972).

Consumption of highly refined cereals, processed foods, and frozen foods has increased considerably in recent years in Japan. Decrease in the intake of fibers in the Japanese diet may therefore cause "fiber deficiency diseases," as is already the case in Western countries.

Much has been reported on the bread-making properties of flours of different milling extractions. Pomeranz et al (1977) studied the effects on bread making of wheat bran, oat hulls, and several samples of commercial cellulose. Prentice and D'Appolonia (1977) studied the functionality and consumer acceptance of brewer's spent grain added to bread in the process of bread making.

Little is known, however, about the effect of fibrous materials from vegetables (gobo residue, gobo holocellulose, and konjac powder) upon bread making. If those vegetable fibers could be added to the food supply in an appealing manner, they could insure the intake of fibers in the Japanese diet.

In this article, we report a comparative study of the effects that gobo residue, gobo holocellulose, and konjac powder have on bread making.

MATERIALS AND METHODS

Flour

Hard wheat flour of Nishin Flour Milling Co. was blended with test dietary fibers. This flour, 14% moisture basis, contained 12% protein (N × 5.7) and 0.37% ash; it had good loaf volume potential.

Gobo Residue

Gobo, the root of edible burdock, is one of the most common foods in Japan and contains a high amount of fibrous residue. It is easily obtained all year. The edible portion of fresh gobo roots was finely mashed by a grinder with some running water. After being leached with running water, the residue was boiled in hot water to remove starches and other water-soluble materials. After extraction with water, the residue was dehydrated with 99% ethanol and air-dried. This treatment is similar to the ordinary method of cooking gobo in the kitchen except for the ethanol treatment and drying. The resultant dry gobo residue was ground on a Wiley mill.

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Gobo Holocellulose

To obtain gobo holocellulose, gobo residue was shaken slowly at 70–80°C for 1 hr in a solution of 1,500 ml of distilled water, 10 ml of sodium chlorite, and 2 ml of glacial acetic acid per 25 g of gobo residue.

This procedure was repeated twice in the solution without adding distilled water. The white residue obtained by the procedure was leached thoroughly in distilled water, dehydrated with 99% ethanol, and then air-dried. The resulting dry gobo holocellulose measured 70% of the net weight of the original gobo residue.

Konjac Powder (Konjac Mannan)

Konjac powder is the purified material of the edible konnyaku, which is a common food in Japan. The tubers of the *amorphophallus* konjac contain a large amount of mannan, which can be gravitationally separated from other components by crushing the dried tuber slices. Ohtsuki (1967) has shown that the tubers of *amorphophallus* contain 20% dry matter that yields about 64% mannan and 10.6% starch. The konjac powder used in this study had highly purified konjac mannan and was obtained from Shimizu Manzo K. K., Hiroshima, Japan.

Determining Particle Sizes

Distribution of particle sizes was determined by subjecting 10-g portions of the milled fibrous materials to sieve analysis. The particle size of each sample is shown in Table I. Particle sizes of gobo residue and gobo holocellulose varied widely, but the size of konjac powder was fairly uniform.

Analytical Procedures

Water absorption was determined subjectively by "feeling" the consistency of a flour-water dough. Absorption is reported as water added to 100 g of flour or composite flour at 14% moisture. The flour with dietary fiber contained a 95:5, 90:10, or 85:15 mixture of wheat flour (14% mb) and dietary fiber, either gobo residue (13% mb), gobo holocellulose (13% mb), or konjac powder (10% mb).

The loaf volume of bread was measured by rapeseed displacement 30 min after removal from the oven. The specific volume of the control loaf was 4.39 cm^3/g. Each loaf of bread was wrapped in a vinyl chloride bag to prevent moisture loss 2 hr after removal from the oven. Three replications of each sample bread

TABLE I
Sieve Analysis of Fibrous Materials, Percent over the Sieve

	Sieve Openings, μm					
Fibrous Material	1,000	500	350	210	149	74 ~
Gobo residue	0.4	4.1	28.0	37.5	15.2	14.8
Gobo holocellulose	···	6.1	29.3	37.4	14.1	13.1
Konjac powder	···	···	···	66.9	23.7	9.4

were made to measure crumb texture values. A texturometer (Zenken Co., Tokyo, GTX-2) was used to determine hardness, cohesiveness, and gumminess of the crumb texture according to the method described by Szczesniak (1963). The measurement factors were as follows: sample height, 15 mm (30 × 30 mm); plunger, Lucite 18 mm (diameter); chart speed, 750 mm/min; bite speed, six times per minute; voltage, 0.5 V; clearance, 2 mm. Each sample was selected from a central part of the bread crumb.

Bread Making

The basic formula for making bread was as follows: flour, 250 g; sugar, 13 g; salt, 5 g; dried yeast, 5 g; shortening, 7.5 g; and water, variable. Part of the flour (0, 5, 10, and 15%) was replaced by the fibrous ingredients. To evaluate the experimental data, bread was baked using the straight dough method. The hard wheat flour (the control) or flour containing dietary fibers was mixed in a kneading mixer (Toshiba Co., Tokyo, KN-300) with other ingredients including the yeast solution, which was dispersed previously in a warmed portion (100 ml) of the formula water. The dough was kneaded for 15–20 min until properly developed. To prepare bread containing konjac powder, 100, 140, and 180 ml of water was taken from the liquid in the dough formula and added to 12.5, 25, and 37.5 g of konjac powder, respectively. After standing for a while, the homogeneous mixture containing the konjac-gel was mixed with other ingredients.

All doughs were fermented one hour at 37°C in a fermentation cabinet; the dough was punched, molded, put in a pan (5 × 6 × 25 cm), proofed for 45 min, and baked at 190°C for 15 min.

Sensory Evaluation

Sixty students enrolled in a food science course were chosen to be the panelists for sensory evaluation. The breads baked with 5% gobo residue, gobo holocellulose, and konjac powder were evaluated on a scale of 1–7 for color, appearance, crumb texture, mouthfeel, and overall preference by the panelists. The value of 3.5 was taken as the lowest level of acceptability for overall preference.

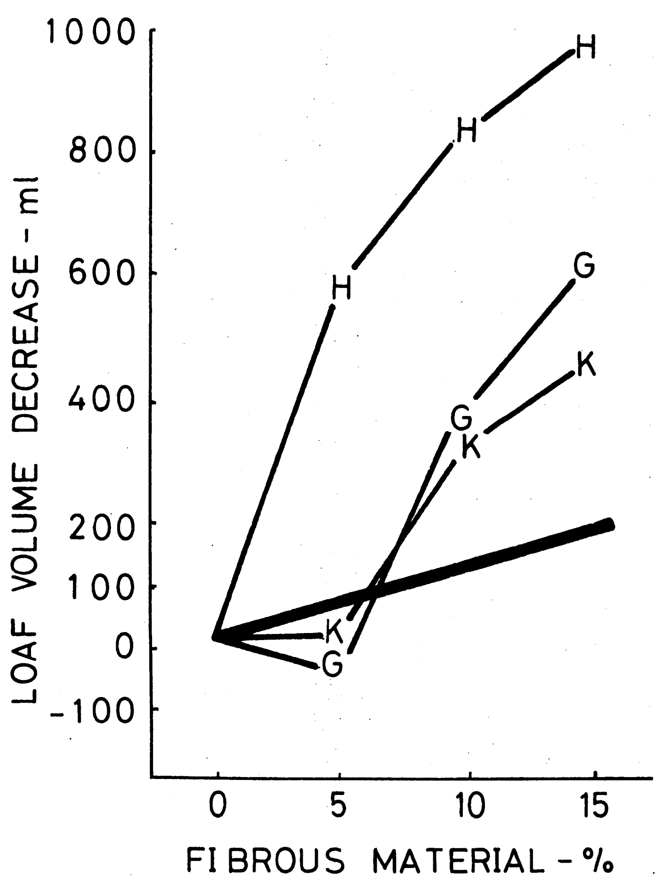

Fig. 1. Loaf volume decrease upon replacement of 5, 10, and 15% of wheat flour with gobo residue (**G**), gobo holocellulose (**H**), or konjac powder (**K**). Values are compared with the theoretical (heavy line) loaf volume decrease (Pomeranz et al 1977).

RESULTS

Water Absorption

The effects of the fibrous raw materials on water absorption are shown in Table II. Water absorption values varied widely. On the average, the fibrous materials increased water absorption above the 60% found for the control. Gobo residue caused some increase in water absorption in comparison to the control. Gobo holocellulose increased water absorption more than gobo residue did at the 10 and 15% replacement levels, whereas konjac powder greatly increased water absorption. Replacing 15% of the flour with konjac powder increased the water absorption from 60% in the control to 126%. This increased water absorption indicates that the konjac powder contains components that dissolve and/or swell highly in water.

Loaf Volume

The actual effects of added fibrous materials on loaf volume were compared with the theoretical effects (Fig. 1). The theoretical line in the figure was calculated using the method described by Pomeranz et al (1977). The gobo residue and konjac powder gave similar loaf-volume reductions. Replacing 5% of the wheat flour with either of these produced a small loaf-volume reduction, as expected theoretically, but at 10 and 15% replacements, reduction in loaf volume was greater than expected. On the other hand, gobo holocellulose at the 5% replacement level reduced loaf volume much more than expected, and at the 10 and 15% replacement levels, loaf expansion was almost nonexistant (Table II).

Crumb Structure of the Bread

Figure 2 shows the internal appearance of the various breads.

TABLE II
Effects on Water Absorption and Loaf Volume of Replacing 5, 10, or 15% of Flour with Fibrous Material

Level of Flour Replacement (%)	Material Added: None (Control)	Gobo Residue	Gobo Holocellulose	Konjac Powder
	Water Absorption, %[a]			
0	60			
5		66	67	92
10		68	90	108
15		76	100	126
	Loaf Volume,[b] cm^3			
0	1,252 ± 30 a			
5		1,299 ± 38 a	654 ± 31 c	1,289 ± 89 a
10		860 ± 36 b	406 ± 25 d	877 ± 119 b
15		614 ± 34 c	253 ± 24 e	771 ± 57 b

[a] Based on 100 g of wheat flour with or without added dietary fiber.
[b] Loaves made from 250 g of wheat flour with or without added dietary fiber. Average of five replications. Mean scores followed by the same letter are not significantly different at the 5% level.

TABLE III
Crumb Texture Values of Bread Containing Fibrous Materials at 5% Replacement

Fibrous Material	Variable[a]: Hardness	Cohesiveness	Gumminess
None (control)	10.9 ± 0.2	0.82 ± 0.01	8.94 ± 0.2
Gobo residue	10.9 ± 0.2	0.78 ± 0.01	8.5 ± 0.2
Gobo holocellulose	11.4 ± 0.1	0.76 ± 0.02	8.6 ± 0.3
Konjac powder	9.2 ± 0.1[b]	0.81 ± 0.03	7.4 ± 0.2[b]

[a] Mean scores ± standard error.
[b] Significantly different from control at 5% level.

The crumb grain of breads made from gobo residue and konjac powder appeared acceptable at the 5 and 10% replacement levels, but the gobo holocellulose grain was acceptable only at the 5% replacement level. The bread made from gobo holocellulose (at 10 and 15% replacements) had thicker cell walls than did the breads containing gobo residue or konjac powder. At 10% replacement, konjac powder generally produced a crumb superior to the crumb of either of the gobo samples. However, all fibrous materials at the 15% replacement level greatly impaired crumb texture, as did the presence of 5% or more of gobo holocellulose. At all replacement levels, konjac powder bread was softest and gobo holocellulose bread was hardest. Gobo residue gave the darkest crumb and konjac powder the whitest.

Physical Properties

The crumb texture data were measured using a texturometer (Table III).

The bread containing konjac powder without crust produced the lowest hardness and gumminess values and turned out to be significantly softer than all the breads, including the control. The softness was probably caused by extra moisture retained by the bread crumb containing konjac powder.

Sensory Evaluation

The sensory evaluation of control bread and bread containing gobo residue or konjac powder at the 5% replacement level is shown in Table IV. Data on gobo holocellulose bread are not given here because the sensory attributes for that bread at the 5% replacement were below the level of acceptability. Crust color and appearance of the breads showed a significant difference between all samples.

The bread containing gobo residue scored low in crust color and appearance; its crust color was significantly darker and less red than that of the control and konjac breads. Scores for the gobo residue bread were only slightly above the level of acceptability (3.5). Bread containing konjac powder scored lower than the control bread for crust color and appearance, but the scores were considered acceptable.

The bread containing gobo residue had a coarser crumb texture and a more abrasive mouthfeel than did the control and konjac breads. Therefore, its overall preference value was lowest. The bread containing konjac powder did not show a significant difference from the control bread for mouthfeel and overall preference. However, this bread showed the highest score for crumb texture and was significantly more tender than the control bread.

At both the 10 and 15% replacement levels, the breads containing fibrous materials were much inferior to the control bread. This was particularly true for bread containing gobo residue. The student panelists reported that 10% replacement of flour with konjac powder was probably the upper limit of replacement. Furthermore, they suggested that 10% replacement of flour with gobo residue seemed undesirable.

DISCUSSION

This study showed that the fibrous additives gobo residue, gobo holocellulose, and konjac powder have different effects on water absorption, loaf volume, crust color, crumb texture, and taste of bread. For bread taste, loaf volume, and crumb texture, and with the exception of crumb and crust color, the gobo residue was rated acceptable only at the 5% flour replacement level.

The gobo holocellulose was prepared to eliminate the color problem found with gobo residue. However, gobo holocellulose is

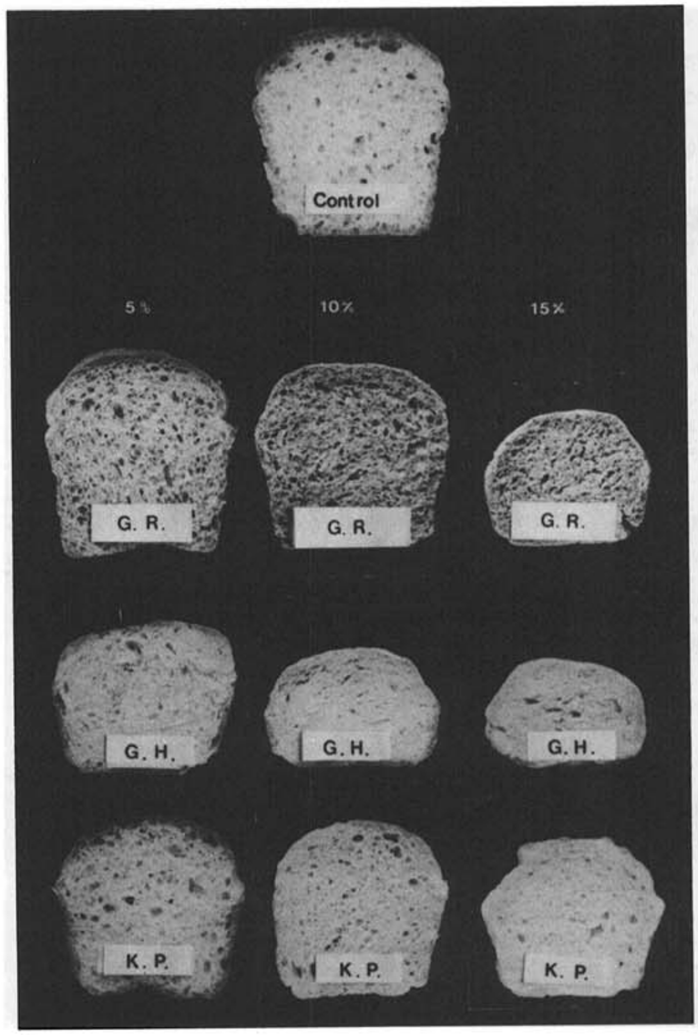

Fig. 2. Crumb structure of the control bread and of bread made with fibrous material: gobo residue (**G. R.**), gobo holocellulose (**G. H.**), and konjac powder (**K. P.**).

TABLE IV
Sensory Evaluation of Control Bread and Fiber Breads at 5% Replacement Level

Fibrous Material	N	Sample Attribute[a] Color[b]	Appearance[c]	Crumb Texture[d]	Mouthfeel[e]	Overall Preference[f]
None (control)	46	5.1 ± 1.1 a[g]	5.0 ± 1.2 a	4.6 ± 1.1 a	4.6 ± 1.1 a	5.1 ± 0.9 a
Gobo residue	47	3.7 ± 1.1 b	3.6 ± 1.2 b	3.9 ± 1.2 b	3.6 ± 1.1 b	3.9 ± 1.1 b
Konjac powder	45	4.4 ± 1.1 c	4.5 ± 1.1 c	5.2 ± 1.3 c	4.8 ± 1.3 a	5.0 ± 1.1 a

[a] Mean score ± standard deviation.
[b] 1 = light brown, 7 = very dark brown.
[c] 1 = very bad, 7 = very good.
[d] 1 = coarse, very hard; 7 = smooth, extremely soft.
[e] 1 = abrasive, 7 = nonabrasive.
[f] 1 = dislike very much, 7 = like very much.
[g] Average of five replications. Scores followed by the same letter are not significantly different at the 5% level.

expensive to produce and gave bread with the lowest scores for loaf volume, softness, crumb texture, and taste. Consequently, gobo holocellulose is considered unsuitable as a source of dietary fiber for bread.

The konjac powder showed the greatest increase in water absorption and gave a softer crumb than did the control bread. The bread containing konjac powder was acceptable in terms of taste, loaf volume, and softness. The student panelists liked the konjac bread as much as they did the control bread; however the uneven appearance of the konjac bread was undesirable. Although the konjac powder seemed to be the most suitable additive for bread making, further studies are needed to investigate its high water-holding capacity in bread crumb.

At the 15% replacement level, all the fibrous materials caused an unexpectedly high decrease in loaf volume; decrease was caused by their gluten-diluting effect, which agrees with the findings of Pomeranz et al (1977).

In conclusion, an acceptable bread was produced from wheat flour of which about 5% was replaced by gobo residue and about 10% by konjac powder. Gobo holocellulose was undesirable for producing an acceptable bread.

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