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Applying a Wet-Type Grinder to Wheat Bran for Developing Breads †

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Abstract: Despite being rich in dietary fibers, wheat bran is scarcely used as a food source because these dietary fibers have adverse effects on texture. In this study, bran was atomized using a wet-type grinder (WG) to improve its physicochemical properties. The WG treatment improved the dispersion ability and viscosity of bran. Bread was then prepared by replacing 5% wheat flour with either WG-treated or WG-untreated bran. The WG-treated bread had a higher specific loaf volume and lower crumb hardness than WG-untreated bran bread. The analysis of the enzymatic digestion of starch indicated a 20% decrease in rapidly digestible starch in WG-treated bran compared to untreated bran bread.

Keywords: bread; dietary fiber; rapidly digestible starch; wet-type grinder; wheat bran

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1. Introduction

Wheat bran is a by-product of the milling process, produced by the separation of the outer layers of the kernel. Wheat bran has many health benefits due to its abundance of dietary fibres (DFs); however, bran is scarcely used as a food source because these DFs result in less smooth texture of final products. Thus, improving the physicochemical properties of bran is important [1].

Wet-type grinders (WGs) are an emerging technology in which the fibres dispersed in water pass between two grinding stone disks. An advantage of this system is that it can prevent clotting, which often occurs in a high-pressure homogenizer [2]. In our previous study, WG treatment was found to be a useful method to enhance the physicochemical properties of okara, such as the dispersion performance and viscosity. Moreover, the addition of WG-treated okara increased the hardness of soybean protein isolate gels [3].

In this study, we examined bran pulverization using WG and the effects of WG-treated bran on the properties of bread and enzymatic starch digestion.

2. Materials and Methods

2.1. Materials

Wheat bran (Nippon Co., Ltd., Tokyo, Japan), wheat flour (Cameria; Nisshin Foods, Inc., Tokyo, Japan), unsalted butter (Snow Brand Hokkaido Butter; Megmilk Snow Brand, Co., Ltd., Tokyo, Japan), and dry yeast (Lesaffre France, Maisons-Alfort, France) were procured for this study.

2.2. Preparation of WG-Treated Bran

Wheat bran (5 wt%) was dispersed in distilled water and was pulverized four times with the ultra-fine friction grinder Supermasscolloider (MKCA6-2; Masuko Sangyo Co., Ltd., Kawaguchi, Japan) with changing gaps (−0.05 mm for the first passage, −0.1 mm for the second passage, and −0.15 mm for the third and fourth passages).

2.3. Viscosity

The viscosity was measured using a TVC-10 viscometer (Toyo Keiki Inc., Tokyo, Japan) with a No. 1 rotor at a shear rate of 0.3 s^{-1} at 25 °C. The data are represented as the average of three measurements for each sample.

2.4. Scanning Electron Microscopy (SEM)

The water in the bran samples was replaced with tert-butyl alcohol (FUJIFILM Wako Pure Chemical Co., Tokyo, Japan) by centrifugation and the samples were then freeze-dried. The freeze-dried powder was examined using a benchtop SEM (JCM-6000Plus NeoScope™, JEOL, Tokyo, Japan).

2.5. Bread Preparation

We prepared three types of bread: WG-treated bran, untreated bran and no-bran (control) bread. The formulation of the bran and control bread is detailed in Table 1. The ingredients were placed into a cell in a kneader (PK660D, Japan Kneader Co., Ltd. Kanagawa, Japan), and kneaded for 20 min. After primary fermentation for 40 min at 40 °C, the dough was kneaded for 20 s, divided equally, placed into a bread mold to allow secondary fermentation (40 °C, 40 min), and then baked for 40 min at 180 °C.

Table 1. Formulation of bran bread.

Ingredient	Bran Bread	No-Bran (Control) Bread
Wheat flour (g)	142.5	150
Bran (g)	7.5	0
Butter (g)	5	5
Sugar (g)	10	10
Salt (g)	3	3
Dried yeast (g)	1.5	1.5
Water (g)	90	110

2.6. Specific Loaf Volume

The loaf volume was determined using the rapeseed displacement method according to the AACC guidelines [4]. The specific loaf volume was calculated as the ratio between the loaf volume (cm^3) and weight (g). In each experiment, nine samples were examined at each point.

2.7. Compression Force Value (CFV)

The compression force (CFV) was determined according to the method described by Sato (2016) [5]. Compression tests were performed using a Texture Analyzer (TA-XT2iHR, Stable Micro Systems, Surrey, UK) attached to a 5 kg loadcell at 25 °C. A cylindrical plunger with a diameter of 20 mm was used and the compression speed was 1 mm/s. The CFV represents the force (N) at 25% deformation. In each experiment, eighteen samples were examined at each point.

2.8. Enzymatic Starch Digestion Assay

Rapidly digestible starch (RDS) and slowly digestible starch (SDS) were measured using a digestible starch and resistant starch assay kit (K-DSTRS; Megazyme Ltd., Wicklow, Ireland) according to the manufacturer's instructions. RDS and SDS were determined by three independent experiments.

2.9. Statistical Analyses

Data are represented as the mean ± standard deviation (SD). The data were analyzed using one-way analysis of variance (ANOVA) followed by Tukey's post-hoc test, using the Origin 2020b software (Origin Lab, Northampton, MA, USA). The data were considered statistically significant at $p < 0.05$.

3. Results and Discussion

3.1. Effect on WG Treatment on Bran Properties

We treated bran dispersed in water four times by the WG with changing gaps. The viscosity of the bran dispersions increased with increasing passage number (Figure 1). The size of bran observed by SEM decreased to 10–30 μm after WG treatment (Figure 2).

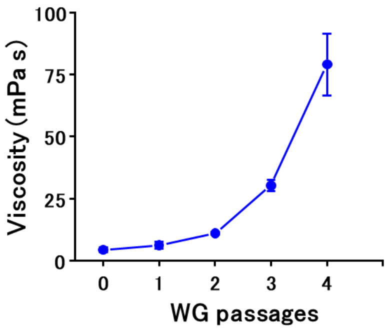
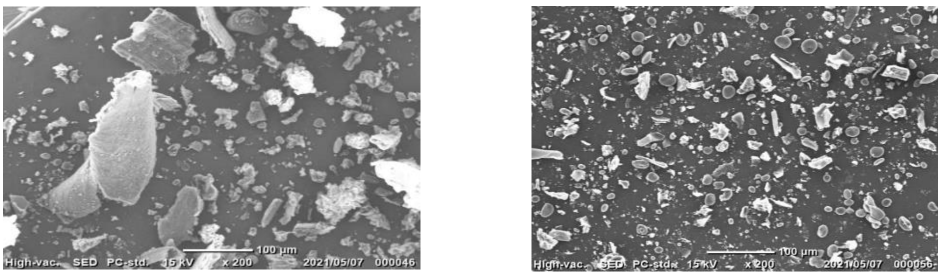


Figure 1. Viscosities of wet-type grinder (WG)-treated bran (5 wt%) after different passages at a shear rate of 0.3 s^{-1} (25 °C).



(**a**) (**b**)

Figure 2. Scanning electron microscopy images of (**a**) untreated bran and (**b**) wet-type grinder-treated bran. The scale is 100 μm.

The WG-treated bran was dispersed homogeneously in water after 6 h (Figure 3). These results show that WG is effective in increasing the viscosity and improving the dispersion performance of bran. This is in line with our previous study conducted on okara [3].

Figure 3. The dispersion of (**a**) untreated bran and (**b**) WG-treated bran in water after 6 h.

3.2. Bread Properties

WG-treated and untreated bran were used to replace 5% wheat flour to prepare bread (Figure 4). The specific loaf volume and crumb CFV (hardness) were determined (Table 2). The specific loaf volume of WG-treated and untreated bran bread was lower than that of the non-bran (control) bread. Between the bran bread, the specific loaf volume was significantly higher in WG-treated bran bread compared with untreated bran bread ($p < 0.05$). In contrast, the CFV of WG-treated and untreated bran bread were higher than that of the control bread. Between bran bread, the CFV was significantly lower in WG-treated bran bread compared with untreated bran bread ($p < 0.05$). These results indicate that WG treatment is useful in reducing the adverse effects of bran on bread making. In a previous study, the effect of microfluidized corn bran on bread properties was studied. The addition of water to bread formulations comprising 18–22% microfludized corn bran achieved similar quality properties to that of the control bread in terms of the specific loaf volume, microstructure, and textural properties [6]. In this study, we could not achieve WG-treated bran bread that had a similar quality to that of the control bread, although we also optimized the water content of dough.

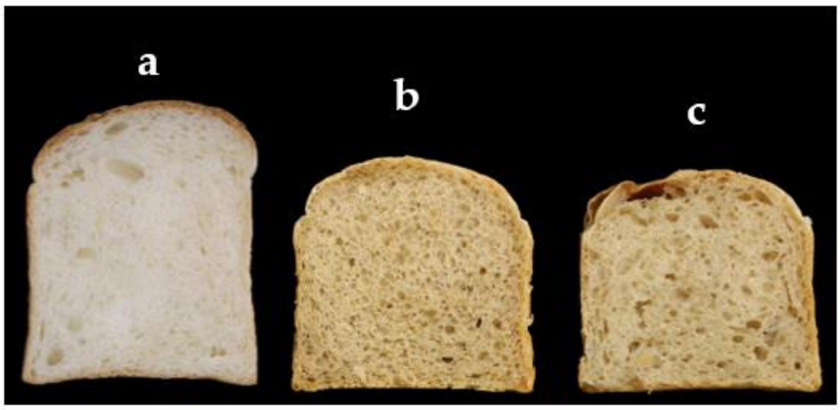


Figure 4. Images of the cross-sections of (**a**) no-bran (control) bread, (**b**) wet-type grinder-treated bran bread, and (**c**) untreated bran bread.

Table 2. Specific loaf volume and crumb compression force value (CFV) for wet-type grinder (WG)-treated bran, untreated bran and no-bran (control) bread.

	Specific Loaf Volume (cm^3/g)	Crumb CFV (N)
Control bread	4.00 ± 0.09 [a]	0.73 ± 0.11 [a]
WG-treated bran bread	3.09 ± 0.17 [b]	1.75 ± 0.40 [b]
Untreated bran bread	2.68 ± 0.09 [c]	1.99 ± 0.28 [c]

Different letter denotes significant differences ($p < 0.05$).

3.3. Enzymatic Starch Digestion Assay

We examined the glucose content released from bread by enzymatic starch digestion at 20 and 120 min to evaluate RDS and SDS, respectively (Table 3) [7]. The RDS content in WG-treated bran bread was lower than that in the control bread and significantly lower (20% lower) than that in untreated bran bread ($p < 0.05$). In contrast, the SDS content in WG-treated and untreated bran bread was lower than that in the control bread. There was no significant difference in SDS content between WG-treated and untreated bran bread. These results demonstrated that WG treatment reduced the RDS content, suggesting an anti-obesity effect of WG-treated bran.

Table 3. Rapidly digestible starch (RDS) and slowly digestible starch (SDS) in wet-type grinder (WG)-treated bran, untreated bran and no-bran (control) bread.

	RDS (g/100 g bread)	SDS (g/100 g bread)
Control bread	22.7 ± 2.9 [a]	10.7 ± 5.0 [a]
WG-treated bran bread	18.3 ± 0.8 [b]	2.5 ± 1.3 [b]
Untreated bran bread	22.8 ± 1.9 [a]	1.6 ± 0.8 [b]

Different letter denotes significant differences ($p < 0.05$).

In summary, wheat bran was pulverized using a WG to improve its physicochemical properties, resulting in enhanced dispersion ability and viscosity. The WG-treated bread had a higher specific loaf volume and lower crumb hardness compared to the untreated bran bread. The RDS content of WG-treated bran bread was 20% lower than that of untreated bran bread. These results indicate that a WG can improve the physicochemical properties of bran and are useful for developing bread with added bran.

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