

Pasting Properties of Crude β -Glucan from Spent Brewer's Yeast on Wheat Flour and Starch

Moon-Sik Yoo and Young-Tack Lee*

Department of Food Science and Biotechnology, Kyungwon University, Seongnam, Gyeonggi 461-701, Korea

Abstract Plentiful amount of spent yeast has been produced as a by-product from breweries. β -Glucan was prepared from the spent brewer's yeast in a crude form with hot water extraction and subsequent enzymatic treatment. The crude β -glucan preparation consisted of mainly glucan (53% of total wt), containing approximately 35% β -glucan content of total weight. The effects of crude β -glucan substitution (1-9%) on pasting properties of wheat flour and starch were determined using a Rapid Visco-Analyzer (RVA). Incorporation of yeast β -glucan into wheat flour and starch significantly decreased peak and final viscosities, but slightly increased setback viscosity. The setback viscosity was considerably higher in starch/ β -glucan suspension than in flour/ β -glucan suspension. It was suggested that preparation of yeast β -glucan into aqueous dispersion might affect pasting behaviors of wheat flour and starch.

Keywords: spent brewer's yeast, β -glucan, Rapid Visco-Analyzer (RVA), pasting property

Introduction

β -Glucan is described as a polymer of glucose that is widespread in many bacteria, fungi, mushrooms, algae, and higher plants such as barley and oat. One important source of β -glucan is the cell wall of yeasts, particularly the baker's and brewer's yeast *Saccharomyces cerevisiae*. Yeast β -glucan is the main component (50-60%) of the cell wall that may account for up to 20-30% of the yeast cell (dry weight), and is localized in the inner layer of the cell wall (1, 2). A common structural feature of yeast β -glucan is a backbone chain of β -(1 \rightarrow 3)-linked glucose units with a low degree of branching points through β -(1 \rightarrow 6)-linkages (3). The β -glucan has been attracting great attention of pharmaceutical and functional food industry because of its bioactive and medicinal properties such as immune stimulating, anti-inflammatory, antimicrobial, antitumoral, wound-healing, hypoglycemic, and cholesterol-lowering effects (4-8).

Recently, a large amount of spent brewer's yeast is produced as a major by-product from breweries. The spent brewer's yeast is generally sold as an inexpensive supplement for animal feeds (9), and therefore may be utilized as an ideal raw material for producing a high value-added product, β -glucan. The yeast β -glucan has demonstrated potential in improving functional properties of food products, i.e., being used as thickening, water-holding, or oil-binding agent, and emulsifying or foaming stabilizer (10). Wheat flour and particularly wheat starch is widely used in food industries. The gelatinization and pasting of starch are considered important properties in the processing of starch-containing foods. Hydrocolloids or gums could be added in starch-containing products to alter pasting characteristics of starch (11-15).

There are a few reports on the effect of barley and oat

β -glucan on wheat flour and starch (16, 17). However, there is no literature available on the effect of spent brewer's yeast β -glucan on pasting properties of wheat flour and starch. Therefore, the objectives of this study were to investigate physicochemical properties of crude β -glucan prepared from spent brewer's yeast and to determine the effects of partial β -glucan substitution on the pasting behavior of wheat flour and starch.

Materials and Methods

Materials Spent brewer's yeast, a by-product from brewery, was kindly provided by Oreintal Brewery Co., Ltd., Icheon, Korea.

Preparation of crude yeast β -glucan Preparation of crude β -glucan from spent brewer's yeast was modified from the procedure described by Freimund *et al.* (18). A suspension of spent yeast (26 g) in water (176 mL) was adjusted to pH 7 with NaOH and the suspension was heated to 100°C with stirring. After 5 hr, the suspension was cooled to 45°C and diluted with water (146 mL). The insoluble residue was separated with a centrifuge, washed twice with water, and diluted with water yielding a total volume of 200 mL. After heating to 45°C and adjustment of the pH to 10.5 with NaOH, a protease Savinase (Novozymes Corp., Bagsvaerd, Denmark) was added at 0, 1.5, and 3 hr under stirring. After 5 hr of reaction, the suspension was neutralized with conc. acetic acid, and the insoluble residue was separated by centrifugation and washed twice with distilled water. The washed sediment was treated with an excess of acetone and filtered. The residue was washed twice with distilled water and dried at 50°C.

Chemical assays Moisture, protein, fat, and ash contents were determined according to AOAC (19) official methods. β -Glucan content was determined using a yeast β -glucan assay kit (Megazyme Pty., Ltd., Wicklow,

*Corresponding author: Tel: 82-31-750-5565; Fax: 82-31-750-5273
E-mail: ytleee@kyungwon.ac.kr
Received January 11, 2006; accepted March 12, 2007

Ireland). The sample (100 mg) and 8 mL of aqueous ethanol (80%, v/v) were added to a tube and stirred vigorously on a vortex mixer. The tube was centrifuged (1,500×g, 10 min), and the supernatant was carefully decanted to remove low molecular weight sugars. Ice cold sulfuric acid (60%, v/v, 2 mL) was added to each tube while stirring on a magnetic stirrer for 1 hr. The tubes were mixed with 12 mL of distilled water and then incubated in a boiling water bath at 100°C for 2 hr. The contents of each tube were adjusted to 100 mL with distilled water and centrifuged (1,500×g, 10 min). Aliquots (0.2 mL) of the centrifuged extracts were transferred to glass test tubes and analyzed with glucose-peroxidase reagent (GOPOD, Megazyme Pty., Ltd.) to measure total glucan content. For measurement of α -glucan, low molecular weight sugars were also removed as previously described. Two mL of 2 M KOH was added to each tube to suspend pellets by stirring for 20 min in an ice water bath. The suspension was added with 8 mL of 1.2 M sodium acetate buffer (pH 3.8), mixed with 0.1 mL of amyloglucosidase (3,300 U/mL), and incubated in a water bath at 40°C for 30 min. The tubes were centrifuged (1,500×g, 10 min), and aliquots (0.1 mL) of supernatants were analyzed with glucose-peroxidase reagent to measure α -glucan content. β -Glucan content was determined by subtracting the α -glucan from the total glucan content.

Monosaccharide composition of crude β -glucan preparation was determined by gas chromatography following acid hydrolysis and derivatization (20). The resulting alditol acetates were separated on a fused silica column SP-2330 (15 m × 0.25 mm i.d., Supelco, Bellefonte, PA, USA) using a Hewlett-Packard gas chromatography system.

Color, water absorption index, and water solubility index Colors of spent brewer's yeast and crude yeast β -glucan were measured with a colorimeter (CR-200; Minolta, Osaka, Japan) which was calibrated using a white standard porcelain plate. Water absorption index (WAI) and water solubility index (WSI) were measured by the method described by Anderson *et al.* (21).

Pasting properties Pasting properties of wheat flour and starch substituted with different levels (0, 1, 3, 6, and 9%) of crude β -glucan from spent brewer's yeast were determined by a Rapid Visco-Analyzer (RVA; Newport Scientific, Sydney, Australia). Wheat flour (3.5 g, 14% m.b.) or wheat starch (3 g, 14% m.b.) substituted with crude yeast β -glucan was transferred into water (25 mL) in an aluminum cup and mixed thoroughly. The mixture was stirred at 960 rpm for 10 sec, and then at 160 rpm for the heating and cooling cycles. The temperature was first maintained at 50°C for 1 min to have a uniform temperature and then raised to 95°C at a rate of 12.16°C/min. The hot paste was held at 95°C for 2.5 min, cooled to 50°C at a rate of 11.84°C/min, and then maintained at 50°C for 2.5 min. The viscosity was expressed as rapid viscosity units (RVU).

Results and Discussion

Physicochemical properties of β -glucan preparation

Table 1. Physicochemical properties of spent brewer's yeast and crude β -glucan preparation¹⁾

	Spent brewer's yeast	Crude β -glucan
Chemical composition ²⁾		
Moisture	3.5	9.3
Protein ³⁾	59.9	34.0
Fat	3.2	0.6
Ash	7.2	4.0
Total glucan	20.30	52.82
α -Glucan	9.97	18.23
β -Glucan	10.33	34.59
Color value		
L	81.55	81.46
a	0.85	1.90
b	1.90	6.82
Water absorption index (g/g)	3.33	6.29
Water solubility index (%)	22.42	3.45

¹⁾Values are means of triplicate analyses.

²⁾%(w/w) on a dry basis.

³⁾Nitrogen × 6.25.

from spent brewer's yeast Table 1 shows the chemical composition of spent brewer's yeast and crude β -glucan preparation. The spent brewer's yeast contained 59.9% protein, 3.2% fat, and 7.2% ash on a dry basis. Total and α -glucan content in the spent brewer's yeast were 20.30 and 9.97%, respectively. The α -glucan content was estimated to be glycogen present in the spent brewer's yeast. β -Glucan content (10.33%) was determined by subtracting the α -glucan from the total glucan content. Yeast cell wall is mainly composed of (1→3),(1→6)- β -D-glucan, chitin, glycogen, lipids, mannoproteins (protein-bound polymannose), and other proteins and they are covalently linked to a great extent (18).

The crude β -glucan prepared from spent brewer's yeast contained 34% protein, 0.6% fat, and 4.0% ash. The crude β -glucan preparation yielded β -glucan content of 34.59%. The total glucan content (α - and β -glucan) considerably increased to 52.82%, partially due to a high level of glycogen, whereas protein content decreased to 34%. The major component of the crude β -glucan preparation appeared to be polysaccharides, consisting of mainly glucan with a little amount of mannan. Glucose was confirmed by gas chromatography after acid hydrolysis of (1→3),(1→6)- β -D-glucan and glycogen (Fig. 1).

Table 2 shows the color, water absorption index (WAI), and water solubility index (WSI) of the spent brewer's yeast and crude β -glucan preparation. The L-value (lightness) of the crude β -glucan was similar to the spent brewer's yeast sample. Compared to the spent brewer's yeast, the crude β -glucan exhibited higher a-value (redness) but lower b-value (yellowness). WAI of the crude β -glucan was higher than that of the spent brewer's yeast, while WSI was lower in the crude β -glucan.

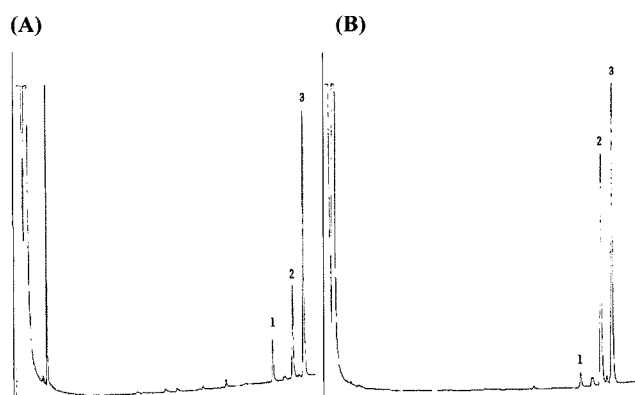


Fig. 1. Separation of alditol acetates from acid hydrolysate of brewer's spent yeast (A) and crude β -glucan (B). 1, mannose; 2, glucose; 3, myoinositol (internal standard).

Pasting properties of crude yeast β -glucan on wheat flour and starch The effects of crude yeast β -glucan levels (1-9%) on RVA pasting properties of wheat flour and starch are shown in Table 2. A slight decrease in the pasting temperatures was observed when the crude yeast β -glucan was included in wheat starch. Incorporation of crude β -glucan into wheat flour decreased peak, breakdown, and final viscosities. The effect on the viscosities was more pronounced when the level of β -glucan increased. Increasing levels of crude β -glucan incorporation into wheat starch also decreased peak and final viscosities, but did not change breakdown viscosities. The peak viscosity could be reduced with the increasing gum concentrations, but some opposite results were also found (11, 14, 22). However, Satrapai and Supphantharika (23) reported that addition of yeast β -glucan increased

peak viscosity, breakdown, setback, and final viscosities of rice starch, which was not in good agreement with this experiment. β -Glucan isolated from yeast cell wall is not water-soluble, but can absorb and retain water, resulting in restricted swelling (24), and thus it was thought that the degree of yeast β -glucan swelling in aqueous dispersion might affect pasting viscosities of starch/yeast β -glucan mixture. It was also reported that drying methods of yeast β -glucan influenced the microstructure of the glucan particles (24) leading to differences in physical properties such as swelling capacity, closely relating to the pasting behavior.

Compared to wheat flour, wheat starch with β -glucan showed higher increase in viscosity upon cooling which might indicate a more gelling tendency of starch paste during cooling. With the addition of β -glucan to wheat flour or starch, setback viscosity increased with increasing β -glucan levels. The setback values were considerably higher in wheat starch/ β -glucan suspensions than in wheat flour/ β -glucan suspensions. However, the setback viscosity of wheat flour with 1% β -glucan was not significantly different from that of the control. It was also indicated that the addition of yeast β -glucan retarded the starch retrogradation during storage time (23). β -Glucan from spent brewer's yeast is non-caloric because it is not digested or absorbed in the human digestive tract (25). Thus, the use of yeast β -glucan to starch-based food up to a level of 1% will be advantageous to maintain desirable textural properties as well as to decrease the calorie content of the products.

References

1. Klis FM, Mol P, Hellingwerf K, Brul S. Dynamics of cell wall structure of *Saccharomyces cerevisiae*. FEMS Microbiol. Rev. 26: 239-256 (2002)

Table 2. Rapid Visco-Analyzer (RVA) pasting properties of wheat flour and starch substituted with different levels of crude β -glucan preparation from spent brewer's yeast¹⁾

Level of β -glucan (%)	Pasting temp. (°C)	Viscosity (RVU) ²⁾					
		Peak	Trough	Breakdown	Final	Setback	
Flour							
0	68.5±0.9 ^b	131.4±1.4 ^a	57.9±0.9 ^a	73.5±0.8 ^a	132.5±1.4 ^a	1.1±1.1 ^b	
1	67.5±0.5 ^b	128.8±1.0 ^a	56.8±1.4 ^a	71.9±0.6 ^a	130.5±1.0 ^a	1.7±0.8 ^b	
3	68.0±0.0 ^b	105.8±2.1 ^b	45.3±0.9 ^b	60.4±1.6 ^b	111.4±1.3 ^b	5.6±1.5 ^a	
6	70.5±1.3 ^a	74.9±1.4 ^c	31.6±1.4 ^c	43.3±1.0 ^c	84.0±1.5 ^c	9.1±1.2 ^a	
9	70.7±0.6 ^a	64.1±2.4 ^d	26.3±1.3 ^d	37.8±1.1 ^d	69.7±1.4 ^d	5.6±1.7 ^a	
Starch							
0	73.0±1.7 ^a	186.7±0.2 ^a	146.5±0.7 ^a	40.2±0.8 ^{ab}	254.7±1.1 ^a	68.0±1.1 ^d	
1	70.8±0.6 ^b	165.6±1.3 ^b	125.8±0.3 ^b	39.8±1.2 ^{ab}	240.8±1.0 ^b	75.2±0.8 ^c	
3	71.8±0.8 ^{ab}	153.3±1.7 ^c	111.9±0.8 ^c	41.4±0.1 ^a	231.2±0.3 ^c	77.9±1.5 ^b	
6	71.2±0.6 ^b	140.6±1.4 ^d	100.1±1.0 ^d	40.4±0.7 ^{ab}	220.8±2.3 ^d	80.2±1.2 ^a	
9	71.7±0.3 ^{ab}	129.2±0.7 ^c	90.3±0.5 ^e	38.9±0.2 ^b	207.8±1.1 ^e	78.6±1.7 ^b	

¹⁾Values are means of three replicates±SD. Means with the same alphabet in each column are not significantly different at $p<0.05$ using Duncan's multiple range test.

²⁾Trough= minimum viscosity after the peak, breakdown = peak viscosity minus trough viscosity, setback = final viscosity minus peak viscosity.

2. Nipke PN, Ovalle R. Cell wall architecture in yeast: new structure and new challenges. *J. Bacteriol.* 180: 3735-3740 (1998)
3. Manners DJ, Mason AJ, Patterson JC. The structure of a β -(1,3)-D-glucan from yeast cell walls. *Biochem. J.* 135: 19-30 (1973)
4. Kogan G. 1 \rightarrow 3, 1 \rightarrow 6- β -D-Glucans of yeasts and fungi and their biological activity. *Stud. Nat. Products Chem.* 23: 107-152 (2002)
5. Machova JS. Mitogenic activity of particulate yeast - (1-3)-D-glucan and its water-soluble derivatives. *Int. J. Biol. Macromol.* 17: 323-326 (1995)
6. Zekovic DB, Kwiatkowski S, Vrvic MM, Jakovljevic A, Moran CA. Natural and modified (1 \rightarrow 3)- β -D-glucans in health promotion and disease alleviation. *Crit. Rev. Biotechnol.* 25: 205-230 (2005)
7. Bohn JA, BeMiller JN. (1 \rightarrow 3)- β -D-Glucans as biological response modifiers: a review of structure-functional activity relationships. *Carbohydr. Polym.* 28: 3-14 (1995)
8. Robbins EA, Seeley RD. Cholesterol lowering effect of dietary yeast and yeast fractions. *J. Food Sci.* 42: 494-498 (1997)
9. Supphantharika M, Khunrae P, Thanardkit P, Verduyn C. Preparation of spent brewer's yeast β -glucans with a potential application as an immunostimulant for black tiger shrimp, *Penaeus monodon*. *Bioresource Technol.* 88: 55-60 (2003)
10. Thammakiti S, Supphantharika M, Phaesuswan T, Verduyn C. Preparation of spent brewer's yeast β -glucans for potential applications in the food industry. *Int. J. Food Sci. Technol.* 39: 21-29 (2004)
11. Rojas JA, Rosell CM, Benedito de Barber C. Pasting properties of different wheat flour-hydrocolloid systems. *Food Hydrocolloid* 13: 27-33 (1999)
12. Shi X, BeMiller JN. Effect of food gums on viscosities of starch suspensions during pasting. *Carbohydr. Polym.* 50: 7-18 (2002)
13. Yoo B, Shon KJ, Chang YS. Effect of guar gum on rheological properties of acorn flour dispersions. *Food Sci. Biotechnol.* 14: 233-237 (2005)
14. Song JY, An YH, Kim JS, Choi J, Kim YC, Shin M. Swelling and pasting properties of non-waxy rice flour/food gum systems. *Food Sci. Biotechnol.* 15: 207-213 (2006)
15. Chun SY, Kim HI, Yoo B. Effect of gum addition on the rheological properties of rice flour dispersions. *Food Sci. Biotechnol.* 15: 589-594 (2006)
16. Biliaderis CG, Arvanitoyannis I, Izydorczyk MS, Prokopowich DJ. Effect of hydrocolloids on gelatinization and structure formation in concentrated waxy maize and wheat starch gels. *Starch* 49: 278-283 (1997)
17. Lee YT, Schwarz PB, D'Appolonia BL. Functional properties of β -glucans from hull-less barley on wheat starch and flour. *Food Sci. Biotechnol.* 7: 51-55 (1998)
18. Freimund S, Sauter M, Kappeli O, Dutler H. A new non-degrading isolation process for 1,3- β -D-glucan of high purity from baker's yeast *Saccharomyces cerevisiae*. *Carbohydr. Polym.* 54: 151-171 (2003)
19. AOAC. Official Methods of Analysis of AOAC Intl. 16th ed. Method 996.01, 979.09. Association of Official Analytical Communities, Arlington, VA, USA (1997)
20. Blakeney AB, Harris PJ, Henry RJ, Stone BA. A simple and rapid preparation of alditol acetates for monosaccharide analysis. *Carbohydr. Res.* 113: 291-299 (1983)
21. Anderson RA. Water absorption and solubility and amylograph characteristics of rolled-cooked small grain products. *Cereal Chem.* 59: 265-271 (1982)
22. Christianson DD, Hodge JE, Osborne D, Detroy RW. Gelatinization of wheat starch as modified by xanthan gum, guar gum, and cellulose gum. *Cereal Chem.* 58: 513-517 (1981)
23. Satrapai S, Supphantharika M. Influence of spent brewer's yeast β -glucan on gelatinization and retrogradation of rice starch. *Carbohydr. Polym.* 67: 500-510 (2007)
24. Hromadkova Z, Ebringerova A, Sasinkova V, Sandula J, Hribalova V, Omelkova J. Influence of drying method on the physical properties and immunomodulatory activity of the particulate (1 \rightarrow 3)- β -D-glucan from *Saccharomyces cerevisiae*. *Carbohydr. Polym.* 51: 9-15 (2003)
25. Worrasinchai S, Supphantharika M, Pinjai S, Jamnong P. β -Glucan prepared from spent brewer's yeast as a fat replacer in mayonnaise. *Food Hydrocolloid* 19: 1-11 (2005)