Glucomannan as an anti-staling agent to improve the texture value of whole wheat bread

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Abstract. Utilization of whole wheat flour to make bread has disadvantages of having a bad texture which is hard, not springy, non-uniform pores and has a higher level of staling. Glucomannan can affect the level of hardness, springiness, cohesiveness and inhibit the staling process by forming a gel that will absorb water which can easily hold the gas during fermentation. This causes bread to have a uniform pore with soft crusts so that the hardness value and staling process decreases. This research aimed to examine the properties of mixture of whole wheat flour with high, medium and low protein flour modified by 0.5%, 1%, and 1.5% of glucomannan gel to improve the physical and organoleptic properties of the bread by using TPA methods. The data obtained were tested statistically with α = 5%. The best proportion was mixture of high protein flour and whole wheat flour with 1.5% glucomannan concentration. This produces bread with 3.54 N of hardness, 4.39 mm of springiness and 0.85 of cohesiveness. Bread with this formula undergoes a staling process longer than wheat bread without added glucomannan. The staling process began on the 3rd day and has increased by 21.87% from day 1 with a hardness value 26.65 N. On visual observation, bread crusts occurred on the 5th day. Therefore, the addition of glucomannan is able to improve the texture and can inhibit the process of staling on bread.

1. Introduction

Whole wheat bread was rich in essential nutrients such as vitamins, minerals, polyunsaturated fatty acids and dietary fibre as well as numerous biologically active components [1]. Despite its positive benefits, a hurdle to consumption of whole wheat bread is related to production challenges limiting the development of high flavour quality products. When cereal foods are manufactured with whole grain instead of refined grain flour, lower product acceptability is observed [2, 3].

Glucomannan is a strong water-soluble food fiber and low in calories, which is widely used in the food industry. Glucomannan that found in porang tuber is very large. By extracting (leaching) on porang flour using ethanol solution will dissolve impurities found in porang flour [4]. High glucomannan levels and relatively small size of porang flour will determine the ability of flour to absorb water, form gels and form high viscosity that can be utilized in the food industry [5]. The addition of glucomannan to whole wheat flour leads to changes in water absorption. Among the strategies to enhance acceptance and inhibit the staling process, the use of glucomannan can help improve the staling rate and sensory quality of these bread [6]. Protein variation used to see the interaction of gluten with glucomannan and how it interacts with the volume of wheat bread. Therefore, this study aimed to investigate the effect of glucomannan addition and protein variation on physical quality characteristics of whole wheat bread.
2. Materials and Method

2.1. Glucomannan gel

Glucomannan flour was obtained from PT. Ambico Surabaya, East Java, Indonesia. Glucomannan gel was done by weighing 1 g and then put it in a vial bottle. Added hot water (95 °C) as much as 50 ml. The solution was then stirred manually using a stirring rod continuously for 15 minutes until gel was formed. Once homogeneous, the vial bottle was closed and put into PP plastic and tied with rubber for sterilization. Sterilization was performed on 110 °C for 1 hour using autoclave. After sterilization, glucomannan gel is then allowed to stand at room temperature for 30 minutes for ready to use [7].

2.2. Preparation of whole wheat bread

Whole wheat bread was made by using Dan Lepard method [8]. A mixture of whole wheat flour and flour (50 g of whole wheat flour and 50 g of flour) was prepared. Added instant yeast. Stirred and added sugar and then cold water. Knead until its evenly mixed. Added glucomannan gel and butter started kneading the dough. Window pane test was carried out to find out the dough has been smooth elastic. Covered the surface of the bowl with plastic wrap. Rest the dough for 1 hour (proofing 1). After that, deflated the dough then kneaded for 15 minutes. Left again for 45 minutes (proofing 2). Preheated the oven set at 180 °C. Put the batter in the oven and baked for 45 minutes. Remove the bread from the oven, leave it for 5 minutes then removed it from the baking sheet and cooled it on a wire rack. Control treatment used wheat bread made with the same process but not given glucomannan gel [8].

2.3. Preparation of sample

The sample was made by combining a mixture of 50 g whole wheat flour and 50 g wheat flour with a variety of proteins (High = 12-14%, medium = 9-11%, and low = 7-9%), previously added glucomannan by 0.5%, 1%, and 1.5% of the total weight of each flour mixture, as shown in Table 1.

| No. | Sample | Combination of Treatments |
|-----|--------|---------------------------|
| 1.  | P1G1   | Mixture of whole wheat flour and high protein flour with 0.5% glucomannan |
| 2.  | P1G2   | Mixture of whole wheat flour and high protein flour with 1% glucomannan |
| 3.  | P1G3   | Mixture of whole wheat flour and high protein flour with 1.5% glucomannan |
| 4.  | P2G1   | Mixture of whole wheat flour and medium protein flour with 0.5% glucomannan |
| 5.  | P2G2   | Mixture of whole wheat flour and medium protein flour with 1% glucomannan |
| 6.  | P2G3   | Mixture of whole wheat flour and medium protein flour with 1.5% glucomannan |
| 7.  | P3G1   | Mixture of whole wheat flour and low protein flour with 0.5% glucomannan |
| 8.  | P3G2   | Mixture of whole wheat flour and low protein flour with 1% glucomannan |
| 9.  | P3G3   | Mixture of whole wheat flour and low protein flour with 1.5% glucomannan |

2.4. Texture profile analysis

Texture profile analysis (TPA) used a TA-AACC3 type probe with trigger load 4.0 g and test speed 1 mm/s. The TPA curve was analysed for hardness, elasticity, cohesiveness and stalling rate. To see micropore uniformity, microscopic tests were used by storing samples in the freezer for 24 hours [9].

2.5. Organoleptic analysis

Organoleptic tests were carried out on all variations in concentration and type of hydrocolloid using 20 panellists. The sample used is whole wheat bread modified by glucomannan which has been cooled for 30 minutes [6]. Sliced the samples into sizes 5x2x3 cm (p x t x l cm) and then presented to panellists with coding randomly using 2 digit numbers. Organoleptic tests using the Hedonic Scale Scoring method
scale from 1 to 5 (score 1 = most dislike, to score 5 = most like) for color, taste, flavor, texture, and overall attributes.

2.6. Chemical analysis
Chemical analysis was carried out on whole wheat bread modified by glucomannan products including water content, ash content, fat, protein, carbohydrate, crude fiber content, starch and amylose [10, 11].

2.7. Data analysis
Data analysis was performed using Analysis of Variance (ANOVA) with 5% level of significant to determined differences or influenced on each treatment. If the test results show a significant difference, further testing was carried out with SSD test (the Smallest Significant Difference). Organoleptic test results data were analyzed using Hedonic Scale Scoring test. While the best treatment analysis uses the Multiple Attribute method based on physical and organoleptic parameters.

3. Results and Discussion

3.1. Texture profile
The addition of hydrocolloid could increase the consistency of the dough compared to whole wheat bread with no glucomannan added (control). The addition of hydrocolloids to bread dough could increase viscoelastic dough, due to the ability of hydrocolloids to form gels [14]. Increasing the concentration of glucomannan added to the formulation of dough caused a decrease in the consistency of the dough. It is because the acetyl group in glucomannan prevents its molecules from binding to each other and forming a gel. The higher concentration of glucomannan given or mixed in the mixture, the more acetyl groups that block gel formation [15]. Heating and cooling carried out on glucomannan gel produces a gel that resistant to boiling temperatures, even without melting and produces a gel that is strong and elastic. The higher concentration of glucomannan added, the pore of the bread has improved which can be seen using a microscope. Figure 1 shows the difference in appearance of the bread pore to increase the addition of glucomannan.

![Figure 1. The bread pore with the addition of glucomannan](image)

3.2. Hardness
The value of hardness decreases as well as the combination of whole wheat flour with medium protein flour and a combination of whole wheat flour with high protein flour with the same variation in glucomannan concentration. The most significant glucomannan concentration in reducing the hardness of bread was 1.5%. The addition of 0.5% glucomannan can decompose complex structures into simpler (shorter) structures because they have many acetyl groups in molecular structure of glucomannan, so that during baking, intermolecular bonds and hydrogen bonds will be difficult to absorb water and the resulting bread becomes harder. The addition of 1.5% glucomannan causes excess water absorbed by the bread to decrease the hardness value. Overall, it can be seen in Figure 2.

The hardness value of whole wheat flour with high protein flour bread is higher than the control and mixture with medium and low protein flour bread. Gluten causes the bread dough to become elastic so that it can easily trap and hold gas during fermentation. The molecule forms a double helix bond that
binds the chain into a three-dimensional network. The formation of the gel causes a decrease in hardness on bread [15].

3.3. *Springiness*  
The higher proportion of glucomannan added did not cause the springiness value to differ significantly according to statistical calculations. This is presumably because the higher glucomannan in the formulation of bread will cause the consistency of the dough to decrease. Low consistency dough does not have enough ability to bind gas bubbles produced during fermentation so that the dough cannot expand properly and has a low elasticity value. Overall it can also be shown in Figure 3.

3.4. *Cohesiveness*  
The cohesiveness of bread increased compared to controls with the addition of glucomannan. Hydrocolloid can create a strong gel structure so as to increase the value of cohesiveness on whole wheat bread. The value of cohesiveness also illustrates the strength of bonds between molecules in food products. The higher the cohesiveness value, the stronger the bond between food molecules. In bread products, this will create a sturdy texture with uniform pores. It can also be seen from Figure 4.

![Figure 2. The relation of hardness to the addition of glucomannan concentration](image)

![Figure 3. The relation of springiness to the addition of glucomannan concentration](image)

![Figure 4. The relation of cohesiveness to the addition of glucomannan concentration](image)

3.5 *Staling rate of whole wheat bread modified by glucomannan*  
The process of staling on bread observed visually occurred on day 3 when placed at room temperature with the percentage increase in the value of hardness by 21.87%. The longer the bread is stored, the texture changes the bread becomes harder (Table 2).
## Table 2. Hardness value of whole wheat bread

| Sample                               | Average Hardness Value of Whole Wheat Bread (N) |
|--------------------------------------|-----------------------------------------------|
|                                      | Day 1  | Day 3  | Day 5  | Day 7  |
| Control High Protein flour           |        |        |        |        |
| High protein flour + 0.5% glucomannan| 2.45   | 3.4    | 4.5    | 16.55  |
| High protein flour + 1% glucomannan  | 2.4    | 10.65  | 7.7    | 5.55   |
| High protein flour + 1.5% glucomannan| 4.35   | 22.1   | 26.65  | 8.4    |
| Control Medium Protein Flour         | 6.35   | 9.95   | 4.7    | 7.65   |
| Medium protein flour + 0.5% glucomannan | 2.5    | 2.9    | 5.6    | 3.35   |
| Medium protein flour + 1% glucomannan | 2.3    | 3.4    | 6      | 4.8    |
| Medium protein flour + 1.5% glucomannan | 3.15   | 6.55   | 8.55   | 7.3    |
| Control Low Protein flour            | 5.9    | 8.55   | 12.1   | 9.05   |
| Low protein flour + 0.5% glucomannan | 3.8    | 5.9    | 9.8    | 5.6    |
| Low protein flour + 1% glucomannan   | 6.05   | 8.55   | 8.15   | 6.2    |
| Low protein flour + 1.5% glucomannan | 6.6    | 10     | 13.35  | 10.85  |

During baking, gelatinized starch forms an amorphous structure. After the bread comes out of baking, the kinetic energy of the molecule cannot resist the tendency of the starch molecules, inter amylose-amylose and long amylopectin-amylopectin between each other to reconnect. In addition, on the inside of the bread (crumb) there is also a shift in the distribution of water which originally existed in gluten moving to starch. This results in the availability of water as forming the film layer on the gluten matrix down and resulting in the appearance of the crumb texture becoming dry and brittle.

### 3.6. Organoleptic

The flavor component is closely related to the concentration of the flavor component in the vapor phase in the mouth. The results of the analysis of variance as can be seen in Table 3. The results of the variance analysis showed that the mixture of whole wheat flour and wheat flour with a variety of protein content and various glucomannan concentrations did not significantly influence the panelists preference for bread samples (p value 0.00 ≤ 0.05). The increasing amount of glucomannan that exceeds the value which has been determined will cause the texture of the bread to become hard.

## Table 3. Average value for sensory attributes

| Sample                                      | Sensory Attributes                  |
|---------------------------------------------|-------------------------------------|
|                                             | Flavor    | Taste     | Texture   | Overall    |
| Low protein flour + 0.5% glucomannan        | 2.80 ± 0.41b | 3.45 ± 0.51b | 2.45 ± 0.47d | 3.65 ± 0.49b |
| Low protein flour + 1% glucomannan          | 2.80 ± 0.41b | 3.75 ± 0.44b | 2.50 ± 0.37d | 3.70 ± 0.47b |
| Low protein flour + 1.5% glucomannan        | 2.75 ± 0.44b | 3.40 ± 0.50b | 2.75 ± 0.31c | 3.60 ± 0.50b |
| Medium protein flour + 0.5% glucomannan     | 2.95 ± 0.22b | 3.55 ± 0.51b | 3.05 ± 0.37b | 3.75 ± 0.44b |
| Medium protein flour + 1% glucomannan       | 3.05 ± 0.61b | 3.50 ± 0.51b | 3.30 ± 0.37b | 3.85 ± 0.37b |
| Medium protein flour + 1.5% glucomannan     | 3.10 ± 0.55b | 3.45 ± 0.51b | 3.60 ± 0.44b | 3.85 ± 0.37b |
| High protein flour + 0.5% glucomannan       | 3.05 ± 0.51b | 3.65 ± 0.49b | 3.95 ± 0.50b | 3.90 ± 0.31b |
| High protein flour + 1% glucomannan         | 3.60 ± 0.50b | 3.80 ± 0.41b | 4.20 ± 0.49b | 3.85 ± 0.37b |
| High protein flour + 1.5% glucomannan       | 3.50 ± 0.51b | 3.70 ± 0.47b | 4.15 ± 0.47b | 3.70 ± 0.47b |
3.7. Chemical characteristics of raw material and whole wheat bread

Analysis of raw materials is carried out to determine the chemical content that can affect the final quality of the bread products to be made. The value of the chemical analysis of raw materials of whole wheat flour and wheat flour in various variations of protein in full can be seen in Table 4.

Table 4. Result of chemical analysis of raw materials

| Type of Flour   | Water Content (%) | Ash Content (%) | Fat Content (%) | Protein Content (%) | Carbohydrate Content (%) | Starch Content (%) |
|-----------------|-------------------|-----------------|-----------------|---------------------|--------------------------|-------------------|
| Whole Wheat Flour | 9.19 ± 0.14       | 1.54 ± 0.01     | 3.31 ± 0.24     | 13.35 ± 0.00        | 73.30 ± 0.00             | 53.78 ± 0.02      |
| High Protein Flour | 9.66 ± 0.21       | 0.56 ± 0.02     | 2.28 ± 0.04     | 12.19 ± 0.01        | 74.62 ± 0.00             | 53.06 ± 0.00      |
| Medium Protein Flour | 8.67 ± 0.43      | 0.55 ± 0.32     | 1.73 ± 0.01     | 11.45 ± 0.02        | 77.50 ± 0.01             | 53.74 ± 0.13      |
| Low Protein Flour  | 11.15 ± 0.02      | 0.50 ± 0.01     | 1.28 ± 0.01     | 8.56 ± 0.14         | 78.51 ± 0.02             | 51.36 ± 0.02      |

Note: the value obtained was from 4 times repetitions.

During the baking process, there will be an increase in temperature which causes starch to swell because it absorbs water, damages hydrogen bonds between molecules and forms a hydroxyl group that is hydrated [14]. The values of starch, amylose and amylpectin levels are presented in Table 5.

Table 5. Starch, amylose and amylpectin levels of raw materials

| Raw Materials     | Starch Content (%) | Amylose Content (%) | Amylopectin Content (%) |
|-------------------|-------------------|---------------------|-------------------------|
| Low Protein Flour | 51.36             | 14.97               | 36.39                   |
| Medium Protein Flour | 53.74           | 17.65               | 36.09                   |
| High Protein Flour | 53.06            | 17.65               | 35.41                   |
| Whole Wheat Flour | 53.78             | 19.98               | 33.80                   |

High levels of amylose can cause the development of high volumes and are not easily broken, but the resulting bread products will become dry, less tender, and hard when cold [15]. Data from the proximate results of whole wheat bread can be seen in Table 6.

Table 6. Proximate analysis of whole wheat bread

| Code              | Parameter (%)                  |
|-------------------|-------------------------------|
|                   | Ash Content (%) | Water Content (%) | Carbohydrate Content (%) | Fat content | Protein Content (%) | Fiber Content (%) |
| High Protein Flour | 1.46 ± 0.02     | 31.97 ± 0.02       | 52.76 ± 0.14            | 3.50 ± 0.01 | 9.19 ± 0.00         | 18.03 ± 0.29     |
| Medium Protein Flour | 1.24 ± 0.01    | 26.85 ± 0.01       | 50.40 ± 0.11            | 3.54 ± 0.00 | 9.07 ± 0.01         | 18.03 ± 0.29     |
| Low Protein Flour  | 1.31 ± 0.02     | 29.54 ± 0.00       | 50.79 ± 0.14            | 3.76 ± 0.00 | 7.94 ± 0.02         | 18.03 ± 0.29     |

Note: the value obtained was from 4 times repetitions.
During the fermentation process, microbes will break down starch into simple sugar components, so that the starch content will decrease further. In addition, the activity of the enzyme amylase contained in whole wheat flour will work optimally in hydrolyses starch into a simpler component.

4. Conclusions
Addition of glucomannan concentration of 0.5%; 1% and 1.5% for whole wheat bread mixed with whole wheat flour and low protein flour, medium protein and high protein respectively resulted in a decrease in hardness, increased elasticity and cohesiveness. For sensory parameters, panelists preferred wheat bread with a mixture of whole wheat flour and high protein flour with a glucomannan content of 1%. Addition of glucomannan with a concentration of 0.5%; 1% and 1.5% of the total weight of the flour mixture causes the value of the staling rate to decrease.

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