Bread Quality of Pre-Gelatinized Cassava Flour with Frozen Storage

Ratnaningsih*, R Nilasari2 and E Y Purwani1

1Indonesian Center for Agricultural Postharvest Research and Development, Jl. Tentara Pelajar 12 Cimanggu, Bogor – Indonesia 16114
2Department of Chemistry, Faculty of Mathematic and Natural Sciences, Pakuan University, Bogor – Indonesia

*Email: ratnaningsih@pertanian.go.id

Abstract. Cassava flour can be processed into bakery products such as bread, by modifying it. It has elastic properties approaching the elasticity of wheat flour after pre-gelatinization treatment. For preservation purposes, the dough was frozen before the bread production. The objective of this research was to study the influence of dough frozen storage on the quality of bread that produced from pre-gelatinized cassava flour as main raw material. The research included preparation of pre-gelatinized cassava flour production, mixing the dough ingredient in two formulas, storing the frozen dough at 5 levels storing time, 0, 3, 6, 9, and 12 days, thawing the frozen dough, baking and analyzing the resultant bread. The research design was factorial completely randomized design consisting of two factors (dough formulas and frozen storing times). The results showed that the dough of pre-gelatinized cassava flour could inflate after thawing and baking processes. Frozen storage up to 12 days slightly decreased the inflate ability and characteristics of the bread. The optimum frozen storage of dough was 6 days, which produced bread with no significantly different properties with non-frozen dough.

1. Introduction

Bakery product, such as bread and noodle, becomes popular in Indonesia. Based on basic health research in 2013, it was reported that 10 to 15 percent of peoples consumed bread for more than once a day. The bakery product were mostly made from wheat flour, which must be completely imported. Cassava which is one of the indigenous food crops in Indonesia reached up to 23 million tons of productivity in 2011 to 2015. Whereas its consumption rate is reported only 13.3 million tons in 2014. Therefore, the potency of cassava flour utilization for bakery product raw materials are still large.

Cassava is usually consumed in traditional and simple form of food product, such as fried cassava, boiled cassava, steamed cassava, chips, tape and gethuk. Although cassava can be processed into cassava flour, which makes more affordable, longer shelf life, and easier distribution, but its utilization has not increased. The main constraint on cassava flour utilization is the inability of cassava flour to create gluten-like matrix, which makes the dough to be elastic. Gluten is a specific protein within wheat flour that caused the dough could be elastic and stretchy. Some studies and modifications have been done to improve the character of cassava flour including enzymatic modification[1, 2, 3, 4], microbial fermentation [5, 6], physical treatment [7] and hydrocolloid addition [8, 9]. Physical treatment uses the temperature in material treatment, such as heating, cooling and freezing. Pre-gelatinization treatment which utilized heat below the temperature of starch gelatinization were reported could modify the
characteristic of cassava flour. While freezing technology has been widely applied in the bakery industries, which is reported could extend the shelf life of its dough. However, during the frozen storage the dough quality would be gradually deteriorated. The volume and firmer texture of the bread loaf would be decreased that caused by the loss of yeast activities and the dough structure disruption.

The objective of this research was to study the characteristics of pre-gelatinized cassava bread with frozen storage dough to extend its shelf life.

2. Materials and methods

The research has been conducted from September to December 2017 at the Laboratory of Indonesian Center for Agricultural Postharvest Research and Development (ICAPRD) – Bogor Indonesia. The materials were used consist of ingredients of cassava bread production and materials for analysis. The ingredients for bread making consisted of pregelatinised cassava flour, rice flour, sago flour, sorghum flour, xanthan gum, bread improver, margarine, milk powder, sugar, yeast, egg and water. The materials for analysis were used consist of distilled water, hexane, HCl (Merck), 1N of NaOH, 95% ethanol, selenium powder, 25% HCl, H2SO4, (Sigma-Aldrich) and other chemicals. The equipment were used in this research consist of standard equipment for bread producing, such as hand mixer, final proofer (Heng Wei), bread maker (Re-bread); freezer, oven (Memmert); and analytical equipment for physicochemical analysis, such as texture analyzer (CT3 – 4500 Brookfield), chromameter (Minolta 300), and proximate test devices.

The research were started by pre-gelatinized cassava flour production using a rotary dryer with temperature between 70 – 80°C for 8 hours. Then the cassava flour and others ingredients were processed into baking dough using two formulations (Table 1). After that, the dough were stored at frozen temperature (−4°C) for 0, 3, 6, 9 and 12 days. The frozen dough were removed and then processed into bread, with thawing processed before baking. The bread produced were analyzed for their characteristics, such as color (L, a, b, and whiteness indexes), texture, expansion ratio, and the proximate analysis (moisture, ash, protein, fat, and carbohydrate). The whiteness indexes were determined using equation 1.

\[
Whiteness \text{ index}(\%) = 100 - \sqrt{(100 - L)^2 + a^2 + b^2} \tag{1}
\]

While the expansion ratio were determined by following equation 2.

\[
Expantion \text{ ratio} = \frac{Volume \ of \ product}{Volume \ of \ dough} \tag{2}
\]

Table 1. Dough formulation of pre-gelatinized cassava bread

| Ingredients           | Formulation A | Formulation B |
|-----------------------|---------------|---------------|
| Cassava flour         | 100           | 100           |
| Rice flour            | 80            | -             |
| Sorghum flour         | -             | 80            |
| Sago flour            | 20            | 20            |
| Gum xanthan           | 5             | 5             |
| Bread improver        | 0.6           | 0.6           |
| Instant yeast         | 3             | 3             |
| Sugar                 | 20            | 20            |
| Butter                | 40            | 40            |
| Milk powder           | 25            | 25            |
| Egg                   | 50            | 50            |
| Water (v/w)           | 250           | 250           |

Determination of moisture content used the oven convection procedure by drying the sample at 105°C until it reached a constant weight. The ash contents were determined by measurement of the residues left after combustion in the furnance at 550°C for 8 h. Fat extractions were carried out with anhydrous diethyl ether solution in the soxhlet. Kjeldahl analysis were used to determine the protein.
levels with Nitrogen assay (N x 6.25). The carbohydrate content were calculated using the differences with moisture, ash, fat, and protein content in the sample.

The research design was factorial completely randomized design consisting two factors, dough formulas (formula A and formula B) and storing time (0, 3, 6, 9, 12 days). The data were analyzed by the analysis of variance (ANOVA) and the significant differences among means were determined by Duncan’s multiple range tests. P values less than 0.05 were considered statistically significant.

3. Results and discussion

3.1. Bread color

The quality of bread can be seen from the color produced after baking process. It is expected to be uniform and appealing. The crust color should be golden brown, and the crumb color should be creamy white [10].

| Table 2. The crust color of pre-gelatinized cassava bread |
|----------------------------------------------------------------------------------|
| Flour type – Storing time (day) | L | a | b |
| Cassava + rice                    |   |   |   |
| 0 day                             | 65.42<sup>a</sup> | 9.45<sup>d</sup> | 46.31<sup>c</sup> |
| 3 days                            | 66.06<sup>a</sup> | 7.75<sup>cd</sup> | 46.15<sup>c</sup> |
| 6 days                            | 68.18<sup>a</sup> | 6.01<sup>bc</sup> | 43.34<sup>bc</sup> |
| 9 days                            | 69.84<sup>a</sup> | 5.73<sup>bc</sup> | 39.68<sup>ab</sup> |
| 12 days                           | 68.62<sup>a</sup> | 2.54<sup>a</sup>  | 39.23<sup>ab</sup> |
| Cassava + sorghum                 |   |   |   |
| 0 day                             | 65.58<sup>a</sup> | 9.62<sup>d</sup> | 40.98<sup>b</sup> |
| 3 days                            | 66.13<sup>a</sup> | 7.06<sup>bc</sup> | 38.92<sup>ab</sup> |
| 6 days                            | 67.87<sup>a</sup> | 6.92<sup>bc</sup> | 39.37<sup>ab</sup> |
| 9 days                            | 66.33<sup>a</sup> | 5.72<sup>bc</sup> | 35.25<sup>a</sup> |
| 12 days                           | 68.20<sup>a</sup> | 5.16<sup>b</sup>  | 35.42<sup>a</sup> |

<sup>a–<sup> The same letter in the same column indicates no significantly differences at 5% level by Duncan’s test.

![Figure 1. Whiteness Indexs of pre-gelatinized cassava bread.](image-url)
As frozen dough was stored for longer periods, the color of the resultant bread was darker and less uniform in color. Whiteness indexes of the resultant bread increased and were significantly different with the length of storing time (Figure 1). The dough formulas were not significantly contribute on the bread color. The bread color was related to the increasing of leached amylose and degraded dextrins, which contribute to Maillard reactions [11].

3.2. Bread texture
Figure 2(a) describes the hardness level of crumb from pre-gelatinized cassava bread. Sorghum flour addition on the dough provided harder crumb than bread with rice flour addition, for all storing time 0 to 12 days. The crumb hardness of pre-gelatinized cassava bread rose with the increasing of storage time. Both rice and sorghum flour addition provided gradually increased of the crumb hardness during storing time.

![Figure 2(a)](image)

Letter A for dough formula variable. Letter a, b, c for storing time variable. Values followed by different letters showed significantly different at 0.05 level.

![Figure 2(b)](image)

Letter A for dough formula variable. Letter a, b, c for storing time variable. Values followed by different letters showed significantly different at 0.05 level.

**Figure 2.** The hardness of the crumb (a) and crust (b) from pre-gelatinized cassava bread.
Figure 2 (b) shows the crust hardness level of pre-gelatinized cassava bread. There were no significantly different between rice and sorghum flour addition on the crust hardness level. It relatively stable during storing time, except for 9 days storing time.

Increased bread strength is affected by frozen storage of dough that changes the dough structure or yeast activities. It supports the occurrence of hardening in the next baking or cooling processes. In addition, amylose re-crystallization plays a prominent role in crumb hardness. After the dough is frozen, the starch granules being damaged as results of the increased of ice recrystallization during frozen storage. It causes the intracellular amylose leaching, the interaction between intra- and inter-granular amylose increasing and the formation of amylose tissue which increases the crumb hardness [12].

3.3. Expansion ratio of the bread

Figure 3 illustrates the expanding ratio of the pre-gelatinized cassava dough after baked. In both formulas, there were still indicated the dough inflating ability during the baking process.

The dough with sorghum flour addition caused slightly higher of expanding ratio comparing with the dough using rice flour addition. The expanding ratio of the bread with sorghum flour addition, gradually declined during storing periods. While the expanding ratio of the bread using rice flour formulas was relatively constant until 9 days of storage, and reduced at 12 days storing time. This is in line with Yi and Kerr [11], Wang et al. [13], and Frauenlob et al. [14].

Damaged starch granules in the dough could be caused by longer periods of frozen storage. It caused moisture retention, increased loaf weight dan decreased loaf volume [11], which due to decreasing of the yeast viability and damaging the starch ultra-structure. Ma et al. [15] stated that loaf volume were affected by amount of damaged starch during frozen storing which is undesirable and provided unfavorable effects.

![Figure 3. Expanding ratio of pre-gelatinized cassava bread during storage time.](image)

3.4. Proximate analysis

Table 3 describes the proximate analysis results of the bread from several storing periods. It can be seen that the bread moisture content ranged from 37.72 to 42.69%. Bread from non-frozen storing dough has lower moisture content comparing to bread which derives from frozen storing the dough. Furthermore, with and without frozen storing dough provided greater moisture content than bread from wheat flour. The starch damaged during frozen storage may encourage the moisture retention, that produces bread with increasing loaf weight and decreased loaf volume [11].
Ash of the bread ranged between 0.33 to 0.89%. It is seen to be influenced by mineral content inside the fresh cassava as the raw material of the pre-gelatinized cassava bread. The protein content of the bread ranged from 4.56 to 6.74%. This result is in line with Pasqualone et al. [16]. The egg addition provided higher protein content on the resultant cassava bread. It also contributed on the formation of a continuous solid phase that suitable for effectively retaining gases in gluten-free product. In addition, it also provided improving the coherence between starch granules, and increasing the stability of the dough [17]. The resultant bread contained 6.62 to 9.06% of fat. This result was higher than Pasqualone et al. [16]. It may be contributed by the addition of margarine and hydrocolloid compounds. The carbohydrate content of the bread ranged from 42.18 to 46.62%, that obtained from others content differences, such as moisture, ash, fat and protein.

| Table 3. The proximate analysis of bread from several types of flour and storing time. |
|---------------------------------|--------|--------|--------|--------|-------------------|
| Flour type – Storing time       | Moisture (%) | Ash (%) | Protein (%) | Fat (%) | Carbohydrate (%)* |
| (day)                           |         |        |         |        |                   |
| Cassava + rice                  |         |        |         |        |                   |
| 0 day                           | 37.72   | 0.85   | 5.78    | 9.03   | 46.62            |
| 3 days                          | 41.48   | 0.83   | 5.48    | 8.06   | 44.15            |
| 6 days                          | 42.10   | 0.80   | 5.14    | 8.01   | 43.95            |
| 9 days                          | 41.12   | 0.64   | 5.71    | 9.00   | 43.53            |
| 12 days                         | 42.42   | 0.33   | 5.08    | 8.55   | 43.62            |
| Cassava + sorghum               |         |        |         |        |                   |
| 0 day                           | 40.72   | 0.59   | 6.01    | 9.06   | 43.62            |
| 3 days                          | 41.74   | 0.76   | 6.74    | 7.66   | 43.10            |
| 6 days                          | 42.15   | 0.63   | 4.56    | 8.66   | 44.00            |
| 9 days                          | 42.69   | 0.89   | 5.31    | 8.93   | 42.18            |
| 12 days                         | 41.96   | 0.78   | 5.61    | 6.62   | 45.03            |
| Wheat                           | 33.71   | 0.91   | 11.13   | 8.15   | 46.10            |

a–b  The same letter in the same column indicates no significantly differences at 5% level by Duncan’s test.
*) by different

4. Conclusions
The characteristics of pre-gelatinized cassava bread was influenced by the frozen storing periods, including the crust color, crumb and crust hardness, expansion ratio, and the proximate analysis results. The crust color became darker with a longer dough storing period. The crust hardness level relatively stable during storing time, while the crumb hardness level were gradually increased with longer storing period. The dough of pre-gelatinized cassava flour is still suitable acceptance for producing bread during 6 days of frozen storage, with no significantly different character with non-frozen dough.

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