BALI (Beras Analog Umbi Gembili):
The Utilization of Gembili Tuber (Dioscorea esculenta) as The Raw Material for Rice Analogue Production

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Abstract—The inevitable dependency on rice as considered staple food in Indonesia raised concerns on various subjects such as food diversification and sufficiency. Rice analogue is artificial rice made from other carbohydrate sources than rice and wheat flour, i.e. gembili (Dioscorea esculenta). In 100 g gembili, contains 31.3 g carbohydrates, 1.1 g protein, 0.2 fat and 131 calories. Furthermore, gembili is also a potential source of inulin - a nutritional component confers a health benefit - with up to 14.62% in total, higher than the usual amount of inulin contained in other plants. BALI was made by adding sorghum flour into the mashed gembili tuber. The addition of sorghum flour provides increase in carbohydrate content of the final product, approaching to those of commercial rice. From the result obtained, in 100 g of BALI contains 43.81 g carbohydrates, 4.07 g protein, 1.13 fat and 191.3 calories. These amounts are able to provide Indonesian people daily nutrition. Based on organoleptic test that has been conducted to several respondents, the average score is between 3–4 from 5 scale in each parameter i.e. flavor, color, texture, shape, and size.

Keywords—BALI, food diversification, rice analogue

I. INTRODUCTION

Rice is the main staple food for the majority of Indonesian people. In fact, Indonesian rice consumption has reached 114 kilograms (kg) per capita per year, or 312 grams per capita per day. This value is very high when compared with average Asians consumption of rice that is only reached 90 kg per capita per year and the average world rice consumption which is only 60 kg per capita per year [1]. Indonesian rice consumption also took the largest share, with almost 90% of the total national food consumption. This indicates that the country depended too heavily on rice as the national staple food.

Along with population growth, the demand for food consumption will increase which will then increase domestic rice production. In the past ten years, rice production increased by 10 million tons. This increase happened when the total production of rice only 31 million tons in 2004 and become 41 million tons in 2014. Despite an increase happened in the production rate, but the population continues to grow that making rice production with an increase of 10 million tons will be meaningless.

Additionally, unfavorable climatic conditions as supporting infrastructure factors may be able to inhibit the growth rate of rice production. This will cause rice production cannot meet the needs of the society and lead to increasing prices. In the last three years, the average domestic price is always higher than the world price with an increasing trend. The Ministry of Agriculture (2015) reported that in February 2015 there was a sharp increase in domestic rice prices in Jakarta and other major cities with 25% value. In fact, the price of rice remains inflated after the imported rice procurement business. These conditions certainly will not happen if Indonesia actively pursued food security and also national rice self-sufficiency. However, based on those reasons, due to the shortfall of rice production, various efforts must be done to encourage rice production. In order to overcome the challenges and problems of food supply, which is heavier, one of the efforts is food diversification and rice analogue became one of the alternatives for food diversification in Indonesia.

In Indonesia, development of rice analogue is very potential. Because Indonesia has many local raw material containing carbohydrates sources which potential to become raw material for rice analogue. The local raw materials that potential to used are cassava, corn, sago, and other tubers that contain carbohydrates resources. One of the tubers which has great source of carbohydrates and available in Indonesia is gembili.
Gembili (Dioscorea esculenta L) is a tuber of the family Dioscoreaceae. This tuber is growing vines with green leaves and stems of prickly around bulbs. Gembili tuber has a spherical shape to oval, but some are branched and wide. Gembili is white meat clean up murky white, while for the skin cream colored gembili until light brown [2]. Currently, gembili cultivation is concentrated in Southeast Asia (particularly Papua New Guinea and Irian Jaya). In Indonesia, a total of 70 ton/ha gembili crops can be produced mainly in Irian Jaya. Cultivation of gembili crops can also be found in almost Indonesian mainland, such as South Sulawesi, Java, Madura, and Bali. Although land planted gembili is still very limited, less than 1000 ha [3].

Based on the research about rice analogue, it has many problem, such as the less savory rice aroma, texture that is not yet able to resemble the rice padi and flavor of rice analogue which tend to be blander. The benefits of gembili are in its nutrients. In 100 g of gembili containing 31.3 g carbohydrates, 1.1 g protein, 0.2 g fat and can contribute to an energy of 131 calories [2,4–6]. Gembili also contains components that are very important for the health, which is inulin. Inulin levels contained in gembili is equal to 14.629%. This level is higher than the levels of inulin from several other types of tubers. Inulin is a type of dietary fiber that can’t be digested and serves as a prebiotic that selectively stimulate the growth and activity of beneficial bacteria in the digestive tract [6]. Inulin also stimulates the immune system in the body. Another function of the inulin is that it can help the absorption of some nutrients such as Fe, Cu, Zn, and Ca. Research on Gembili (Dioscorea esculenta L) also shows higher inulin levels than other bulbs, and has lower glycemic levels than cassava [7–9].

II. METHODS

A. Materials

The raw materials for BALI productions are gembili tuber and sorghum flour. Gembili tuber was obtained from Pasar Rebo, Jakarta. Meanwhile sorghum flour was obtained from Bantul, Yogyakarta.

B. Production Methods

Production of BALI consists of 2 main processes i.e. preparation and manufacturing process.

1) Preparation

Preparation was done by peeling the gembili tuber in order to obtain gembili tuber flesh. Gembili tuber flesh were then washed and cleaned by flowing water to remove the latex and remaining dirt and then it was drained. Afterwards, gembili tuber fleshes were steamed. In order to ease the steaming process, gembili tuber flesh were sliced thinly before. Steaming was done for 30-45 minutes until gembili tuber flesh cooked. Steamed gembili tuber fleshes were then mashed until it was fine evenly.

2) Manufacturing

Manufacturing of BALI was done by adding the sorghum flour into the mashed gembili tuber. Sorghum flour was added about 10% w/w of total mashed gembili tuber. Both materials were then mixed until the dough was not sticky and well mixed. The addition of sorghum flour aimed to increase the content of carbohydrates in BALI.

The next process was granulating the dough into rice granule that resemble with the paddy rice. Granulating was done using rice granulator. Granulated BALI was then dried to reduce the water content in BALI.

Overall production methods of BALI are represented in the Figure 1, below.

Fig. 1. Process Flow Diagram of BALI Production

C. Organoleptic Test

Organoleptic test was done to analyze the acceptance of BALI by people, according to their sense. This test was conducted to several persons that randomly chosen. Product that has been tested was cooked BALI. This test was done using several parameters. The parameters are flavor, color, texture, shape, and size of BALI.

III. RESULTS

A. Nutritional Content of BALI

BALI is one of alternative food diversification, which suitable for Indonesian people. This rice analogue has been made from gembili tubers and sorghum flour. From the nutritional content, BALI is resembling with paddy rice that contains nutrition such as carbohydrates, protein, fat, fiber, ash, calcium, phosphor, iron, vitamin B1, vitamin C, and water. From the result that has been conducted, the nutritional content of 100 grams BALI can be seen in the Table 1.
TABLE I. NUTRITIONAL CONTENTS IN 100 GRAMS OF BALI

<table>
<thead>
<tr>
<th>No.</th>
<th>Nutrition</th>
<th>Unit</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Calorie</td>
<td>kcal</td>
<td>191.3</td>
</tr>
<tr>
<td>2</td>
<td>Protein</td>
<td>g</td>
<td>4.07</td>
</tr>
<tr>
<td>3</td>
<td>Fat</td>
<td>g</td>
<td>1.13</td>
</tr>
<tr>
<td>4</td>
<td>Carbohydrate</td>
<td>g</td>
<td>43.81</td>
</tr>
<tr>
<td>5</td>
<td>Fiber</td>
<td>g</td>
<td>4.19</td>
</tr>
<tr>
<td>6</td>
<td>Ash</td>
<td>g</td>
<td>0.7</td>
</tr>
<tr>
<td>7</td>
<td>Calcium</td>
<td>mg</td>
<td>18.2</td>
</tr>
<tr>
<td>8</td>
<td>Phosphor</td>
<td>mg</td>
<td>125.3</td>
</tr>
<tr>
<td>9</td>
<td>Iron</td>
<td>mg</td>
<td>1.74</td>
</tr>
<tr>
<td>10</td>
<td>Vitamin B1</td>
<td>mg</td>
<td>0.17</td>
</tr>
<tr>
<td>11</td>
<td>Vitamin C</td>
<td>mg</td>
<td>2.8</td>
</tr>
<tr>
<td>12</td>
<td>Water</td>
<td>g</td>
<td>49.84</td>
</tr>
</tbody>
</table>

* This content is calculated based on Hardinsyah and D. Briawan (1994) and Departemen Kesehatan (1992) [10]

B. Appearance and Flavor of BALI

BALI which made from gembili tuber and sorghum flour has light brown color. The color is resulted from the raw material. Gembili has original color that is white, while sorghum flour has brown color. Therefore, the color of BALI produced becomes light brown. The appearance of BALI is shown in the Figure 2.

![Appearance of BALI](image)

Meanwhile, for the flavor of BALI, it resembles with rice originating from paddy rice. This is because both gembili tuber and sorghum does not have specific flavor. Therefore, the flavor of BALI can resemble the flavor of paddy rice.

C. Organoleptic Test Results

Based on organoleptic test that has been conducted to 15 random respondents, the results are shown in the Figure 3, below.

![Organoleptic Test Results of BALI](image)

On the Figure 3 can be seen that flavor aspect of BALI got score of 3.5 out of 5. It means that the flavor of BALI is fairly good and can be accepted to the public relative to paddy rice. Color aspect of BALI got score of 3.5 out of 5. The color of BALI is reddish brown and similar to red rice. However, shape aspect of BALI is still fair, showed by score of 3.1 out of 5. The shape of BALI is still not as same as paddy rice. For texture aspect, BALI has similar texture to paddy rice; it is reinforced by the score of texture aspect of BALI, which is 3.7 out of 5. Granule size aspect of BALI got the highest score relative to other organoleptic aspects. Granule size aspect of BALI got score of 3.9 out of 5. This indicates that the size of BALI is almost similar to the size of paddy rice. Overall, BALI can be received by the respondents, with a mean score - average of 3.5 out of 5.

IV. DISCUSSION

Based on the result obtained, gembili tuber has a potential to become raw material of rice analogue. This is because gembili tuber has quite higher carbohydrates content compared by another tuber and has another nutritional content that resemble paddy rice. In 100 g of gembili containing 31.3 g carbohydrates, 1.1 g protein, 0.2 g fat and can contribute to an energy of 131 calories [2,4–6]. However, if compared with paddy rice, gembili tuber has lower carbohydrates content. In order to improve carbohydrate content of BALI, it is necessary to add another material that has high carbohydrate content. Therefore, the addition of sorghum flour was done in the production of BALI. Sorghum flour was added because it has 70.70 g of carbohydrates in 100 g of sorghum [13].

From the results, in 100 grams of BALI contains 191.3 kcal energy, 43.81 grams carbohydrates, 4.07 grams protein, 1.13 grams fat, and others. Although the
content is not higher than paddy rice, but it can still be improved in the following research and this amount is still sufficient for Indonesian people daily nutrition who diet.

Instead of them, BALI has many advantages for health, which are not owned by other rice analogue. Because BALI has bioactive compound, higher inulin level, easily digested, has lower glycemic index which beneficial for diabetics. Therefore, by producing BALI, it will help to improve Indonesian people health.

For the appearance, BALI has light brown color. Actually, this will be a lack of BALI to be accepted by Indonesian people, because Indonesian people always eat rice with white color. But, this can be solved by BALI flavor that much resemble to paddy rice. This can happen because both gembili tuber and sorghum does not have specific flavor. Moreover, the appearance of cooked BALI is resembled with the color of cooked brown rice. Therefore, BALI can be accepted by Indonesian people generally and easily accepted by Indonesian people who consume brown rice.

V. CONCLUSION

Gembili tuber as foodstuffs with fairly high carbohydrate sources can be used as raw material of rice analogue. Utilization of gembili as the raw material for rice analogue is an effort to diversify food for Indonesian people. From the result, in 100 grams of BALI contains 191.3 kcal energy, 43.81 grams’ carbohydrates, 4.07 grams’ protein, 1.13 grams’ fat, and others. Although the content is not higher than other rice, but it can still be improved in the following research and this amount is still sufficient for Indonesian people daily nutrition who diet.

For the appearance, BALI has light brown color, while the appearance of cooked BALI is resembled with the color of cooked brown rice. However, for the flavor of BALI, it resembles with rice originating from paddy rice. This is because both gembili tuber and sorghum does not have specific flavor.

From the organoleptic test, BALI can be received by the respondents, with a mean score - average of 3.5of 3.5 out of 5.

REFERENCES