Local tubers and beans processing innovation for micro enterprises diversification

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Abstract. Local commodities such as tubers and beans are abundant throughout Indonesia, but its economic value is low and still only a minor source of income for the rural areas community. The purpose of this study was to improve technological access of inferior local tubers and beans processing thus increasing the added value and facilitates the community economic revenues. The first step of this study was conducted to identify the nutrients content of local commodities correspond to the requirements of food bars production. The second stage done to seek the composition of each component i.e. sweet potato flour, cowpea flour, and mung beans flour and also konjac flour addition to reach a good food bars characteristics. The product was then evaluated in terms of product appearance, nutritional value, and acceptance by consumers. The outcome of this study was to utilize local commodities convert to product that can be adopted by the rural community. The result show that the composition of sweet potato flour, cowpea flour, and mung bean flour of 50: 20: 30 with the addition of 25 grams konjac flour was the best composition. Glucomannan of konjac flour affects to the quality of food bars especially to its strength.

1. Introduction

More than 30 types of tube are commonly grown and consumed as a source of carbohydrate for Indonesian. However, the existing potentials are not yet to be fully utilized by people who normally only use fresh bulbs or beans. Development of tuber-based products combined with additional material commodities such as nuts would provide an added value for the public. Local foods have a wide diversity and potential to be developed as an ingredient of food bars, both in terms of availability, diversity and nutritional value.

Food bars are dense and compact food without causing thirst (non-thirsty provoking), has high protein content and able to provide normal daily requirement of vitamins and minerals [1]. In addition, food bars should be nutritious [2], ready to eat, satiety, effective and efficient in long term packaging, storage, supply, and distribution [3]. Food bars produced from sweet potatoes, mung beans, cowpea, konjac expected to be a food product which is easily consumed, as well as provided an added value to the pattern of today’s modern society [4].
Sweet potato is a plant that has the potential to be a non-rice food. Use of sweet potato as a source of carbohydrates and food ingredient has advantages of improving people's nutrition. Besides being rich in calories, sweet potatoes contain high nutrients. In addition to sweet potatoes, mung beans have also been considered as one of the commodities that can be used as food ingredients due to their quite high nutrient levels. However, some compounds of anti-nutrients such as polyphenols (tannins) and azamphytate, as well as antitrypsin and oligosaccharides were also found in mung beans which can cause flatulence [5]. The third ingredient is cowpea, which contains protein in the range of 13 to 22.5%. Based on the location of accumulation, granule protein is mostly contained in the embryo and cotyledon, while only small amount is found in the seed coat. Protein in cowpea consists of 90% and 10% albumin globulin [6]. These three materials can be homogenised into a mixture with konjac flour. Konjac contains glucomannan polysaccharide compounds and has a high content of water-soluble dietary fiber [7].

This study simed to valorise sweet potato, cowpea, mung beans, and konjac into flour mixture to produce food bars. The outcome of this study was expected to promote the creation of small-scale industries in the community and create jobs for the local economy.

2. Materials and Methods
2.1. Materials
Raw materials used to make food bars i.e yellow sweet potato, cowpea, and mung beans were purchased from local market in Malang City, East Java, Indonesia. Those materials were dried using oven at temperature of 60 °C for 24 hours. Following a grinding process to achieve flour powder with 200 mesh. Konjac flour obtained from its producer in Madiun City. All flour was roasted for 10 minutes prior use in the food bars mixture.

2.2. Methods
Completely randomized design was employed in this study with two factors i.e. flour composition ratio and Konjac flour concentration (12.5% w/w - F₁ and 25% w/w - F₂). Three level of flour composition ratio (w/w) were as follows:

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W₁ = \text{Sweet potato: Cowpea: Mung beans in proportion of 5: 2: 3 respectively.}
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W₂ = \text{Sweet potato: Cowpea: Mung beans in proportion of 5: 2.5: 2.5 respectively.}
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W₃ = \text{Sweet potato: Cowpea: Mung beans in proportion of 5: 3: 2 respectively.}
\]

2.3. Experimental procedures
To produce food bars, all flour was mixed together with eggs and butter to make a dough. At this stage, the ideal consistencies of the dough need to be achieved. Stir well all ingredients using mixer and then transfer the mixture to square metal baking pan. The use of mixer in stirring process helps to form a homogenous dough without causing an excessive proofed [8]. Firmly pressed the mixture into baking pan and tightly packed to keep the bars from crumbling. The important factor to consider in this process is the speed of material flow, gradient, temperature, humidity and air velocity. The use of oven to bake was aimed to transform the raw dough into a product that is lightweight, porous and easy to digest. In previous study, the focus was on physical effect of heat to the CO₂ gas trapped by increasing the pressure. During drying process, heat penetration occurs at the bottom and at the top. Heat penetration was running slow in the middle section, making it easier to form an air cavity and a porous structure. During baking process, the bonding in the flour particles was reduced because the fat was melting. Such condition, combined with the influence of increasing temperatures, can trigger the air to move the dough, thus creating a more porous structure and an expanding volume [9].

The parameters analyses include water content, texture and colour. Colour of food bars was measured using a color reader with parameters readings include (L⁰) express the brightness or dark light, redness value (a*) and yellow value (b*).
3. Results and Discussion

3.1. Water content of raw materials

Water content of yellow sweet potato flour, mung bean flour, and cowpea flour was analysed and compared with several literatures as seen in Table 1.

| Parameter       | Sweet potato flour | Mung beans flour | Cowpea flour |
|-----------------|--------------------|------------------|--------------|
| This study      | 6.91               | 7.00             | 8.04         |
| Da Silva et al. | 10                 | This study       | 5.07         |
| Santos and      | 8.4                | Purwani [5]      | 7.61         |
| Purwani and     |                    | Santosa [6]      | 6.88         |

The water content affects the durability of both wet and dry food products. A high water content in the food leads the growth of moulds, thus reducing the food shelf-life. Although all flour ingredients used in this study have higher water content, the values were still within the safe limits for storage of 14%.

3.2. Water content of food bars

Figure 1 shows that the water content of food bars in all treatments, either before or after baking process, was higher than that of the control product. This was possibility influenced by the water content of main ingredients (i.e. all flour), as well as the use of egg and the melted butter. According to Cauvain and Young [11], an increase in the water content can reduce the hardness of the products due to loss of the crunchy characteristics. Food bars product in this study was expected not too crunchy, which has similar characteristics with biscuits and cakes, and a little bit hard. Therefore, the values of water content in this emergency food bars can further be used as quality parameter to estimate the life-span of food product.

![Figure 1. Water content of food bars.](image)

3.3. Texture of raw materials and food bars

The texture of raw material used in the making of food bars affects the product’s texture. Texture of yellow sweet potato, cowpea and mung beans in different treatments is shown in Table 2.

| Treatment     | Water content before | Water content after |
|---------------|----------------------|---------------------|
| F1W1          | 24.5                 | 19.8                |
| F1W2          | 25.2                 | 20.9                |
| F1W3          | 26.3                 | 21.7                |
| F2W1          | 25.8                 | 21.3                |
| F2W2          | 26.4                 | 22.2                |
| F2W3          | 27.1                 | 22.7                |
| Control (Soyo) | 24.0                | 19.0                |
| Skin          |                      |                     |
| Skinless      |                      |                     |

A high value of texture indicates that the material is hard, while a small texture value represents that the material tend to be softer. Table 2 shows that yellow sweet potato has a softer texture compared to that of cowpea and mung beans. In addition, when comparing between with and without skin (skinless) cowpea, it can be seen that skinless cowpea has higher texture values in all pre-treatment. This is possibly due to the presence of the under layer of the cowpea skin which kept the seeds attached and provided strong enough protection. Both, mung bean and cowpea have a hard texture, therefore, pre-treatment of soaking and steaming was employed to make it softer.
Table 2. Comparison of hardness (texture) in sweet potato, cowpea and mung beans

| Materials | Treatment | Texture (g/mm²) |
|-----------|-----------|----------------|
|           |           | Sweet potato   | Cowpea          | Mung beans       |
|           |           | With skin      | Without skin    |  (Skinless)      |
| Raw       | -         | 0.00042        | -               | -               |
| Soaking   | -         | 0.319          | 0.718           | 3.636           |
| Steaming  | -         | 0.349          | 0.835           | 8.58            |

In the making process of food bars, yellow sweet potatoes flour is used as a source of carbohydrates and it can form its own texture. Both mung beans and cowpea are used as sources of protein. Therefore, using potato flour can make the food bars becoming denser and looks hard. Roasting treatment has no impact on the potato starch, flour cowpea and mung beans flour. However, the roasting process was found to destruct the surface texture food bars possibly due to excessive swelling of potato starch. Such condition can develop cracks in the food bars, thus reducing the appearance and the value of sensory acceptance of the product. The resulting product textures are relatively dry on the outside and wet on the inside. The texture level of the product was also influenced by the concentration of konjac flour added (Figure 2 and 3). Konjac flour contains glucomannan and has a high ability to absorb water, causing the dough to become more resilient. In addition, konjac also has the ability to expand in the water reached the values of 138-200%. When heated, the heat energy can break the hydrogen bonds thus water binding capability in the starch is increasing and can expand larger [12].

Nuts provide an important role in the increase levels of a protein that cannot be fulfilled by the sweet potato flour. On emergency food products, protein are essential to meet the protein’s energy needs which amounted for 7-10% of total calories [13]. In making bread, fat or fatty acids plays an important role as an ingredient that helps the development of the dough’s texture, causing cake to become softer [14]. Eggs and margarine are known as a source of essential fatty acids and used as the main source of fat in food bars.

![Figure 2. Texture of food bars with concentration of konjac 12.5%](image-url)
3.4. Colour of food bars

Table 3 shows the test results on the product of the color produced. Colour is an aspect that is considered by consumers when receiving products other than appearance. The colour of a product is influenced by the physicochemical properties of the raw material (dough) [10] include water content, reducing sugar, amino acids, and the operating conditions during the process [15]. The ratio of flour combination was found to influence the level of brightness, reddish and yellowish of the food bars products. An increase in the ratio of mung beans flour added has impacts on increasing the redness level and decreasing the yellowish level. This is possibly because the protein contained in mung beans prompts Maillard reactions to occur. The Maillard reaction is a reaction between carbohydrates, especially sugars with primary amino groups. This reaction triggers the browning process in any food products.

Table 3. Colour of food bars (in average values).

| Treatment | Colour |
|-----------|--------|
|           | L*     | a*     | b*     |
| F1W1      | 40.13  | 15.23  | 19.30  |
| F1W2      | 41.07  | 15.07  | 19.57  |
| F2W1      | 39.53  | 17.40  | 16.87  |
| F2W2      | 37.40  | 16.03  | 15.95  |
| F3W1      | 36.63  | 14.93  | 15.10  |
| F3W2      | 35.40  | 15.87  | 15.27  |

Figure 4. Food bars.
4. Conclusion
The best composition to make food bars was 50% of yellow sweet potato flour, 30% of cowpea flour, mung bean flour, and 25% of Konjac flour. The composition of this material has 20% the texture of the highest value is 19.4 N. This is because the amount of Konjac flour used higher so the dough will be more glue. The protein content 7.42% has been meeting the needs of a protein on that product, and also has the higher fat content 18.27%. The brightness colour is a result from the higher level of sweet potato.

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