Production of Chinese bun from sweet potato and its financial feasibility analysis

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Abstract. The physical, chemical and sensory characteristics of Chinese buns prepared from purple and orange-fleshed sweet potato paste were studied in terms of supporting local food diversification. The promising genotypes used were MSU 10003-07 (purple) and MSU 14014-84 (orange). The steamed tubers from both genotypes were analyzed physically and chemically (including anthocyanin and beta-carotene contents) then processed into Chinese bun with the proportion of sweet potato paste 0% (100% wheat flour), 10%, 20%, 30% and 40%. The results showed that the proportion of sweet potato paste significantly affected the moisture content, color, hardness, porosity, volume development, and yield of Chinese bun. Based on physical, chemical and sensory analysis, the use of 30% purple and orange-fleshed sweet potato paste was preferred by panellists and had better quality than other levels. Using the selling price of IDR 3,000 per piece, the use of 30% purple and orange-fleshed sweet potato paste showed a slightly higher profit margin compared to 0% sweet potato paste, consecutively 64.8, 65.1, and 64.3. The production of Chinese bun from sweet potato was profitable and financially feasible to be applied further indicated by the value of B/C ratio which was more than 1 (1.74 for purple and 1.76 for orange-fleshed). This suggests that sweet potato is promising and feasible for Chinese bun production, thus needs to be promoted for its health benefits.

1. Introduction

Chinese bun is a fermented and steamed wheat flour product, which usually has a white color and soft texture with a round pillow shape. The main ingredients of Chinese bun are wheat flour, water, and yeast, with additives such as sugar, baking powder, shortening, alkaline salt, and emulsifier that are added to improve product’s quality and yield [1]. Along with the development of food technologies, Chinese bun products can be prepared using a variety of local food sources which one of potential is sweet potato. In Indonesia, the product is known as ‘bakpao ubi’ or ‘bakpao telo’.

Sweet potato is promising in the future as it is projected as an important raw material for food industries [2]. Sweet potato also belongs to functional food due to its potential health benefits with the respect to the natural presence of beta carotene, which has high pro-vitamin A and anti-oxidative activities in the orange-fleshed [3] and anthocyanin, which has anti-oxidative activities in the purple-fleshed [4]. In terms of Chinese bun preparation, carotenoid and anthocyanin pigments in sweet potato can provide natural colors to the buns (orange and purple, respectively), thus they can be clearly distinguished from the common color of Chinese bun (white). Currently, the development of food products with an attractive appearance is essential for food industries. However, the use of particular artificial colorshas demonstrated negative impacts to human health, therefore food industries are increasingly turning to the use of natural food colorants [5].
Two genotypes of sweet potato, namely MSU 10003-07 for purple-fleshed and MSU 14014-84 for orange-fleshed are promised to be released as new improved varieties. Both genotypes are also promised to be used as Chinese bun ingredients in the form of paste or mash. Previous study [6] showed that the use of 20% of Beta 1 paste could give good physical and chemical characteristics of Chinese bun. Beta 1 is the improved variety of orange-fleshed sweet potato released by the Indonesian Ministry of Agriculture in 2009. The bun had moisture content of 32.3%, the number of pores of 37.7, and the volume development of 136.5%. However, another study reported that sweet potato paste could substitute wheat flour up to 30% in Chinese bun preparation [7]. Therefore, the physical, chemical and sensory characteristics of Chinese buns prepared from sweet potato paste derived from promising genotypes of purple-fleshed (MSU 10003-07) and orange-fleshed (MSU 14014-84) were studied in terms of enhancing the adoption by farmers and utilization by food industries once they are released as new varieties. The economic aspect of Chinese bun production from sweet potato was also studied to find out its financial feasibility.

2. Materials and Method
The study was performed at the Food Chemistry and Technology Laboratory of Iletri, Malang. Sweet potato promising genotypes, namely MSU 10003-07 (purple-fleshed) and MSU 14014-84 (orange-fleshed) were grown at Karangnongko Village, Poncokusumo Sub-regency, Malang Regency in the rainy season (October 2017) and harvested after 4.5 months of planting.

The steps of making sweet potato paste [6] included sorting the fresh tubers, washing, steaming, removing the peels, then mashing to obtain the paste or mash. The Chinese bun making was referred to [6]. All ingredients (wheat flour, sweet potato paste, white margarine, and sugar) were mixed, then instant yeast and water were added and stirred until smooth. The dough was fermented in two stages, the first was allowed for 60 min under anaerobic condition, then the dough was weighed 50 g each, formed into Chinese buns, fermented in the second stage (proofing) for 20 min under anaerobic condition, and steamed for 7 min.

The study was conducted in three stages. The first stage was analyzing the physico-chemical properties of steamed tubers from two promising genotypes which include moisture content [8], beta carotene [9] and anthocyanin [10] for chemical analysis and color using color reader [11] for physical analysis. The second stage was making the Chinese buns using five levels of sweet potato paste proportion (0% or 100% of wheat flour, 10%, 20%, 30% and 40%). The trial was conducted using a Completely Randomized Design (CRD) with three replicates. Analysis of Chinese buns’ chemical properties included moisture content [8], while the physical properties included Hunter color (L*, a*, and b*) using a color reader [11], hardness using Texture Profile Analyzer [12], number of pores, and volume development. The sensorial attributes were analyzed for color, taste, aroma, and texture preferences using a hedonic test with 20 panelists [13]. Data obtained was then analyzed using Analysis of variance (ANOVA), followed by Least Significant Difference (LSD) test with a confidence level of 5%. The third stage was performing a financial feasibility analysis of Chinese buns production using the selected level of sweet potato paste obtained from the second stage (30%). Variables measured were production costs, revenue, and profit. Data analysis was profit margin and B/C ratio.

3. Results and Discussion
3.1. Physico-chemical characteristics of steamed sweet potato tubers
The moisture content of orange-fleshed sweet potato decreased from the fresh form into steamed tuber due to evaporation of some water in the tuber during steaming process [14]. In addition, mashing of steamed tuber into paste caused the surface area larger, thus more water might be evaporated and consequently decreased the moisture content of the paste [15]. However, it contrasted with the increase of the purple-fleshed sweet potato moisture content that could be caused by gelatinisation when the tubers were steamed and the water penetrated into the starch [16].
The decrease of anthocyanin in purple-fleshed genotype was due to a high temperature and long time during steaming [17]. Steaming can reduce anthocyanin content by 8-16% [18] and it was in accordance with the result of this study which was 12-15% (Table 1). The decrease of beta carotene from fresh sweet potato to steamed tuber was 81% (Table 1). Heating can trigger oxidation and degradation of carotenoid thus increasing the possibility of losing carotenoids compounds [19].

Table 1 showed that there was a difference in the flesh color of sweet potato after steaming. The lightness colors (L*) of both steamed sweet potato were lower than those of their fresh tubers. It indicated that steaming could make the tuber color darker. Similar decrease was also occurred in the value of a* (redness) and b* (yellowness) paste in relation to steaming.

Table 1. Physico-chemical characteristics of fresh and steamed tubers of sweet potato

| Characteristics       | Purple-fleshed sweet potato (MSU 10003-07) | Orange-fleshed sweet potato (MSU 14014-84) |
|-----------------------|--------------------------------------------|-------------------------------------------|
|                       | Fresh | Steamed | Fresh | Steamed |
| Moisture (%)          | 69.2  | 70.2     | 77.0  | 74.7    |
| Beta carotene (µg/100 g %fw) | -     | -        | 7,261.7 | 1,366.7 |
| Beta carotene (µg/100 g %dw) | -     | -        | 28,657.0 | 5,381.5 |
| Anthocyanins (%fw)    | 139.7 | 118.5    | -     | -       |
| Anthocyanins (%dw)    | 454.0 | 397.9    | -     | -       |
| Fleshcolour:          |       |          |       |         |
| L*                    | 40.4  | 29.1     | 72.0  | 54.0    |
| a*                    | 38.3  | 23.9     | 68.7  | 45.0    |
| b*                    | 11.7  | 8.9      | 54.3  | 40.2    |

Notes: fw = fresh weight; dw = dry weight; L* = lightness level that ranges from 0 (dark/black) to 100 (bright/white); a* = green (-100) up to red (+100); b* = blue (-100) up to yellow (+100)

3.2. Physico-chemical characteristics of Chinese bun

The substitute proportion of sweet potato paste to wheat flour for making Chinese buns showed a significant effect on the physico-chemical properties of Chinese buns as shown in Table 2 and 3.

Table 2. Physico-chemical characteristics of Chinese buns with various proportion of purple-fleshed sweet potato paste (MSU 10003-07)

| Characteristics               | Proportion of sweet potato paste | 0%       | 10%      | 20%      | 30%      | 40%      |
|--------------------------------|----------------------------------|----------|----------|----------|----------|----------|
| Moisture (%)                   | 34.7c                            | 36.6b    | 38.1a    | 37.8a    | 37.7a    | 1.1      |
| Number of pores                | 104a                             | 78b      | 62c      | 61c      | 57d      | 1.3      |
| Volume development (%)         | 130.4a                           | 115.1b   | 112.8b   | 114.1b   | 92.4c    | 0.3      |
| Hardness (N)                   | 2.0d                             | 2.5d     | 4.1c     | 6.6b     | 7.8a     | 0.6      |
| Fleshcolour:                   |                                  |          |          |          |          |          |
| L*                             | 75.4a                            | 55.9b    | 49.9c    | 44.8d    | 42.9e    | 0.8      |
| a*                             | 43.5a                            | 41.5b    | 40.6c    | 37.8e    | 38.6d    | 0.6      |
| b*                             | 33.6a                            | 15.8b    | 12.0c    | 10.1d    | 8.4e     | 0.5      |

Notes: Values in the same line that followed by different letters are significantly different at p < 0.05. L* = lightness level that ranges from 0 (dark/black) to 100 (bright/white); a* = green (-100) up to red (+100); b* = blue (-100) up to yellow (+100)

The proportion of sweet potato paste significantly affected the moisture content of Chinese buns. The bun made from 100% of wheat flour had the lowest moisture content, followed by 10% paste...
substitution, while the highest moisture was observed in the substitutions of 20%, 30%, and 40%. The differences in moisture content were related to the initial moisture content of sweet potato paste used, which was 70.2% for the purple-fleshed and 74.7% for the orange-fleshed (Table 1), which were much higher compared to that of wheat flour, i.e. 14.5% [20]. Therefore, the higher the proportion of sweet potato paste used, the higher the moisture content of Chinese bun.

Pores in bread products are formed due to the development of CO₂ gas during steaming. This gas was produced by yeast activity during fermentation. The highest number of pores was observed in the bun prepared from 0% of sweet potato paste, while the proportion of 40% of sweet potato paste had the least number of pores. The more pores formed on the Chinese bun, the volume development of the dough also increased (Tables 2 and 3). In addition, the pores formed were influenced by the moisture content of the dough. The higher the moisture content, the less pores formed because the dough was heavier, and the volume was difficult to be highly developed [21].

The proportion of sweet potato paste showed a significant effect on the level of hardness of the Chinese bun. The bun with the proportion of 40% of sweet potato paste had the highest hardness level (firm), followed by the treatments of 30%, 20%, and 10% paste, while the lowest was 0% of sweet potato paste (tender). This showed that the greater the proportion of sweet potato paste, the higher the hardness level of Chinese bun due to a lower of gluten content which had elastic characteristic, thus the bun dough was more difficult to expand when steamed. Hardness was closely related to volume development. A product with high volume development usually has a low hardness level.

Table 3. Physico-chemical characteristics of Chinese buns with various proportion of orange-fleshed sweet potato paste (MSU 14014-84)

| Characteristics          | Proportion of sweet potato paste | 0%     | 10%    | 20%    | 30%    | 40%    | LSD 5% |
|--------------------------|---------------------------------|--------|--------|--------|--------|--------|--------|
| Moisture (%)             |                                 | 35.3e  | 36.4d  | 38.0c  | 40.2b  | 42.8a  | 0.2    |
| Number of pores          |                                 | 169a   | 131b   | 117c   | 102d   | 72e    | 8.6    |
| Volume development (%)   |                                 | 180.8a | 162.3ab| 145.3bc| 140.0c | 118.6d | 20.1   |
| Hardness (N)             |                                 | 2.2d   | 2.3ed  | 2.6c   | 3.6b   | 5.8a   | 1.1    |
| Fleshcolour:             |                                 |        |        |        |        |        |        |
| L*                       |                                 | 76.0a  | 74.2a  | 67.9b  | 66.3b  | 62.8c  | 1.8    |
| a*                       |                                 | 42.8b  | 43.7b  | 43.5b  | 45.3a  | 45.8a  | 0.9    |
| b*                       |                                 | 34.3d  | 38.7c  | 41.9b  | 43.0ab | 43.5a  | 1.2    |

Notes: Values in the same line that followed by different letters are significantly different at p < 0.05. L* = lightness level that ranges from 0 (dark/black) to 100 (bright/white); a* = green (-100) up to red (+100); b* = blue (-100) up to yellow (+100)

The result of Chinese bun color analysis showed that the proportion of sweet potato paste had a significant effect on the lightness level (L*). The higher the proportion of sweet potato paste, the lower the Chinese bun lightness level (Tables 2 and 3). In purple-fleshed sweet potato Chinese bun, the redness (a*) and yellowness (b*) also decreased with the increasing of purple-fleshed sweet paste potato proportion (Table 2). The color of Chinese bun with a proportion of 0% of purple-fleshed sweet potato paste was yellowish white, while the bun prepared with 40% of purple-fleshed sweet potato paste had a deep purple color. This result was in contrast to the orange-fleshed sweet potato Chinese bun, where the values of a* and b* were increasing along with the higher proportion of orange-fleshed sweet potato paste (Table 3). The yellow or orange color of the buns was considerably related to the beta carotene content in sweet potato paste. The higher the proportion of orange-fleshed sweet potato paste used, the deeper the orange color of Chinese bun produced.
3.3. Sensorial attributes of Chinese bun

The results of sensory analysis of Chinese bun made from sweet potato paste with proportion of 0% up to 40% were shown in Table 4. The Chinese bun colour made from 0% of sweet potato paste was the most preferred by panelists as they were already familiar with the yellowish white colour of common Chinese bun. However, panelists also preferred the colour of Chinese bun made from 30% and 40% of purple-fleshed paste as they had attractive bright purple colors. Meanwhile, the buns prepared from 10% and 20% sweet potato paste were less liked due to their pale purple colour. Conversely, the Chinese bun made from orange-fleshed sweet potato paste with 40% proportion had the lowest color preference score compared to those of 0% to 30% proportions. The 40% proportion of sweet potato paste caused the darker color, thus less preferred by panelists.

There was no significant difference in preference scores of aroma and taste of Chinese bun prepared from various proportions of purple and orange-fleshed sweet potato paste. The proportion of sweet potato paste up to 30% was fairly liked by panelists. The sweet potato paste could rise the sweet taste of Chinese bun and made its score of preference was similar to that of Chinese bun made from 100% of wheat flour. However, the proportion of 40% of sweet potato paste was less preferred by panelists as it might produce excessive sweet taste due to the more paste used.

The preference for sweet potato Chinese bun texture was also not affected by the proportion of sweet potato paste. The texture of Chinese bun made from sweet potato paste 0% to 30% was fairly liked by panelists. Meanwhile, the proportion of 40% of sweet potato paste was less preferred. Higher proportion of sweet potato paste made the bun moist as it could not maximally expand. This was due to less gluten content, thereby the bun could not properly hold the fermented gas. Chinese bun made from 100% of wheat flour was yet the most preferred by panelists because it had an elastic texture compared to those of the buns with proportion of sweet potato paste 10% up to 40%.

Table 4. Sensorial attributes of Chinese buns with various proportion of sweet potato paste

| Attributes* | Proportion of sweet potato paste |
|-------------|---------------------------------|
|             | 0% | 10% | 20% | 30% | 40% |
| Colour*     | 4.1a | 4.2a | 2.4b | 3.2b | 2.8b | 3.2b | 4.0ab | 3.0b | 4.0ab | 2.7c |
| Aroma*      | 3.5 | 3.6 | 3.4 | 3.5 | 3.7 | 3.4 | 3.6 | 3.5 | 3.8 | 3.3 |
| Taste*      | 3.6 | 3.6 | 3.3 | 3.6 | 3.7 | 3.8 | 3.9 | 3.6 | 3.8 | 3.4 |
| Texture*    | 3.8 | 3.8 | 3.4 | 3.6 | 3.7 | 3.5 | 3.8 | 3.5 | 3.2 | 3.4 |
| Texture**   | 3.7 | 4.0 | 3.6 | 3.8 | 3.8 | 3.7 | 4.0 | 3.7 | 3.6 | 3.7 |

Notes: Values in the same line that followed by different letters are significantly different at p < 0.05.

* Acceptance score of colour, aroma, texture, and taste:
* * Texture score:
1 = Dislike very much 4 = Like moderately 1 = Very firm 4 = Elastic
2 = Dislike moderately 5 = Like very much 2 = Firm 5 = Very elastic
3 = Like slightly 3 = Elastic slightly

Based on the results of physico-chemical and sensory analysis, it was found that the proportion of purple-fleshed sweet potato paste of MSU 10003-07 genotype and orange-fleshed of MSU 14014-84 genotype for preparation of Chinese bun gave good physico-chemical quality and was still acceptable up to 30% of proportion. Therefore, production of Chinese bun with 30% proportion of purple and orange-fleshed sweet potato would further analyzed for their financial feasibility.

3.4. Financial feasibility analysis of Chinese bun production

The average production of Chinese bun was 160 buns per day (home-scale industry) and the selling price was IDR 3,000 per bun, therefore it gave the revenue about IDR 480,000 per day or IDR 124,800,000 per year (1 year = 260 days). The difference in production costs between Chinese bun made from purple and orang-fleshed sweet potato was arisen from the component of raw material,
primarily the price of fresh sweet potato tuber. In the market, the price of purple-fleshed sweet potato was higher than other cultivars of sweet potato like the white, yellow, and orange-fleshed. At present study, the price of purple-fleshed sweet potato was IDR 6,000 per kg, while it was 30% cheaper for orange-fleshed sweet potato, around IDR 4,200 per kg. However, the price of fresh sweet potato was yet lower than that of wheat flour (hard wheat type) which had price of IDR 12,000 per kg. In this case, the use of sweet potato as a substitute for wheat flour in Chinese bun production could compress the cost of raw material up to 4.2% for purple Chinese bun and 7.0% for orange Chinese bun. In addition, the different production cost between the Chinese bun prepared from sweet potato paste and 100% wheat flour due to the depreciation of main equipment i.e. grinder for mashing steamed sweet potato into paste in the processing of Chinese bun from sweet potato which was not performed for processing of Chinese bun from 100% of wheat flour.

The result of profit margin analysis showed that the production of Chinese bun from sweet potato was slightly profitable compared to that of Chinese bun production from 100% of wheat flour. The profit margin obtained from the production of Chinese buns from orange-fleshed sweet potato was higher (65.1%) compared to those of the purple-fleshed (64.8%) and 100% of wheat flour (64.3%) as presented in Table 5. The B/C ratio value for production of both the purple and orange Chinese buns was around 1.7, suggesting that for every IDR 1,000 invested for the Chinese bun production would give the profit around IDR 1,700. It is reflecting that the production of Chinese bun using 30% of both sweet potato paste was profitable and financially feasible. The raw material is also available and can be continuously provided through partnership with sweet potato farmers.

4. Conclusions
The use of 30% of purple and orange-fleshed sweet potato paste gave good physical and chemical characteristics of Chinese bun produced as well as their sensorial attributes were preferred by panelists. The production of Chinese bun using 30% of both purple and orange-fleshed sweet potato paste had a slightly higher profit margin compared to that of 0% of sweet potato paste, that was consecutively 64.8; 65.1; and 64.3 at a selling price of IDR 3,000 per bun. The B/C ratio was 1.74 and 1.76 for purple and orange-fleshed sweet potato Chinese bun production, respectively. This suggests that the production of Chinese bun from sweet potato paste was profitable and financially feasible to be applied.

### Table 5. Financial feasibility of Chinese bun production

| Components                | Formula | Purple 30% | Orange 30% | 0% (as comparison) |
|---------------------------|---------|------------|------------|--------------------|
| Production per day (unit) | A*160   | 160        | 160        | 160                |
| Production per year (unit)| B*41,600| 41,600     | 41,600     | 41,600             |
| Selling price (IDR/unit)  | C*3,000 | 3,000      | 3,000      | 3,000              |
| Revenue per day (IDR)     | D*480,000| 480,000   | 480,000    | 480,000            |
| Revenue per year (IDR)    | E*124,800,000| 124,800,000| 124,800,000| 124,800,000        |
| Production cost per year (IDR) | F*43,970,297| 43,584,847| 44,539,657|
| Initial investment costs (IDR) | G*2,490,000| 2,490,000| 2,290,000|
| Profit                    | H*80,829,703| 81,215,153| 80,260,343|
| Profit margin (%)         | I*64.8   | 65.1       | 64.3       |
| B/C ratio                 | J*1.74   | 1.76       | 1.71       |
| Financial feasibility decission | Feasible | Feasible | Feasible |
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