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# Beta-Carotene, Anthocyanin, Antioxidant Activity, and Microbiological Stability of Steamed Sponge Cakes as Alternative Post-Disaster Snack

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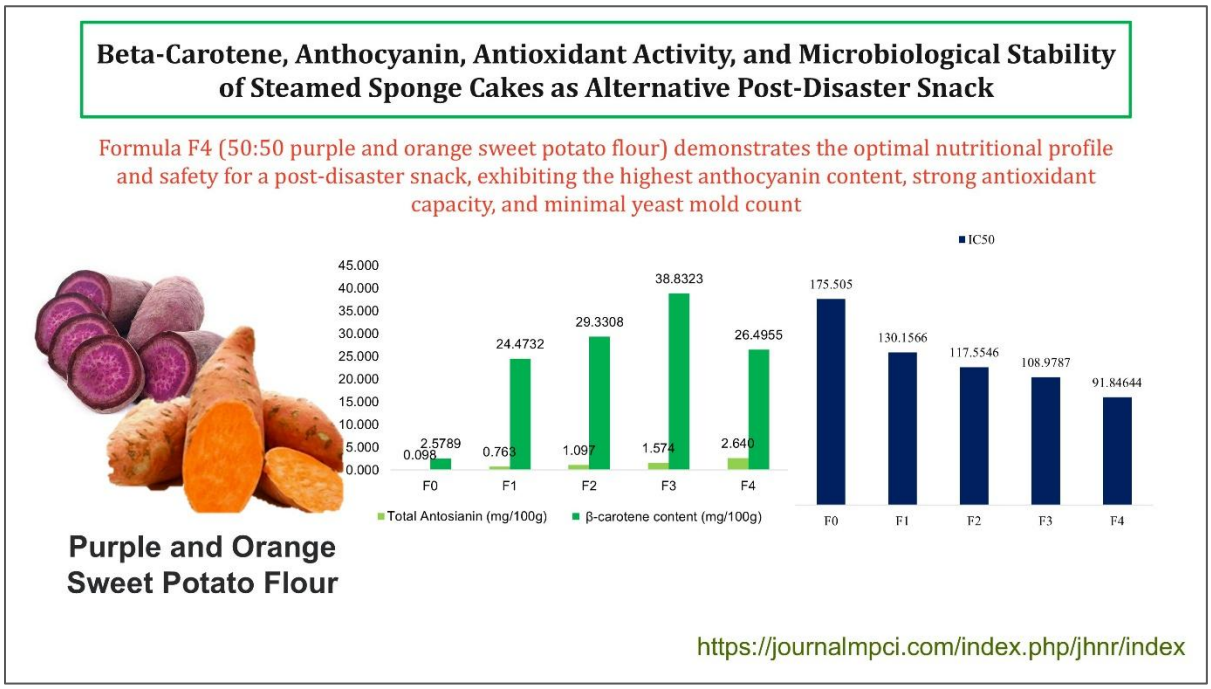
**ABSTRACT**

The research aims to analyze the levels of beta carotene, anthocyanin, antioxidant power (IC50), and yeast numbers of steamed sponge cake mold based on a combination of purple sweet potato flour (Ipomoea Batatas L.) and orange sweet potato flour (Ipomoea Batatas L.) as an alternative post-disaster snack. The type of research was a Factorial Completely Randomized Design (CRD) using a ratio of wheat flour and a combination of purple sweet potato flour and orange sweet potato flour, namely 100:0 (F0), 80:20 (F1), 70:30 (F2), 60: 40 (F3), and 50:50 (F4). Data analysis included beta carotene, anthocyanin, IC50 of antioxidant activity, and mold yeast numbers. The steamed sponge cake with the highest anthocyanin content is formula F4 (2.64 mg/100 g), followed by formula F3 (1.57 mg/100 g). The β-carotene levels (mg/100g) show that the F3 formula is the highest, at 38.83 mg/100 g, and the F2 formula is 29.33 mg/100 g. The most potent antioxidant power is the F4 formula of 91.84 µg/mL. Formula F4, at a dilution of 10-6, obtained the lowest yeast number, 7 CFU/mL. Formula F4 is the best formula of the four formulas tested. Formula F4 has high levels of anthocyanin, β-carotene, antioxidant power, and the lowest number of yeast molds.

**Key Messages:**

- Formula F4 (50:50 purple and orange sweet potato flour) demonstrates the optimal nutritional profile and safety for a post-disaster snack, exhibiting the highest anthocyanin content, strong antioxidant capacity, and minimal yeast mold count

## GRAPHICAL ABSTRACT




## INTRODUCTION

Sweet potatoes *(Ipomoea batatas L.)* are a variety of food raw materials that are abundant and easy to grow in Indonesia, and their productivity continues to increase, but their utilization is still minimal (1). The nutritional content of fresh purple sweet potato consists of 22.64% starch, 0.94% fat, 0.77% protein, 70.46% water content, 0.84% ash content, and 3.00% fiber. (2). Moreover, the nutritional content of fresh orange sweet potatoes consists of 24.47% starch, 0.11% reducing sugar, 0.68% fat, 0.49% protein, 68.78% water content, 0.99% ash content, and fiber 2.79% (3,4). Central Sulawesi Province 2018 had an average productivity of 14.02 tons/year with an average sweet potato growth of 15,464 tons/year (5). Seeing the increasing productivity of sweet potatoes as one of the local foods whose use is still minimal, sweet potatoes have the potential to be a functional food ingredient and an alternative snack menu.

Processing sweet potatoes into flour has the potential to develop into a functional food source with a low glycemic index; namely, white sweet potatoes have a glycemic index of 54, purple sweet potatoes 54, yellow sweet potatoes 54, and orange sweet potatoes 54 (6–8), which, if consumed, will not increase blood sugar levels drastically. Many food preparations can be made using sweet potato flour as the primary raw material, one of which is steamed sponge cake (9). Snack food is a term for foods not part of the main menu (breakfast, lunch, and dinner), which help relieve hunger for a while, provide a little energy to the body, and are eaten to enjoy the taste. Snacks cannot replace breakfast, lunch, and dinner because of their low-calorie count (10).

Steamed bolu is a traditional cake that has long been popular among Indonesians and can be consumed by everyone, from children to older people. Steamed sponge cake is generally made from wheat flour. Still, as food processing methods develop, steamed sponge cake can be modified to use essential ingredients other than wheat flour to increase the nutritional value of steamed sponge cake. A good steamed bolu is a steamed bolu with attractive characteristics in appearance and in terms of its sweet taste and the appropriate texture, namely soft and tender (11). The reason for choosing steamed sponge cake is because steamed sponge cake is very well known by the Indonesian people. Steamed sponge cake is also a snack that is easy to make and created into various forms of steamed sponge cake. The ingredients used are also simple and very easy to obtain.

The research aims to analyze the levels of beta carotene, anthocyanin, antioxidant power ($IC_{50}$), and yeast numbers of steamed sponge cake mold based on a combination of purple sweet potato flour



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*(Ipomoea Batatas L.)* and orange sweet potato flour *(Ipomoea Batatas L.)* as an alternative post-disaster snack.

## METHODS

This research used a factorial Completely Randomized Design (CRD) using a ratio of wheat flour and a combination of purple sweet potato flour and orange sweet potato flour: 100:0 (F0), 80:20 (F1), 70:30 (F2), 60: 40 (F3), and 50:50 (F4) (Table 1). Product formulation was carried out at the Organic Chemistry Laboratory, Faculty of Mathematics and Natural Sciences, Tadulako University. This research was carried out in July 2022. The materials used in this research consisted of three parts: 1) Ingredients for making purple and yellow sweet potato flour, as well as a combination of purple sweet potato flour and orange sweet potato flour; 2) Ingredients for making steamed sponge cake, including paper cups, sugar, eggs, purple and orange sweet potato flour, soda water, emulsion, protein wheat flour, and vanilla, 3) Materials for proximate analysis, such as 1.25% $H_2SO_4$ solution, 1.25% NaOH M, NaOH 3.25%, ethanol 96%, and filter paper.

The steamed sponge cake was formulated by preparing all the ingredients for making steamed cake, such as purple sweet potato flour and orange sweet potato flour, wheat flour, eggs, granulated sugar, soda water, vanilla, emulsifier, and paper cup. Then, the ingredients were weighed according to the predetermined formulation for the raw material formulation for making steamed sponge cake based on a combination of purple sweet potato and orange sweet potato flour (Table 1).

Table 1. Formulation (F) of raw materials for making steamed sponge cake per 100 grams

| **Materials** | **F0** | **F1** | **F2** | **F3** | **F4** |
|---|---|---|---|---|---|
| Purple and orange sweet potato flour (g) | 0 | 20 | 30 | 40 | 50 |
| Flour (g) | 100 | 80 | 70 | 60 | 50 |
| Sugar (g) | 45 | 45 | 45 | 45 | 45 |
| Egg (whole egg) | 1 | 1 | 1 | 1 | 1 |
| Soda water (mL) | 60 | 60 | 60 | 60 | 60 |
| Emulsifier (g) | 4 | 4 | 4 | 4 | 4 |
| Vanilla essence (g) | 1 | 1 | 1 | 1 | 1 |

Anthocyanin levels were measured using the UV-Vis Spectrophotometry method. This method is based on the ability of anthocyanins to absorb light at specific wavelengths. β-carotene levels can be measured using the UV-Vis Spectrophotometry method. This method is based on the ability of β-carotene to absorb light at wavelengths. Antioxidant power was calculated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. This method is based on the ability of antioxidants to inhibit DPPH reactions, which are free radicals. The mold-yeast number determined the food's yeast and mold contamination level. The suspension was then homogenized using a vortex mixer for 1 minute, then diluted gradually until the dilution was $10^{-6}$, then put in the incubator for 1x24 hours, and observed the growing colonies using a colony counter. Data processing for antioxidants ($IC_{50}$), anthocyanins, and yeast-mold numbers was done by comparing each treatment in a description.

## RESULTS

Figure 1 shows that the formula with the highest anthocyanin content is formula F4, 2.64 mg/100 g, followed by formula F3, 1.57 mg/100 g. The β-carotene levels (mg/100g) show that formula F3 is the highest, about 38.83 mg/100 g, and formula F2, about 29.33 mg/100 g. Figure 2 shows that the steamed cake with the most potent antioxidant power is the F4 formula of 91.84 µg/mL, which means the formula is in the powerful antioxidant category. In contrast, the F0 formula is 175.505 µg/mL, which is very weak.



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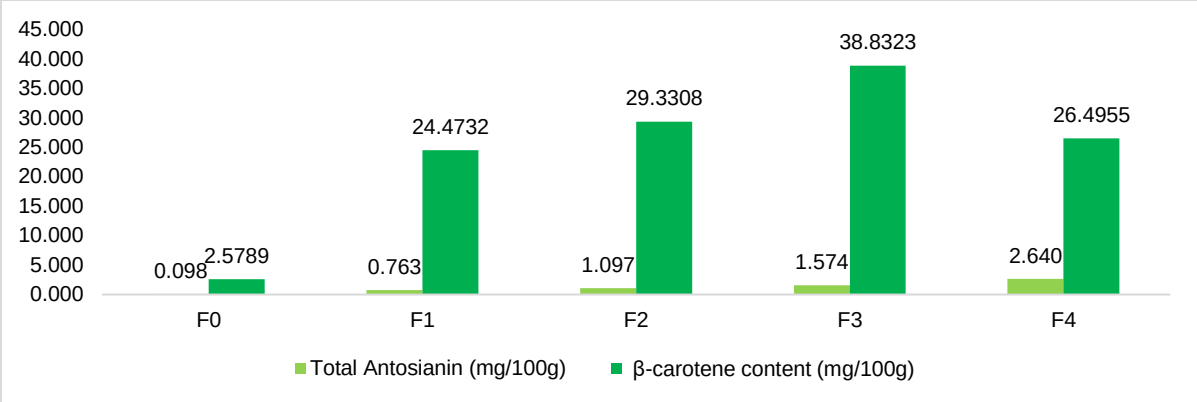


Figure 1. Anthocyanin levels (mg/100g) and β-carotene levels (mg/100g) of 5 steamed sponge cake formulas

Table 2 shows that Formula F4 at dilution $10^{-6}$ obtained the lowest mold-yeast number, about 7 CFU/mL. This indicates that Formula F4 has very low yeast and mold contamination, which means its shelf life can be relatively long. The shelf life of food products will be short if the sugar content in the food product is relatively high. This can be seen in Table 2, where the smaller the dilution (high sugar content), the relatively large the number of bacteria that grows, about >300 CFU/mL.

**Table 2.** Mold-Yeast Number Steamed Sponge Cake

| Dilution | Mold-Yeast Number (CFU/mL) | | | | |
|---|---|---|---|---|---|
| | F0 | F | F2 | F3 | F4 |
| $10^{-1}$ | >300 | >300 | >300 | >300 | >300 |
| $10^{-2}$ | >300 | >300 | >300 | >300 | >300 |
| $10^{-3}$ | >300 | >300 | >300 | >300 | 163 |
| $10^{-4}$ | 285 | >300 | >300 | 180 | 44 |
| $10^{-5}$ | 157 | 111 | 131 | 51 | 11 |
| $10^{-6}$ | 74 | 61 | 63 | 8 | 7 |

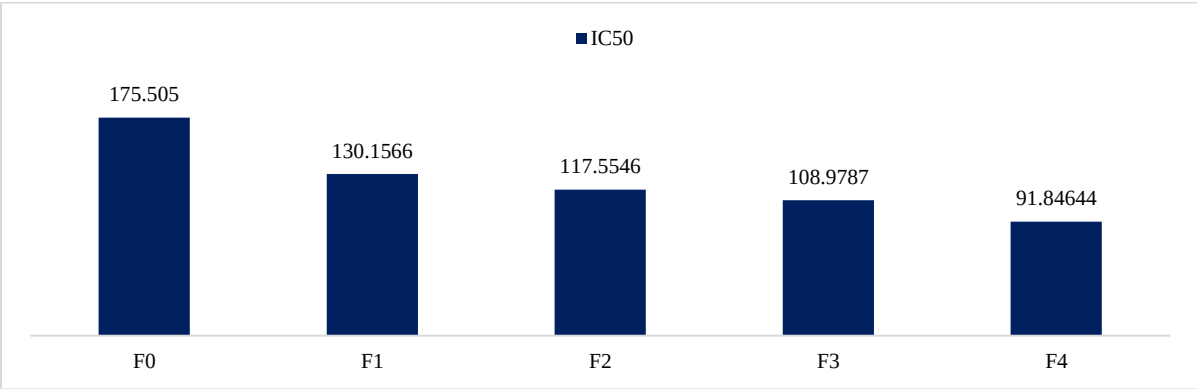


Figure 2. $IC_{50}$ levels of Steamed Sponge Formula

## DISCUSSION

Antioxidant and β-carotene levels determine a food's nutritional and functional value (12,13). The research showed that the steamed sponge cake formula based on a combination of purple sweet potato flour and orange sweet potato flour had high levels of antioxidants and β-carotene. The highest antioxidant content is owned by the F4 formula, namely 2.64 mg/100 g. The high anthocyanin content in purple sweet potatoes causes this. Anthocyanins are antioxidant compounds that protect cells from damage caused by free radicals. Formula F3 has the highest β-carotene content, 38.83 mg/100 g. The high β-carotene content in orange sweet potatoes causes this. β-carotene is a pro-vitamin A found in plant foods, where six µg of β-



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carotene is equivalent to 1 µg of retinol (the active form of vitamin A) (14). Yellow sweet potatoes contain β-carotene reaching 4629 µg/100g (14). Beta carotene is the main component of carotenoids in sweet potatoes (86-90 percent), the compounds that cause the tuber flesh to turn yellow to orange. The beta carotene content is positively correlated with the intensity of the yellow and orange color of the tubers(15). With the high levels of anthocyanin in this steamed sponge cake, this product can provide additional health benefits for consumers, such as protection against heart disease and cancer (16). The effectiveness of anthocyanins for maintaining health and reducing chronic disease levels is when women consume between 19.8 – 64.9 mg and men around 18.4 – 44.1 mg daily. (17). Other research results show that the anthocyanin content of processed light purple sweet potato products ranges from 1.14 - 2.24 mg/100g, and dark purple sweet potato ranges from 6.19 - 46.14 mg/100g (18). After processing, anthocyanin levels decreased compared to fresh purple sweet potatoes. The degradation level of anthocyanins may be as high as 50%, depending on the temperature and the heating time (19). Heat in processing reduces the anthocyanin content in processed products.

The $IC_{50}$ level (inhibitory concentration 50%) is the concentration of a compound that can inhibit 50% of enzyme activity or other biological processes. The $IC_{50}$ level of the steamed sponge formula based on a combination of purple sweet potato flour and orange sweet potato flour shows that the F4 formula has the lowest $IC_{50}$ level, namely 91.84 µg/mL, which means the formula is in the strong category. The low $IC_{50}$ level indicates that the F4 formula can inhibit the activity of prooxidant enzymes to prevent cell damage due to free radicals. The high anthocyanin content in purple and orange sweet potatoes supports this. Anthocyanins are antioxidant compounds that protect cells from damage caused by free radicals (20). Other research results show that the average value of the antioxidant activity of processed light purple sweet potato products ranges from 7.54% - 41.65%, and dark purple sweet potato ranges from 6.28% - 46.5% (18). The antioxidant activity after processing decreased compared to the antioxidant activity of fresh purple sweet potatoes. The best heating process to prevent damage to antioxidants and other flavonoid compounds is processing at high temperatures but for a short period (18). This is because the antioxidant components are not heat resistant.

Mold Yeast Number Examination is one of the tests carried out to see the quality of food ingredients from a microbiological aspect (21). The research showed that the steamed sponge cake formula based on a combination of purple sweet potato flour and orange sweet potato flour had a relatively low mold-yeast number. Formulas F3 and F4 at dilution $10^{-6}$ obtained the lowest mold-yeast number, about 8 and 7 CFU/mL. This shows that both formulas have very low yeast and mold contamination. A low mold-yeast number is positive because it is related to food safety, and the shelf life will be relatively long (22). Steamed cake based on a combination of purple sweet potato flour and orange sweet potato flour can be a safe food for consumption**.**

## CONCLUSION

Steamed sponge cake based on a combination of purple sweet potato flour and orange sweet potato flour has relatively high levels of beta carotene, anthocyanin, and antioxidant activity (IC50) found in Formula F4. This makes steamed sponge cake based on a combination of purple sweet potato flour and orange sweet potato flour, a healthy and nutritious alternative snack. Steamed sponge cake based on a combination of purple sweet potato flour and orange sweet potato flour has good food safety with a relatively low mold-yeast number value. Based on research results, steamed sponge cake based on a combination of purple sweet potato flour and orange sweet potato flour has the potential to be a healthy and nutritious snack (after a disaster).

Further research should investigate the shelf-life stability and sensory evaluation of Formula F4 steamed sponge cake under simulated post-disaster storage conditions to optimize its practical application as a nutritious and safe emergency food.

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## CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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