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Sensory Properties and Antioxidant Activity of Siamese Orange (*Citrus nobilis* L.) Fruit Leather

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Abstract

Siamese orange (Citrus nobilis L.) was a type of fruit widely cultivated and produced in Bali, but its utilization was not optimal. Siamese oranges were usually used for religious ceremonies, and if excess, they would lead to waste. Siamese oranges contain vitamin C, phenols, flavonoids. In addition, the peel contained 30% pectin. Combining Siamese orange fruit and peels into fruit leather with the Zero waste concept (utilizing all parts of the Siamese fruit) is a way to innovate products from waste that have potential as a functional foods. This study aimed to determine the effect of Siamese orange peel concentration on sensory characteristics and the right concentration to produce fruit leather with the best sensory characteristics and its potential as a functional food. Randomized Block Design (RGD) was used with treatment siamese peel puree concentration with six levels (0%; 5%; 10%; 15%; 20%; and 25%), repeated three times to obtain 18 experimental units. Observed variables included sensory characteristics on hedonic test of colour, taste, aroma, texture, and overall acceptance. Data obtained were analyzed using analysis of variance, followed by Tukey test. The products with best sensory characteristics will be continued with antioxidant activity analysis. The results showed siamese peel puree concentration has a significant effect on taste, colour, texture, and the overall acceptances of fruit leather. The addition of siamese orange peel puree at 5% is the right percentage to produce the best sensory characteristics of Siamese fruit leather and contained 74.89% antioxidant activity also has the potential as a functional food.

Keywords: fruit leather, functional food, siamese orange, zero waste concept.

1. Introduction

Bali is one of the favourite tourist destinations for both domestic and foreign tourists. The richness in the form of culture, customs, and various destinations gives Bali its own characteristics. Balinese culture is closely related to religious activities, which always puts Bali in the spotlight and gets the views of various parties. However, the production of waste from religious activities has increased due to various religious activities. According to [1], the average waste production on weekdays is around 0.8 kg/day, while on holy days, it increases by 3 times with an average of 2.4 kg/day.

Apart from the tourism sector, Bali also has potential in agriculture with various types of horticulture that can be cultivated, one of which is siamese oranges. Siamese orange (*Citrus nobilis* L.) is one type of orange that has the highest production level in Bali with the physical characteristics of its bright yellow skin with a slightly greenish color and a fresh sour taste [2]. The results of siamese orange production in Bali have increased greatly from year to year, in 2015 by 100,233.8 tons, in 2016 by 63,425.50 tons, in 2017 by 100,162.77 tons, in 2018 by 106,029.10 tons and by 2,532,062 tons in 2019 [3]. Siamese oranges are generally only used as a means of religious ceremonies such as offerings and consumed directly, so they are not optimally utilized without further processing. According to [2], the shelf life of siamese oranges is one week. The bioactive content in siamese

oranges includes antioxidants, vitamin C, magnesium, phosphorus, calcium, limonene, and pectin. Siamese oranges are known to have 25-30% pectin [4]. Pectin is compounds that have water-soluble properties and have an important role in forming the distinctive characteristics of fruit leather, namely elasticity. All parts of Siamese oranges have bioactive content that can be utilized, so it is very supportive to make a product with the concept of zero waste. Zero waste is a concept that aims to minimize the production of waste by utilizing all parts of the materials used in the production process [5]. To evaluate the diverse attributes and potential of Siamese oranges, it is evident that processing them into food products, such as fruit leather, can significantly enhance their market value.

Fruit leather is one of the processed food products in the form of rolled sheets and is made from fruit puree, which is dried by rehydration until the remaining water content is <20%, has a sweet taste characteristic, and has an elastic texture [6]. The high pectin content in Siamese oranges is mainly found in the rind. This aligns with the concept of zero waste, as it allows for the utilization of all parts of the Siamese orange fruit. It is important to carefully consider the percentage of puree added from Siamese oranges in order to preserve the elastic texture of the fruit leather and achieve optimal results. Based on that, this research is necessary to determine the effect of Siamese orange peel concentration on sensory characteristics and the right concentration to produce fruit leather with the best sensory characteristics and its potential as a functional food.

2. Material and Methods

The materials used in this study are siamese oranges, which are local Balinese fruits from religious ceremonies in Bali and obtained from siamese orange farmers in Kintamani, and sugar and citric acid obtained at UD. Ayu, water (Aqua), distilled water (Rofa), methanol (Merck) and 1,1-diphenyl-2-picrylhydrazyl (DPPH) (Sigma-Aldrich). Tools used in the manufacture of siamese fruit leather are knives, philips brand blender, baking sheet, oven (Blue M), digital scales (Fuji), basin, pan, spatula, baking paper (Best Fresh), gas stove (Rinnai), spoon, plastic gloves (STP), container, analytical balance (Shimadzu), aluminum cup, spectrophotometer (Biochromsn 133467), vortex (Maxi Mix II Type 367000), test tube (Pyrex), erlenmeyer flask (Pyrex), beaker (Pyrex), volumetric flask (Pyrex), dropper pipette, micro pipette (Dragon Lab), volume pipette (Pyrex), rubber pump, tip, glass funnel (Pyrex), tissue (Paseo), filter paper and aluminum foil (Klin Pak). This research was conducted from June to July 2023 at the Food Processing Laboratory and Food Analysis Laboratory, Faculty of Agricultural Technology, Udayana University.

The process of making chayote fruit leather with the addition of siamese peel waste puree includes several modified stages that refer to [7]. The preparation of siamese peel waste puree begins with washing 30 grams of peel waste. Then, proceed with the steam blanching process at 60°C for 2 minutes. The blanching process aims to prevent discolouration of the fruit peel waste. Waste fruit leather that has been blanching is added with 15 ml of water and mashed with a blender until smooth and becomes fruit leather puree. The making of Siamese orange fruit leather begins with peeling the siamese orange fruit. The flesh of the siamese orange fruit was washed and weighed as much as 100 g and then mashed with a blender until siamese orange fruit puree was obtained. The siamese orange fruit puree was mixed with siamese orange peel puree according to the concentration using a blender. Next, 20 g of sugar was added and heated at 70-80°C for 2 minutes. Then, 0.25 g citric acid was added, mixed well and moulded in a baking tray lined with baking paper. Next, the fruit leather was oven-dried at 65°C for 8 hours to produce siamese orange fruit leather. Each fruit leather was then analysed, including sensory tests (colour, texture, aroma, and taste), and the best treatment based on sensory characteristics will be followed by antioxidant activity testing. The parameters observed in this study were sensory characteristics, including hedonic testing of colour, taste, aroma, texture, and overall acceptance [8]. After obtaining the best sensory characteristics, antioxidant activity was

analysed using the DPPH method [9]. The experimental design used in this study was a simple Randomised Group Design (RBD) with the treatment of the addition of chayote peel waste puree at different concentrations. The treatments in this design are:

K1 : 100 g Siamese orange + 0% Siamese orange peel;
K2 : 100 g Siamese orange + 5% Siamese orange peel;
K3 : 100 g Siamese orange + 10% Siamese orange peel;
K4 : 100 g Siamese orange + 15% Siamese orange peel;
K5 : 100 g Siamese orange + 20% Siamese orange peel.

The percentage of addition is based on the total citrus fruits used. Each sample was then tested according to the parameters observed and then continued with the data analysis process. Data obtained from the observations will be statistically analysed using variance analysis with the help of Minitab 19. If there is an effect of treatment on the variable $P < 0.05$, then the test is continued with the Tukey Difference Test.

3. Results and Discussion

Based on the research conducted, the results of sensory characteristics, including color, taste, aroma, texture, and overall acceptance, can be seen in Table 1. The best results of antioxidant activity testing can be seen in Table 1.

Table 1
Sensory Analysis Result of Siamese Orange Fruit Leather

Treatment	Color	Taste	Aroma	Texture	Overall Acceptance
K1 (0%)	4,69±0,60 a	4,19±0,66 a	4,25±0,45 ab	3,81±1,28 ab	4,38±0,50 a
K2 (5%)	4,56±0,51 ab	4,44±0,51 a	4,63±0,50 a	4,25±0,58 a	4,56±0,51 a
K3 (10%)	3,63±1,20 c	2,75±1,06 bc	3,63±0,72 bc	3,31±1,50 ab	3,31±0,70 b
K4 (15%)	3,88±0,96 bc	2,94±0,93 b	3,56±1,03 bc	3,13±0,72 b	3,13±0,72 b
K5 (20%)	3,50±1,46 c	2,06±0,85 c	3,25±1,13 c	3,00±1,15 b	3,00±1,10 b

Information: The numbers followed by the same letter in the same column are not significantly different in Duncan's 5% test.

3.1 Aroma

The results of variance showed that the addition of siamese orange fruit peel waste according to the concentration had a very significant effect ($P < 0.01$) on the hedonic test of siamese orange fruit leather color. Based on Table 1. the average value of the hedonic test on the color of siamese orange fruit leather ranged from 3.50 (neutral) to 4.69 (like). The highest results were obtained in fruit leather, with the highest concentration of 0% concentration of added siamese orange peel puree, namely 4.69 (like), which was not significantly different from 5% concentration of added siamese orange peel puree, namely 4.59 (like). In comparison, the lowest average value was obtained at 20% concentration of added siamese orange peel puree, namely 3.50 (neutral) which was not significantly different from 10% concentration of added siamese orange peel puree, namely 3.63 (neutral), and with 15% concentration of added siamese orange peel puree, namely 3.88 (rather like).

Siamese orange fruit leather has an orange colour due to the carotenoid content in the siamese orange fruit used. Carotenoids are a group of pigments and natural antioxidants that have the ability to counteract free radicals, causing yellow, orange, and red colours in plants and fruits [10]. This is supported by research conducted by [11], which states that the colour results and nutritional value of the product can be influenced by pigments from carotenoids. The range of values indicates that the panelists' preference ranges from neutral to somewhat like, suggesting that no panelists dislike the product's color.

3.2 Taste

The variance analysis results indicate that adding siamese orange fruit peel waste had a highly significant effect ($P < 0.01$) on the hedonic test of the siamese orange fruit leather flavor, based on Table 1. The hedonic test ratings for the taste of siamese orange fruit leather ranged from 2.06 (somewhat dislike) to 4.44 (somewhat like). The fruit leather achieved the highest ratings with 5% concentration of added siamese orange peel puree, scoring 4.44 (rather like), which was not significantly different from the 0% concentration of added siamese orange peel puree, scoring 4.19 (rather like). The lowest average rating was obtained by the fruit leather with a 20% concentration of added siamese orange peel puree, scoring 2.06 (rather dislike), which was not significantly different from the 10% concentration of added siamese orange peel puree, scoring 2.75 (neutral).

The use of siamese orange fruit peel in fruit leather produces a bitter aftertaste. The same thing was reported by [12], who stated that more addition of orange peel causes a decrease in the liking of the panellists due to the aftertaste produced. [4] mentioned that the addition of orange peel and pectinase enzyme to the pectin in orange peel albedo also accumulates bitterness. Based on this statement, it can be seen that the taste of the siamese orange fruit leather product with a concentration of 5% addition of siamese orange fruit peel puree produced is still acceptable to the panelists.

3.3 Aroma

The results of variance showed that the addition of siamese orange peel waste according to the concentration had a very significant effect ($P <0.01$) on the hedonic test of the aroma of siamese orange fruit leather produced. Based on Table 1. the average value of the highest aroma hedonic test was obtained in fruit leather with a concentration of 5% addition of siamese orange peel puree, namely 4.63 (like) which was not significantly different from the 0% concentration of adding siamese orange peel puree, namely 4.25 (rather like), while the lowest average value was obtained in fruit leather with a concentration of 20% addition of siamese orange peel puree, namely 3.25 (neutral) which was not significantly different from the 10% concentration of adding siamese orange peel puree, namely 3.63 (rather like) and the 15% concentration of adding siamese orange peel puree, namely 3.56 (rather like).

Based on the research of [10] the aroma contained in siamese oranges is the volatile component of ethyl butanoate and nootkatone. The most influential citrus aroma is nootkatone, with a total content of 501 μg/L, while ethyl butanoate has a smaller amount content of 102 μg/L so that the aroma of siamese orange fruit leather is not too strong.

3.4. Texture

The results of variance showed that the addition of siamese orange fruit peel waste according to the concentration had a very significant effect ($P < 0.01$) on the hedonic test of the texture of siamese orange fruit leather produced. The mean value of the texture hedonic test ranged from 3.00 (neutral) - 4.25 (rather like). The highest result was obtained in siamese orange fruit leather with a concentration of 5% addition of siamese orange peel puree, namely 4.25 (rather like), while the lowest value was obtained in siamese orange fruit leather with a concentration of 20% addition of siamese orange peel puree, namely 3.00 (neutral). The plasticity of the fruit leather influences the level of panelists' liking for the orange fruit leather produced.

The texture of the siamese orange fruit leather is influenced by the pectin content in Siamese orange fruit peel waste. According to research conducted by [13], orange peel has a dry pectin yield content ranging from 17.08% to 31.81%. Pectin plays a role as a thickening and stabilizing agent in the product, and it acts as a gelling agent, improving the texture of the fruit leather produced [14]. The feedback from panelists indicates that they like and accept the texture of chayote fruit leather produced at different concentrations.

3.5 Overall Acceptances

The results of variance showed that the addition of siamese orange fruit peel puree according to the concentration had a very significant effect ($P < 0.01$) on the hedonic assessment of the overall acceptance of chayote fruit leather produced. Based on Table 1, the average value of the hedonic test on overall acceptance ranged from 3.00 (neutral) to 4.56 (rather like). The highest value was obtained from the 5% concentration of added siamese orange peel puree, namely 4.56 (like) which was not significantly different from the 0% concentration of added siamese orange peel puree, namely 4.38 (rather like), while the lowest value was obtained from the 20% concentration of added siamese orange peel puree, namely 3.00 (neutral) which was not significantly different from the 10% concentration of added siamese orange peel puree, namely 3.31 (neutral) and the 15% concentration of added siamese orange peel puree, namely 3.13 (neutral). The overall average value indicates that siamese orange fruit leather with each concentration is acceptable to panelists.

3.6 Antioxidant Activity

The antioxidant activity of siamese orange fruit leather was tested on the treatment with the best sensory characteristics can be seen in Table 2.

Table 2
Analysis of the Best Results of Antioxidant Activity Testing of Siamese Orange Fruit Leather

Treatment	Antioxidant Activity (%)
K5 (20%)	74,89 ± 1,27

The potential of siamese orange fruit leather produced with the concept of zero waste as a functional food can be seen through the percentage of antioxidant activity of the product tested on samples with the best sensory characteristics (treatment of adding 5% concentration of siamese orange fruit peel puree). The average percentage of antioxidant activity obtained is 74.89%, which is superior when compared to research conducted by [15] which has increased by 12.86% to reach 41.21%. Bioactive components contained in both the fruit and peel of siamese orange can support the percentage of antioxidant activity of the fruit leather produced. Some studies indicate that many bioactive components contained in the skin and fruit of siamese oranges are flavonoids and vitamin C. [16] reported that Kintamani siamese orange fruit (*Citrus nobilis* L.) processed into juice contains ascorbic acid approximately 20-60 mg per 100 ml and contains several other vitamins, such as vitamin A, thiamine, niacin, riboflavin, pantothenic acid, biotin, folic acid, inositol, and tocopherol. In addition, the results of research conducted by [17] showed that siamese orange peel contains secondary metabolite compounds, including flavonoids, phenols, steroids, and triterpenoids. Secondary metabolite compounds that are owned both in the fruit and skin of siamese oranges are compounds that function as antioxidants. Flavonoids and vitamin C in the fruit and skin of siamese oranges are the secondary metabolite compounds that function as antioxidants, which are also believed to have functional effects on the health of the body.

According to [18], vitamin C improves the immune system and can ward off free radicals affecting health. Some studies explain the mechanism of antioxidants as free radical scavenging and donating electrons to free radical molecules become balanced [3];[19]. Phenolic groups such as flavonoids are secondary metabolites with various functions such as anti-inflammatory, antioxidant, and others. According to[20], flavonoids can prevent wounds caused by free radicals by directly capturing free radicals. Flavonoids will be oxidized by radicals and produce more stable and unreactive radicals. In other words, flavonoids can stabilize reactive oxygen through reactions with radical reactive compounds. This is in line with the report of [21], who reported that bioactive components function as antioxidants in the body and can help protect cells from damage caused by free radicals. This is reinforced by the statement of [22], which compared antioxidant activity in vitro and in vivo in six types of flavonoids where antioxidants contained in flavonoids can relieve oxidative stress and inflammation related to oxidative stress in rats. Based on the content contained in the ingredients used in the manufacture of fruit leather and the description above, it can be

indicated that chayote fruit leather processed with the zero waste concept has great potential as a functional food.

4. Conclusion

The addition of siamese peel puree concentration has a significant effect on the sensory characteristics in the hedonic test, which includes taste, colour, texture, and the overall level of product acceptance. Based on the research, the addition of siamese orange peel puree at 5% is the optimal percentage to produce the best sensory characteristics and consumer acceptance. In addition, siamese orange fruit leather products processed using the zero waste concept show great potential as functional food, characterized by high antioxidant content, which is 74.89%.

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