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Physical, chemical, and sensory characteristics of pumpkin jam with porang flour addition

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ABSTRACT

Food processing is a way to extend the shelf life of products. In Indonesia, pumpkin and porang orange tubers are abundantly available and underutilised, but they have the potential to be developed into a local food-based product. Diversifying processed pumpkin into jam is a functional food alternative with high nutritional value. Porang flour is a thickener in foods and beverages that can stabilise the gel structure. This study aimed to determine pumpkin jam's physical, chemical, and sensory characteristics after adding porang flour. The stages of making pumpkin jam begin with making pumpkin puree, first cooking, mixing, second cooking and checking pH, then analysing physical characteristics (total soluble solids, spreadability, viscosity, and colour), chemical analysis including water content, antioxidant activity, total phenols, vitamin E, crude fibre and sensory properties. Variations of porang flour addition to pumpkin jam were (0; 0.5; 1; 1.5; and 2%). The results showed that adding porang flour influenced the physical characteristics, antioxidant activity, total phenols, vitamin C, and crude fibre of pumpkin jam but had no effect on water content and vitamin E. Adding porang flour up to 2% gave a good taste of pumpkin jam.

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INTRODUCTION

One of the local food ingredients with a high nutritional value, growing a lot in Indonesia, and suitable for human health is pumpkin (Halimah and Rahmawati 2021). Pumpkin contains nutritional values of carbohydrates, protein, fat, fiber, minerals, and vitamins (Nurrahman and Astuti 2022). The yellow pulp shows very high carotenoid (β-carotene) content (Millati et al. 2020). The high antioxidant content in yellow pumpkin can also make it potential for functional food ingredients through product innovation and proper processing.

Porang tuber is a tropical plant with a single tuber in the soil with a high glucomannan content compared to other tubers, around 35%. Some research results show the function of glucomannan in food products. Anwar et al. (2017) added glucomannan to manufacture edible films. An edible film with 4 g glucomannan has better properties such as young modulus, highest elongation, and attractiveness.

The addition of porang flour in jam-making has properties as a thickener, caramelization preventer, gelling, film former, coating materials, emulsifier, and stabilizer contained in the glucomannan content of porang flour (Wardhani et al. 2017). Based on the properties of porang flour as a gelling agent, this study will examine the antioxidant activity, total phenols, and vitamin C content of pumpkin-based jam innovation products by adding porang flour as a functional food diversification product. This study aims to determine pumpkin jam's physical, chemical, and sensory characteristics after Porang flour.

MATERIALS AND METHODS

Material

The ingredients used were Bokor pumpkin (*Cucurbita moschata*) obtained from Kopeng Salatiga farmers, porang flour purchased from Brawijaya University *Pilot Plant*, sugar, lemon, and water.

Methods

Pumpkin Porridge Making

The preparation of pumpkin puree begins with sorting good and non-deformed pumpkin fruit to determine the pumpkin's initial weight. Peeling and washing the pumpkin is done with clean running water, and then the pumpkin is cut into small pieces. Then, the pumpkin is mashed using a blender with the addition of water, with the ratio of pumpkin and water (1: 1 b / v). Pumpkin pulp is obtained to facilitate destruction.

Making Pumpkin-Jam with Porang Flour Addition

Pumpkin jam is added in different concentrations with the primary raw material of pumpkin, Porang flour, and additional ingredients, namely sugar and grated lemon peel. The concentration of Porang flour used is 0, 0.5, 1, 1.5, and 2%. The pumpkin jam process begins with pumpkin pulp cooked for 5 minutes at 40˚ C and continues with the first mixing of 55% granulated sugar and Porang flour at 40˚C for 5 minutes. Then, the second mixing is adding grated lemon peel at 70˚C within 5 minutes and cooking for 15 minutes at 70˚C while stirring to prevent clumping in the jam to obtain jam with suitable viscosity. The jam was taken with a spoon and tilted; if the jam did not immediately fall off the spoon, then the cooking process could be stopped. Then, the pH is checked to determine the level of acidity in the jam, and the standard pH in the jam is pH 4-5. Then, the jam is cooled and put in sterilized jar packaging.

Analysis method

The finished pumpkin jam product was analyzed for various physical properties, including total soluble solids, spreadability, viscosity (using the Brookfield Viscometer tool), and color (with the Chromameter tool). Analysis of chemical properties included moisture content, antioxidant activity, total phenols, vitamin C, β-carotene, crude fiber, and vitamin E. An analysis of sensory properties, which is a combination of color, taste, aroma, and texture.

Experimental Design

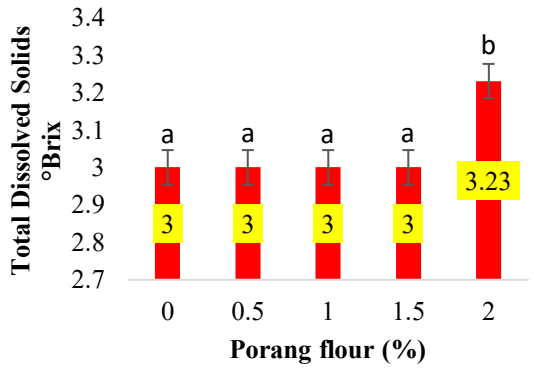
The research method was a completely randomized design (CRD), mono-factor structure with five treatments and four replications. The amount of porang flour concentration has six levels in the form of 0, 0.5, 1, 1.5, and 2%.

RESULTS AND DISCUSSION

Total Dissolved Solids

The results of the total soluble solids analysis of pumpkin jam can be seen in Figure 1. The test results of the total soluble solids of pumpkin jam

can be seen in Figure 1. The results showed that the value of total soluble solids was between 3 to 3.23 °Brix. Anova test of total soluble solids of pumpkin jam with the addition of porang flour showed a significant value of 0.000 <0.05, so it can be concluded that there is a significant effect with the addition of porang flour on the value of total soluble solids of pumpkin jam.



Notes: Different letter notations indicate significantly different results

Figure 1 Graph of total soluble solids of pumpkin jam

Based on Duncan's test, it is known that the pumpkin jam control treatment and the 0.5 to 2% treatment are correlated with the control treatment. This is because the more concentration of Porang flour added, the more the value of total soluble solids in pumpkin jam increases. At a concentration of 2%, the value of total soluble solids increased because Porang flour contains glucomannan, a hydrocolloid polysaccharide consisting of D-glucose and D-mannose residues (Anwar et al. 2017). The viscosity value of pumpkin jam in Figure 1 is between 3 - 3.23°Brix, while the standard for total soluble solids, according to SNI, is a maximum of 65%.

Spreadability

The test results of the spreadability of pumpkin jam can be seen in Figure 2. The results showed that the spreadability value was between 3.05 to 4.18 cm. Anova test of the spreadability of pumpkin jam with the addition of porang flour showed a significant value of 0.000 <0.05, so it can be concluded that there is a significant effect of porang flour addition on the spreadability of pumpkin jam. At concentrations of 1 to 2%, there was a significant increase. The results of the spreadability analysis of pumpkin jam can be seen in Figure 2.

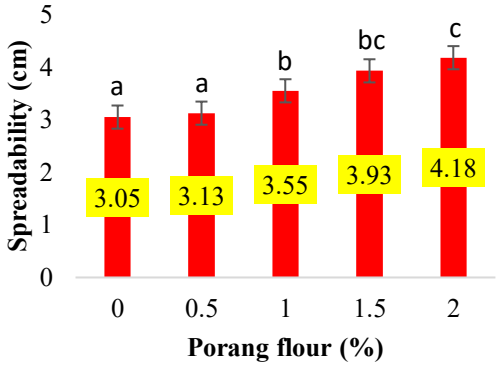


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Figure 2 Spreadability graph of pumpkin jam

Based on the Duncan test, it is known that there is a correlation between the control treatment and 0.5 treatment. In the 0.5 to 2% treatment, there was an increase in distance when pumpkin jam was spread. The concentration of Porang flour addition influences the farthest distance in pumpkin jam. Porang flour is a thickener containing a lot of glucomannan, which binds water and can expand. According to Prastini and Widjanarko (2015), the high glucomannan content causes porang flour to be used as a thickener and additive to food and beverages. The spreadability value of pumpkin jam increased as the concentration of Porang flour increased. This is because the more the concentration of Porang flour is added, the more water is trapped in the polysaccharide and forms a firmer gel (Linggawati et al. 2020). A high value of total soluble solids will produce jam with a rough texture, while the spreadability is low because the jam is too hard and the viscosity value is high (Amelia et al. 2016).

Viscosity

The results of the analysis of the spreadability of pumpkin jam can be seen in Figure 3. The viscosity of pumpkin jam increased along with the increase in porang flour concentration added to the jam-making process. Anova test of total soluble solids of pumpkin jam with the addition of porang flour shows a significant value of 0.000 <0.05, so it can be concluded that there is a very significant effect with the addition of porang flour on the viscosity value of pumpkin jam.

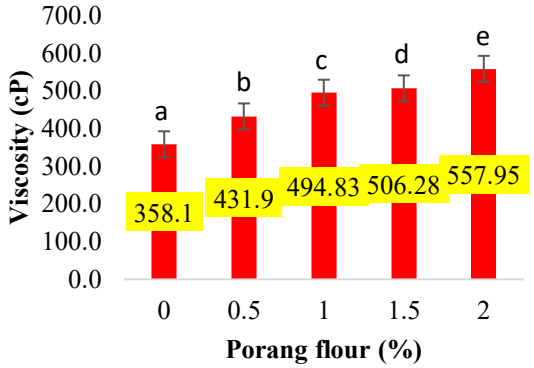

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Figure 3 Viscosity graph of pumpkin jam

Based on the Duncan test, adding Porang flour to pumpkin jam with different concentration levels significantly affects the viscosity value of pumpkin jam. There is a significant difference in viscosity value in the pumpkin jam control, and in the 0.5 to 2% treatment, there is an increase in viscosity value. This is because glucomannan in porang flour is thick, fluffy, and contains many carbohydrates so that it can crystallize and form a thick, sticky mass structure.

The increase in viscosity value in pumpkin jam is influenced by pectin. Pumpkin contains 1.2 g of pectin per 100 g and 0.5 g of fiber (Ardanti et al. 2017). The addition of porang flour to pumpkin jam is also a factor in increasing viscosity. Porang flour, used as a thickener in a jam, contains high glucomannan and can bind large amounts of water. Glucomannan in porang flour is a water-soluble polysaccharide that causes gel formation and results in high viscosity of the jam. The greater the percentage of Porang flour, the higher the viscosity value (Ardiansyah et al. 2019).

Color

Anova test of pumpkin jam color with the addition of porang flour showed a significant value of 0.000 <0.05, so it can be concluded that there is a very significant effect with the addition of porang flour on the color value of pumpkin jam. At concentrations of 1 and 1.5%, there was a significant decrease. Figure 4 shows that the color value of pumpkin jam with the addition of porang flour ranges from 31.66 to 36.03, meaning that the higher the addition of porang flour, the greater the color value of pumpkin jam.

Based on Duncan's test, the control treatment and the 0.5 to 2% treatment decrease, which means there is a significant difference between each treatment because the color of the pumpkin jam is getting darker or darker orange. The decrease in color value in pumpkin jam is due to changes in pumpkin color in the jam-making process.

Pumpkin contains carotenoids, natural elements that form red and orange pigments in pumpkin jam. The carotenoid content in pumpkin is 180.00 SI (about 1,000 - 1,300 IU/100 g of material) and has a vitamin A-like content because it is high in carotene (Soleha et al. 2021). The high level of carotenoids in pumpkin affects the brightness of pumpkin jam, which is characterized by a decrease in the L value of jam. The addition of porang flour concentration also affects the brightness of the jam because porang flour gives color characteristics to the jam which tends to be dark orange to dark brown. This is because porang flour contains phenolic compounds and polyphenol oxidase enzymes (Habibah et al. 2015).

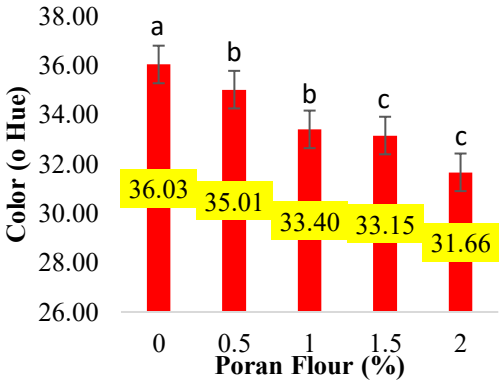

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Figure 4 Color graph of pumpkin jam

Water Content

Figure 5 shows the results of the moisture content analysis of pumpkin jam based on the concentration of Porang flour addition.

Anova test results of pumpkin jam water content with the addition of Porang flour showed insignificant results, namely 0.858>0.05, meaning that there is no effect of the addition of Porang flour on the water content of pumpkin jam. Thus, it can be concluded that adding Porang flour does not affect the water content of pumpkin jam. Figure 5 shows that the moisture content of pumpkin jam ranges from 54.28 to 58.89.

Meanwhile, the standard water content, according to SNI, is a maximum of 35%.

The moisture content of jam is influenced by porang flour because porang flour contains glucomannan, which can absorb water up to 200 times its weight and inhibit syneresis. Glucomannan is a hydrocolloid polysaccharide consisting of D-Glucose and D-Mannose residues bound together in β-1,4 glycoside and β-1,6 glycoside bonds, these compounds are capable of binding water (Anggraeni et al. 2014). The moisture content of jam is influenced by the binding power of water-soluble fibers in the form of Porang flour thickener used against water. According to Astuti et al. (2016), the more hydrocolloid compounds added to the jam, the more hydrocolloid matrices will be formed, and the bonds in pumpkin jam will be more robust and trap more water (Lewerissa et al. 2022).

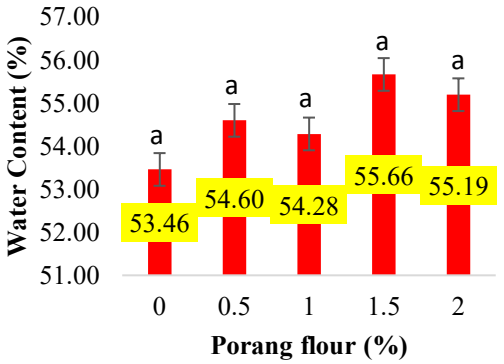

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Figure 5 Moisture content graph of pumpkin jam

Antioxidant Activity

According to Khaira (2010), antioxidants prevent oxidation reactions in the body and inhibit free radicals. The higher the antioxidant activity, the higher the antioxidant content of the ingredients. The results of the antioxidant activity analysis of pumpkin jam based on variations of Porang flour concentration are presented in Figure 6.

Figure 6 shows that the higher the level of Porang flour added, the lower the level of antioxidant activity. The average results of the antioxidant activity of pumpkin jam with porang flour addition ranged from 18.6% down to 8.9% (RSA/Radical Scavenging Activity). Antioxidant activity with the highest result is 16.49 %RSA with 0.5% Porang flour addition, while the lowest result is 8.9% RSA with 2% Porang flour addition. The results of the ANOVA (*Analysis Of Variance*) statistical test showed that the treatment of Porang flour addition had a very significant effect on antioxidant activity in pumpkin jam with a p-value of 0.000 ($p < 0.05$).

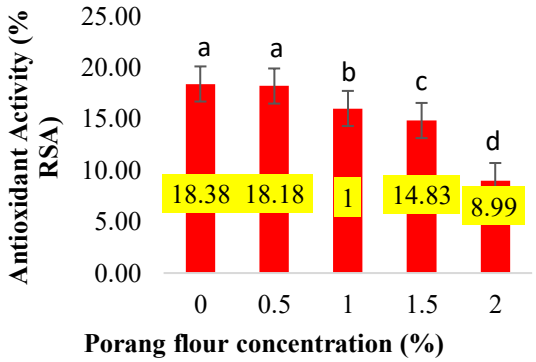

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Figure 6 Antioxidant activity graph of pumpkin jam

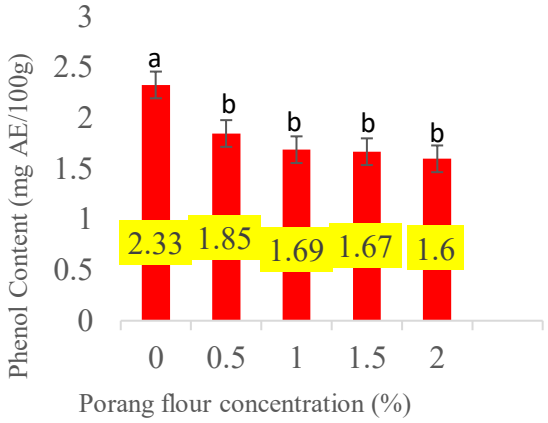
Figure 6 shows that the higher the addition of porang flour, the lower the antioxidant activity value. In terms of antioxidant content in each raw material, bokor pumpkin has a high antioxidant content of 64.84% RSA (Nurrahman and Astuti 2022), and porang flour has a low antioxidant content of 5.1 %RSA (Istiqomah and Muhtadi 2021). So, the addition of Porang flour has not been able to increase the antioxidant activity of pumpkin jam. This is due to the water-soluble nature of antioxidants; besides, porang flour has *gelling agent* properties that can only affect the product's texture.

Total Phenol

The content of phenol compounds can reduce free radicals in the body due to chain reactions. Pumpkin flesh contains carotenoids or ß-carotene (Gumolung and Mamuaja 2018).

Figure 7 shows the average total phenol measurement of pumpkin jam with the addition of Porang flour; the higher the level of Porang flour added, the lower the phenol content of pumpkin jam. The average result of the total phenol of pumpkin jam with the addition of Porang flour from 2.33 decreased to 1.60 mg/100g (*GAE/Gallic acid equivalent*). The total phenol with the highest result is 1.85 mgGAE/100g with adding 0.5% porang flour, while the lowest result is 1.60

mgGAE/100g with adding 2% porang flour. The results of the ANOVA (Analysis Of Variance) statistical test showed that the treatment of Porang flour addition had a very significant effect on total phenols in pumpkin jam with a p-value of 0.000 ($p < 0.05$).



Notes: Different letter notations indicate significantly different results

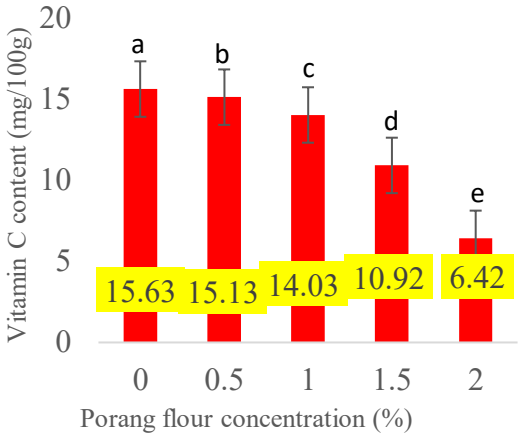
Figure 7 Graph of phenol content of pumpkin jam

Figure 7 shows that the higher the addition of Porang flour, the lower the phenol content. Regarding phenol content in each raw material, bokor pumpkin has a high antioxidant content of 134.59 mg GAE/100g (GAE/*Gallic acid equivalent*) (Nurrahman and Astuti 2022). Porang flour does not contain phenol levels; this is evidenced in the research of Erlina and Muhtadi (2021) that the phenol test results of Porang flour samples are harmful or not found because the ethanol extract in the sample does not give a reduction reaction and does not change the color of the solution. Adding porang flour has not been able to increase the phenol content of pumpkin jam. This is because porang flour has *gelling agent* properties and is a good texture stabilizer. The higher the concentration of porang flour added, the faster the thickening occurs, causing a solid attraction of colloidal particles in binding water, resulting in more free oxidation space and a decrease. The results of this study are similar to the research of Pulu et al. (2022), on the phenol content of nam-nam fruit jam decreased phenol content due to the water-soluble nature of phenol so that it can allow hydrolysis and exposure to free oxygen can reduce phenol content.

Vitamin C content

Vitamin C is a water-soluble vitamin that is stable when dry. However, when vitamin C dissolves in water, it causes oxidation, and the vitamin is quickly damaged (Endang and Yusrin 2008).

Figure 8 shows the average measurement of the vitamin C content of pumpkin jam with the addition of Porang flour; the higher the addition of Porang flour, the lower the vitamin C content. The average results of pumpkin jam's vitamin C content with Porang flour from 15.63 decreased to 6.42 mg/100g. The total vitamin with the highest result is 15.13 mg/100 g with adding 0.5% Porang flour, while the lowest is 6.42 mg/100 g with adding 2% Porang flour. The results of the ANOVA (*Analysis Of Variance*) statistical test showed that the treatment of Porang flour addition had a very significant effect on vitamin C in pumpkin jam with a p-value of 0.000 ($p < 0.05$).



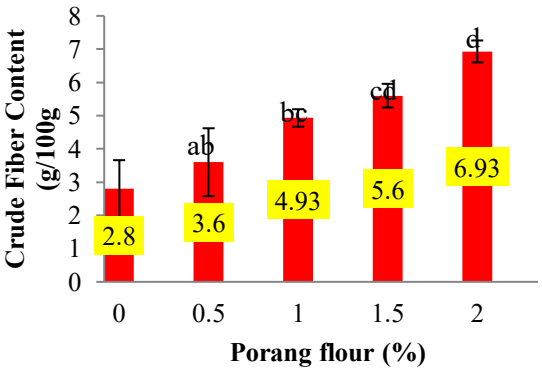
Notes: Different letter notations indicate significantly different results

Figure 8 Vitamin C graph of pumpkin jam

Figure 8 shows that the higher the addition of Porang flour, the lower the value of vitamin C content. Regarding vitamin C content in each raw material, bokor pumpkin has a vitamin C content of 101.31 mg/100g (Nurrahman and Astuti 2022). Meanwhile, porang flour contains a low vitamin C content of 20.2 mg/100 g (Pusat Penelitian dan Pengembangan Porang Indonesia 2013). Adding porang flour has not been able to increase the vitamin C content of pumpkin jam. Vitamin C content is unstable and soluble (Winarno 2005). Judging from the content of porang flour, which has *gelling agent* properties, porang flour can only form and stabilize the gel structure. In addition, the decrease in vitamin C content is due to cell damage during pumpkin fruit peeling, which changes ascorbic acid into DHA (*dehydroascorbic acid*) (Mukaromah et al. 2010).

Crude Fiber Analysis

In Figure 10, it is known that from 0% to 2% treatment, there is an increase in the results of crude fiber content, the results of its significant increase as evidenced by the results of the ANOVA test of crude fiber content, the P value is 0.001 <0.05, in the analysis of crude fiber content of pumpkin jam in all treatments.



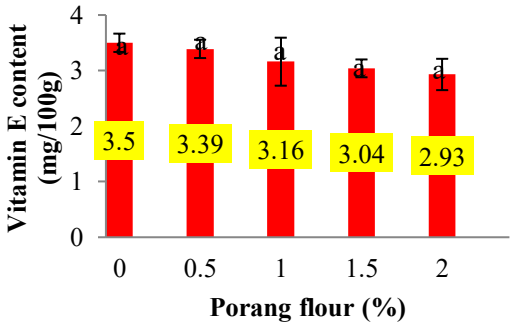
Notes: Different letter notations indicate significantly different results

Figure 9 Graph of the crude fiber content of pumpkin jam

The increase in the value of crude fiber content in pumpkin jam is caused by several factors, including the high content of crude fiber in the ingredients used, namely pumpkin (Maulidya B et al. 2023). Based on the research analysis by Sarifah et al. (2021), the value of crude fiber content in yellow pumpkins is relatively high, at 32.308 g/100 g. When making jam, add Porang flour. When making jam, add Porang flour, which contains glucomannan. Glucomannan is a polymer derived from tubers that is part of crude fiber. This is the opinion of Anwar et al. (2017), who state that the crude fiber content of porang flour is 2-5%. Glucomannan in porang flour has properties as a *gelling agent* and water-binding properties, which can absorb water up to 200 times its weight and can inhibit syneresis (Sembiring et al. 2019). The greater the flour added to the pumpkin jam, the more the water adsorption process will increase, which causes the formation of crude fiber during the jam-cooking process to increase (Rahmawati et al. 2023).

Vitamin E

Figure 10 below shows the results of the analysis of pumpkin jam's vitamin E content.



Notes: Different letter notations indicate significantly different results

Figure 10 Vitamin E graph of pumpkin jam

In Figure 10, it is known that from 0% to 2% treatment, there is a decrease in the results of vitamin E levels. However, the decrease is not significant as evidenced by the results of the ANOVA test of vitamin E levels; the P value is 0.238> 0.05, so it can be concluded that H1 is rejected, which means that there is no significant effect of the addition of porang flour on vitamin E levels of pumpkin jam in all treatments.

The decrease in the results of vitamin E analysis of pumpkin jam is due to the small content of vitamin E in the material, namely in pumpkin which only amounts to 1.06 g of vitamin E (Batool et al. 2022). In addition, porang flour is used to manufacture pumpkin jam, and porang flour containing glucomannan has the main properties and characteristics that can form a transparent edible film (Lufiana et al. 2023). Adding a small formulation of Porang flour in jam products can only retain a small amount of the total vitamins present in pumpkin jam. The small formulation of porang flour added also caused the total results of vitamin E levels to be insignificant.

Sensory Properties

The results of the analysis of the sensory properties of pumpkin jam can be seen in Figure 11.

The addition of porang flour affects the color-sensory properties of pumpkin jam. The color difference in jam is due to the presence of carotenoid components in pumpkin, which is about 3.95 mg/100 g (Nurrahman and Astuti 2022). The results of the analysis of the sensory properties of pumpkin jam can be seen in Figure 11.

Porang flour gives jam color characteristics that tend to be dark orange to dark brown because porang flour contains phenolic compounds and polyphenol oxidase enzymes. The heating process also has an effect because, with the heating process, the jam color tends to be more intense (Habibah et al. 2015)

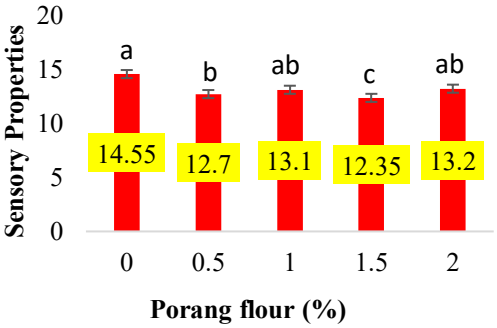


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Figure 11 Graph of sensory properties of pumpkin jam

The aroma produced in jam products is almost the same in each treatment. This is because Porang flour added to pumpkin jam products will not change the product's aroma. The addition of Porang flour concentration does not provide a sensory aroma because Porang flour has a neutral aroma, so panelists do not like the product because there is no distinctive aroma of pumpkin jam products (Anggraeni et al. 2014).

Taste is an attribute that determines the quality of pumpkin jam. Adding Porang flour concentration to pumpkin jam does not affect the taste because pectin does not form flavor but is a gelling agent (Aldi et al. 2018). From the results of the panelists' assessment, it can be concluded that most panelists somewhat disliked the taste of pumpkin jam. This is because the more Porang flour added to pumpkin jam causes the resulting pumpkin jam to be rather rough, thus affecting the panellists' taste assessment.

Texture plays a vital role in jam quality because it is a parameter closely related to the mechanical properties of agar and determinants of jam quality. Adding Porang flour does not affect the texture of pumpkin jam because Porang flour is a gelling agent in a jam (Suneth and Tuapattinaya 2016). From the results of the panelists' assessment, it can be concluded that most panelists somewhat disliked the texture of the pumpkin jam. This is because porang flour contains glucomannan, which can bind water, absorb up to 200 times its weight, and inhibit syneresis. Adding Porang flour will increase the fiber of pumpkin jam, which causes water absorption. In addition, Porang flour with relatively coarse grains into pumpkin jam affects the texture that panelists do not like (Panjaitan et al. 2016).

CONCLUSIONS

The addition of Porang flour influenced the physical characteristics, antioxidant activity, total phenolics, vitamin C, and crude fiber of pumpkin jam. However, it did not affect water content and vitamin E.

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