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Physicochemical and Sensory Characteristics of Instant Pumpkin Soup with Variations of Porang Flour as A Thickener

NURRAHMAN[1]*, AGUS SUYANTO[1], RR ANNISA AYUNINGTYAS[2] and DIODE YONATA[1]

[1]Department of Food Technology, Muhammadiyah University of Semarang, Semarang 50273, Indonesia.
[2]Department of Nutrition, Muhammadiyah University of Semarang, Semarang 50273, Indonesia.

Abstract

Pumpkin (*Cucurbita moschata*) can be processed into instant soup. However, the weakness is its low viscosity. Porang flour as a thickening agent is expected to improve the shortcomings of instant pumpkin soup. This study aimed to investigate the effect of porang flour addition on the physical and sensory characteristics of instant pumpkin soup. This study used a non-factorial, completely randomized design, where the concentration of porang flour (0; 0.5; 1; 1.5 and 2%) was the independent variable. The result showed that the addition of porang flour caused an increase in moisture content, dietary fiber, viscosity, water solubility index and water absorption index in instant pumpkin soup. However, there was a decrease in the value of water activity, vitamin E, rehydration ratio, color, and sensory characteristics of instant pumpkin soup. In conclusion, adding 0.5% porang flour is recommended to produce instant pumpkin soup with good sensory and physicochemical properties.

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Introduction

Pumpkin (*Cucurbita moschata*), better known as "waluh" in Indonesia, is a type of vegetable used as a fruit with a distinctive taste and aroma. Yellow pumpkin is known to be rich in functional compounds such as phenolics, flavonoids, β-carotene, α-tocopherol, vitamin C, and vitamin E in high concentrations.[1-2] These compounds act as antioxidants, which have various benefits for the quality of food products and the health of the body when consumed.[3] As well as being used as a vegetable, the flesh of the pumpkin can also be processed as an instant soup ingredient.[4]

One of the qualities of instant pumpkin soup is influenced by the thickening agent used.[5] Without a

CONTACT Nurrahman nurrahman@unimus.ac.id Department of Food Technology, Muhammadiyah University of Semarang, Semarang 50273, Indonesia.

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thickening agent, the resulting instant pumpkin soup tends to melt.[6] Xanthan gum has previously been used as a thickening agent in product manufacturing. However, its use is more appropriate for thick beverage products than soups because it produces a weak gel strength and viscosity.[7-8] Recent research has developed a thickening agent from porang flour.9 Porang flour contains water-soluble polysaccharides such as glucomannan, one of the dietary fibers than can bind with water to form a thick texture.[10]

Porang glucomannan has a molecular structure rich in hydroxyl and carbonyl groups, which can increase water absorption capacity. This level of water absorption capacity has a positive relationship with good gel-forming ability and product viscosity.[11-12] The gelation properties and viscosity of glucomannan from porang tubers have previously been reported.[13] Such as increasing the viscoelasticity of noodles with the porang addition.[14] Adding porang flour, which is rich in glucomannan, into the dough can improve the rheological and microstructural properties of the resulting product and does not reduce the product's functional properties.[14-15]

As a food additive, the use of konjac flour as a thickening agent for soups and broths has been regulated, that is a maximum of 10 g/kg individual.[16] Using konjac flour also affects the palatability of the resulting product, which is generally low.[17] Another challenge of concern is the level of konjac flour used which is known to produce varying effects on the rheological and structural characteristics of the product.[18] The preparation of instant pumpkin soup using porang flour as a thickening agent has yet to be reported. Therefore, this study aims to investigate the effect of adding porang flour on the moisture content, water activity, dietary fiber, vitamin E, viscosity, water soluble index, water absorption index, rehydration ratio, morphology structure, color and sensory of instant pumpkin soup.

Materials and Methods

Raw Materials

The primary materials for this study are pumpkin and porang flour. The pumpkin was purchased from Demak (Indonesia), with a harvest age of ± 3 months. Porang flour was obtained from the Pilot Plant Project, Brawijaya University (Indonesia).

The Making Instant Pumpkin Soup

Pumpkin (500 g) was initially mashed with a blender and 6% (w/w) skimmed milk powder. Chicken stock was added as much as 1:1 (w/v) and 40 g of seasoning, then mixed until homogeneous. The porang flour was added to the mixture with different percentages: 0, 0.5, 1, 1.5, and 2%. The mixture was then homogenized and cooked for 5 minutes until boiled. The cooked soup is then dried using a cabinet drying for 6 hours at 70 ºC.[19]

Analysis Procedure

Analysis of moisture content using a moisture analyzer by Shimadzu, water activity is determined using a water activity meter by Amittari, dietary fiber was determined according to the method described by,[20] vitamin E was obtained based on the method described by,[21] powder morphology was determined using the Scanning Electron Microscopy by Jeol tool (JSM-6510LA), analysis of sample viscosity using a Lamy Rheology tool, water-soluble index, water absorption index and rehydration ratio with[22] methods. Analysis of color characteristics using a Chromameter color reader WR-10 and sensory analysis using 20 individuals evaluated the samples based on the 5-point hedonic scale for descriptive sensory analysis. A 5-point hedonic scale was provided to rate the preferences, with 0 as not acceptable and 5 as most acceptable.[23]

Statistical Analysis

The study design used single-factor completely randomized design with five treatments. The different treatment test was analyzed using One Way Anova, if there is an effect of p-value <0.05, continue with Duncan's Multiple Range Test. The difference test for hedonic parameters uses the Friedman Test, if there is an influence of p-value < 0.05, continue with the Wilcoxon Test. Statistical analysis was performed using SPSS 22.0 software.

Results and Discussion

Moisture Content and Water Activity

The moisture content of the original instant pumpkin soup (IPS) is 6.59%. The moisture content of instant pumpkin soup with the addition of porang (IPS-PF) ranges from 6.99 to 7.41%, slightly increased from the original ingredients that contain 6.59% of water. However, the moisture content of IPS-PF formula is

still within the safe limits (14-15%) for powder and flour products.[24] The moisture content of the IPS-PF formula in this study was found to be slightly lower compared to the moisture content of instant soup from pineapple (7.91%),[22] and peas (10.02%).[25] The increase of moisture content in the IPS-PF formula is thought to be due to the role of porang in forming a denser structure by reducing the porous structure.[26] During the drying process, powder with a high-porous structure tends to lose water more easily compared to powder with a denser structure.[22] The water activity range of the IPS-PF formula in this study was 0.39 to 0.48, similar enough to the water activity value of cream mushroom soup (0.35 to 0.45).27 The increase in porang flour concentration reduces the water activity of the IPS-PF formula significantly. Enzymes generally experience inactivation when the food system has a water activity below 0.85, while bacteria and yeast cannot grow at water activities less than 0.91 and 0.80, respectively.[28] Reduction of water activity prevents microbial growth, reduces enzymatic response, and delays the Maillard reaction.[22] Lower water activity improves powder product stability.[29]

Tabel 1. Chemical properties of instant pumpkin soup

Parameters	Porang Flour (%)				
	0	0.5	1	1.5	2
Moisture (%)	6.59 ± 0.23^{a}	6.99 ± 0.09^{b}	7.14 ± 0.07^{b}	7.33 ± 0.09^{c}	7.41 ± 0.10^{c}
Water activity	0.48 ± 0.01^{d}	0.45 ± 0.02^{c}	0.44 ± 0.01^{c}	0.41 ± 0.02^{b}	0.39 ± 0.02^{a}
Dietary fiber (%)	8.63 ± 0.03^{a}	8.90 ± 0.08^{b}	9.38 ± 0.10^{c}	9.56 ± 0.15^{d}	10.08 ± 0.09^{e}
Vitamin E (mg/Kg)	1.01 ± 0.04^{c}	0.89 ± 0.04^{b}	0.84 ± 0.04^{ab}	0.82 ± 0.03^{a}	0.80 ± 0.05^{a}

Note: The data are representations of the mean values ± standard deviation. Different superscripts in the same row showed statistically significant differences ($p < 0.05$). The lowest value starts from superscripts a.

Dietary Fiber and Vitamin E

IPS contains high levels of dietary fiber, around 8.63-10.08% (Table 1). The addition of porang flour significantly increases the product's dietary fiber. Porang flour is known for its glucomannan content. Glucomannan in porang flour is classified as a water-soluble polysaccharide with β-1–4 bonds in the D-glucose and D-mannose chains.[10] As a water-soluble dietary fiber, glucomannan in porang can decrease glycemic response after consuming high-carbohydrate food.[30] In contrast to dietary fiber, vitamin E levels in IPS-PF tend to reduce significantly (from 1.01 to 0.80 mg/Kg) after adding porang flour to the formula. Pumpkin is a source of valuable functional components, including vitamin E.[31] The vitamin E content in fresh pumpkin even reaches 6.4 to 17.4 mg/Kg.[32] Vitamin E is a collective term for the four tocopherols (α-, β-, γ-, and δ-tocopherol) and four tocotrienols (α-, β-, γ-, and δ-tocotrienol) found in foods.[33] The kind of vitamin E analyzed in this study is α-tocopherol. Each type of vitamin E has potent antioxidant activity, but only α-tocopherol that can meet human vitamin E needs.[34] Vitamin E is a major fat-soluble antioxidant, and many studies have been conducted to explain its role in cancer.[35] In addition, vitamin E also has other beneficial effects, such as immunomodulatory effects, which have been observed in animal models and humans in both standard and diseased conditions.[33]

Viscosity

Viscosity is a measure that shows the thickness of a liquid, which shows the amount of friction on the substance. The higher the viscosity, the more difficult it is for the liquid to flow and move.[36] The viscosity value of IPS and IPS-PF formula are presented in Table 2. The viscosity value of the soup ranged from 6.8 to 142.4 m. It can be inferred that the viscosity of the IPS-PF formula increased significantly with the addition of porang flour, in line with the previous studies which reported that glucomannan increased the viscoelasticity of noodles.[14] Glucomannan has a molecular structure that is rich in hydroxyl and carbonyl groups. Thus, it can increase the water absorption capacity and thicken the instant soup formula.[11-12] Glucomannan has a high level of water

absorption. A gram of glucomannan can absorb 50-100 grams of water. In concentration, one percent of glucomannan produces a thickness level of 35,000 cps in the form of a gel solution that is not easily damaged.[37] According to,[38] adding 3% of porang and 15% of cornstarch resulted in the best sausage structure. The chewy structure of sausage is influenced by the amount of porang added to the formula. The more porang added to the formula, the better the texture. In conclusion, the use of porang will affect the desired sausage quality.

Water Soluble Index

Water solubility index (WSI) is an indication of the solubility of biomolecules beyond water.[39] During rehydration, good instant soup powder slowly when moistened will soak and mix homogeneously with water, not swell. Table 1 shows that the solubility of IPS-PF ranges from 44.41-45.68%. This value is much better than the instant green bean soup (17.93-23.14%) from.[40] Instant soup powder should have a high WSI rating because it needs to dissolve quickly and be ready for immediately consumption. The addition of porang flour significantly increased the solubility of pumpkin soup. Porang flour is known to contain high glucomannan. Porang flour is known to contain high glucomannan. Glucomannan is a water-soluble polysaccharide,[9] so its presence increases the WSI of IPS-PF. Apart from that, the presence of complex carbohydrates, proteins and lipids in the ingredients can also affect the solubility of instant soup (Mishra *et al*., 2014). WSI is generally associated with starch degradation and dextrinization. Higher dextrinization will produce more hydroxyl to form bonds with water hydrogen. Starch will be degraded into smaller but more soluble molecules and increase WSI.[40]

Tabel 2: Functional properties of instant pumpkin soup

Parameters	Porang Flour (%)				
	0	0.5	1	1.5	2
Viscosity (m.Pas)	6.80 ± 0.63^{a}	19.04 ± 1.90^{b}	36.46 ± 0.73^{c}	77.90 ± 2.95^{d}	142.4 ± 0.01^{e}
WSI (%)	44.41 ± 0.46^{a}	44.97 ± 0.16^{b}	44.94 ± 0.23^{b}	45.38 ± 0.29^{c}	45.68 ± 0.19^{c}
WAI (%)	5.15 ± 0.05^{a}	5.22 ± 0.10^{a}	5.66 ± 0.16^{b}	6.34 ± 0.09^{c}	6.63 ± 0.12^{d}
Rehydration ratio	4.73 ± 0.07^{d}	4.42 ± 0.09^{c}	4.17 ± 0.09^{b}	4.04 ± 0.06^{a}	3.96 ± 0.06^{a}

Note: The data are representations of the mean values ± standard deviation. Different superscripts in the same row showed statistically significant differences ($p < 0.05$). The lowest value starts from superscripts a. WSI: water soluble index; WAI: water absorption index.

Water Absorption Index

The water absorption index (WAI) in instant soup is an indirect measure of the level of cooking that provides the viscosity and instantaneous ability of powder.[39] The WAI value of instant yellow lab soup ranged from 5.15 to 6.16 g/g (Table 2), the same as the value of instant rice/bean soup (5.5vg/g).[41] The low WAI may be due to the drier structure and hygroscopicity of the product.[32] In this research, the WAI value of IPS increased significantly with the addition of porang flour. Glucomannan in porang flour has an excellent ability to hold water.[13] Furthermore, it is even able to absorb water up to 200 times.[9] A high WAI value can maintain moisture in the product, improve handling characteristics and avoid dehydration during storage.[22]

Rehydration Ratio

The rehydration properties of dry products are generally used as a quality index. The rehydration ratio of IPS and IPS-PF is presented in Table 2, ranging from 3.96 to 4.73. This value align with the rehydration ratio value of instant mushroom soup (3.02-4.51).[43] Instant soup with a high rehydration ratio indicates that the product is more porous, so the water can more easily enter the cells.[44] Insoluble dietary fiber is one of the factors for the high rehydration ratio value.[25] Glucomannan in porang flour is a type of water-soluble dietary fiber,[9] thus, porang flour has been confirmed to reduce the rehydration ratio value of IPS-PF.

Morphology Structure

Further observations regarding the effect of porang flour on the structural morphology of IPS samples with the addition of 0-2% porang flour were observed using a scanning electron microscope (Figure 1). The structure of instant soup powder without porang flour shows more chunks of larger size with irregular shapes. Adding porang flour does not change the morphology of the powder, but larger particles tend to decrease and become smaller flakes. The addition of porang flour causes aggregation. This is in line with what was reported by Li,[26] who observed that the addition of the glucomannan component caused aggregation to occur in the dough morphology. Other research also reports that the addition of porang glucomannan will produce a more compact matrix and appear to have lots of aggregates.[45] Glucomannan can bind water and fill the structure, thereby creating stronger bonds between particles and water molecules. These results can explain the increase in WAI and WSI of instant pumpkin soup, which increased with the amount of aggregate formed. Aggregation can bind more water upon contact and produce a denser structure.[46]

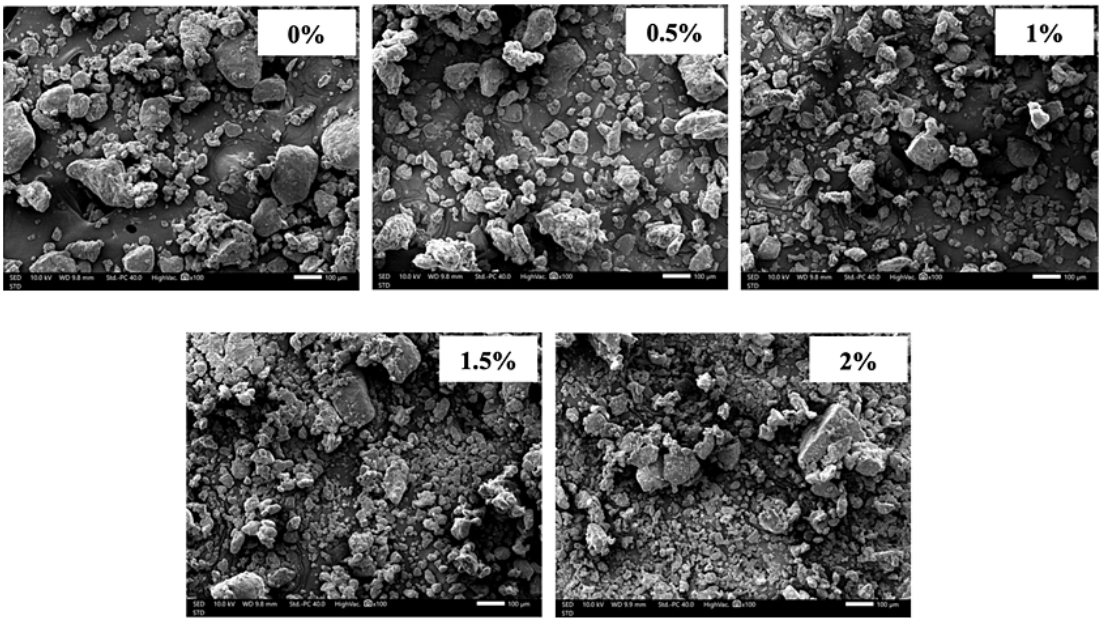

Fig. 1: SEM Images of Instant Pumpkin Soup

Tabel 2: Color characteristics of instant pumpkin soup

Parameters	Porang Flour (%)				
	0	0.5	1	1.5	2
L*	20.07 ± 0.05^{c}	19.88 ± 0.10^{b}	19.76 ± 0.31^{b}	19.10 ± 0.08^{a}	18.96 ± 0.16^{a}
a*	7.03 ± 0.56^{b}	6.95 ± 0.12^{b}	6.80 ± 0.08^{b}	6.06 ± 0.17^{a}	6.01 ± 0.23^{a}
b*	19.09 ± 0.27^{b}	19.04 ± 0.19^{b}	19.03 ± 0.47^{b}	18.03 ± 0.11^{a}	18.03 ± 0.28^{a}

Note: The data are representations of the mean values ± standard deviation. Different superscripts in the same row showed statistically significant differences ($p < 0.05$). The lowest value starts from superscripts a.

Color characteristics

Color is a physical attribute that is one of the indicators in assessing the quality of a product that can influence consumer preferences. The results of chromatic color measurements are presented in Table 3. IPS and IPS-PF has a brightness value (L*) of around 18.96 to 20.07. The higher the addition of porang flour, the more the brightness of the soup decreases significantly. In addition, the a* (6.01 – 7.03) and b* (18.03 – 19.09) values of instant soup also decreased with the increase in the addition of porang flour as a soup coating. The high sugar content and carotenoid pigments in pumpkin will cause Maillard reactions during drying.[47] High-temperature drying may alter sugar or starch materials and turn the color of the soup into brown.

Tabel 4: Sensory characteristics of instant pumpkin soup

Porang Flour (%)	Sensory Characteristics			
	Flavor	Color	Taste	Viscosity
0.0	3.90 ± 0.23^{d}	3.65 ± 0.44^{b}	3.80 ± 0.16^{c}	3.35 ± 0.22^{c}
0.5	3.30 ± 0.17^{b}	4.15 ± 0.56^{d}	3.65 ± 0.31^{c}	3.65 ± 0.13^{d}
1.0	3.75 ± 0.10^{c}	3.55 ± 0.13^{b}	3.70 ± 0.22^{c}	3.40 ± 0.24^{c}
1.5	3.30 ± 0.41^{b}	3.75 ± 0.52^{c}	3.30 ± 0.31^{b}	2.35 ± 0.15^{b}
2.0	2.95 ± 0.05^{a}	2.80 ± 0.71^{a}	2.95 ± 0.44^{a}	1.90 ± 0.21^{a}

Note: The data are representations of the mean values ± standard deviation. Different superscripts in the same column showed statistically significant differences ($p < 0.05$). The lowest value starts from superscripts a.

Sensory Characteristics

Panelists' preference levels for the parameters of aroma, taste, thickness, and color of instant pumpkin soup were analyzed using the Friedman method. The test result explained that the variations of porang flour differed significantly in aroma, color, taste, and thickness. In general, adding porang flour was negatively correlated with the panelist's preference level in terms of aroma, color, taste, and thickness (Table 4). Porang flour has a distinctive smell. As previously reported, incomplete drying will cause an unpleasant odor when added to food.[48] The color of porang flour tends to be slightly brownish. The higher percentage of porang in IPS-PF formula may darken the color of the instant soup formula. However, this brown discoloration is not something that consumers like.[49] Glucomannan in porang flour is a gelling agent.[50] The increasing amount of porang flour added are in line with the formation of more tough and high-dense texture of the powder.[51]

Conclusion

The addition of porang flour has a significant effect on the physical and sensory characteristics of IPS-PF formula. The higher addition of porang flour significantly increases water content, dietary fiber, viscosity, WSI, and WAI and significantly decreases water activity, vitamin E, rehydration ratio, color profile, and sensory properties of IPS-PF. Even though the viscosity of IPS-FS is very good, the use of too high porang flour affects the level of panelist acceptance. Adding 0.5% of porang flour produced IPS with a moisture content value of 6.99%, water activity of 0.45, dietary fiber of 8.90%, vitamin E 0.89 mg/Kg, and viscosity of 19.04 m.Pas, WSI 44.97%, WAI 5.22 g/g, RR 4.42. Fragmented and aggregated structures, color characteristic with an L* value of 19.88; a* 6.95, and b* 19.04, as well as the panelist's preference level of "rather like" on the aroma parameter, "like" on the color, taste, and thickness parameters.

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Author's Contribution
All authors contributed to data collection, data analysis, data presentation and discussion.

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Not applicable

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