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Process optimization for producing pumpkin (*Cucurbita moschata* D) and arrowroot (*Marantha arundinaceae* L) starch-based instant porridge

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Abstract. Pumpkin is a potential source of vitamin A and β -carotene as an antioxidant, thus it is promising to be developed as functional food ingredients. However, pumpkin-based manufactured food is still limited. Hence an experiment is initiated to produce pumpkin and arrowroot starch-based instant porridge which is easy to prepare and people ranging from children to adults fond of it. Pumpkin was whisked and mixed with arrowroot starch in the ratio of 1:1, 2:1, 3:1, 4:1, and 5:1 until it became an instant porridge. The porridge was then put into a drum dryer (1 bar) and it was rotated at the speed of one or one and a half round per minute. Color and viscosity of the produced instant porridge were determined. The results indicated that physical characteristics of instant porridge were affected by ratio of pumpkin with arrowroot starch and the rotation speed of the drum dryer. Instant porridge made from pumpkin-arrowroot starch in the ratio of 5:1 and produced at the speed of one and a half round per minute had a color value of L: 74.43, a: 9.33, b: 32.50, and viscosity 47.4 cP.

1. Introduction

Pumpkin (*Cucurbita moschata* D.) is a type of annual plant from the *Cucurbitaceae* family. Availability of pumpkin in Indonesia is relatively high. The three most common varieties are *Cucurbita pepo*, *Cucurbita maxima* and *Cucurbita moschata*. Pumpkin is also rich in carotene, vitamins, minerals and fiber [1]. The chemical composition as well as the antioxidants content makes pumpkin an important food product for human consumption and industrial utilisation [2]. Just as in most fruits, pumpkins are very sensitive to microbial spoilage, even under refrigerated conditions. Thus, it is best if they are preserved in order to increase shelf life [3]. This is especially true as the perishable nature of pumpkin tends to limit its utilisation, hence the need to be processed by drying [4]. Pumpkin contains high carotenoids reaching 160 mg/100 g. Pumpkin comes from the *Cucurbitaceae* family and *Cucurbita* genus. Common cultivars (*Cucurbita moschata* D.) for human consumption are called pumpkins [5].

Pumpkin names are vary between different countries, among others, pumpkins are called Kabocha (Japan), buttercup (New Zealand). Pumpkin has a yellow-orange color, sweet taste and sweeter than other pumpkin varieties [6]. Pumpkin is stable during storage about 3 to 4 months after harvesting. However, after the skin is peeled off, the pumpkin is in a state that is susceptible to softening, microbes, discoloration and decay. Pumpkin is rich in fiber (dietary fiber), contains bioactive compounds, β -carotene, vitamin A and tocopherol [7]. Besides these vitamins, pumpkin also contains other vitamins, namely B6, K, C, thiamine and riboflavin. The mineral contents in the pumpkin include K, P, Mg, Fe and Se [8] Pumpkin is rich in fiber (dietary fiber), contains bioactive compounds, β -carotene, vitamin A and tocopherol [9]. In addition to these vitamins, pumpkin also contains other vitamins, namely B6, K, C, thiamine, and riboflavin.

Arrowroot (*Maranta arundinacea* L.) is a starch carbohydrate source that has the advantage of having a low glycemic index, making it suitable for people with diabetes mellitus. Arrowroot tubers have health benefits because of the lower glycemic index (14), compared to other tubers, such as gembili (90), kimpul (95), canna (105), and sweet potato (179). The glycemic index states a measure of an increase in a person's blood sugar level after consuming the food in question [10].

The optimal drying process with drum dryer which produces pumpkin powder with good aroma uses a vapor pressure of 313.54 kPa with a 1.27 rpm drum dryer rotation. Drum dryer at a vapor pressure of 313.54 kPa and with drum rotation of 1.27 rpm 7.5% in the process of processing the noodles with the highest fiber and β -carotene content [11].

The purpose of this study is to determine the optimization of the process of making instant porridge of pumpkin and arrowroot starch to produce instant porridge of pumpkin and arrowroot starch which has optimal physical properties.

2. Materials and methods

2.1. Materials

The main ingredients used in this study were pumpkin (*Cucurbita moschata* D.) and arrowroot starch. Pumpkin was obtained from the Ungaran area of Central Java. The specifications of the pumpkins that were used were already ripe optimally at the age of 3 months of harvest, had orange skin and flesh. The pumpkins used were weighing between 8-10 kg/fruit. Arrowroot starch was obtained from a group of arrowroot processed craftsmen from Mekar Jaya in Pajangan Area, Bantul, Yogyakarta. The tool used in this study was drum dryer for instant porridge of pumpkin and arrowroot starch production.

2.2. Methods

The skin of the pumpkin was peeled, then the fruit was cut into pieces with a size of 2 x 2 x 2 cm³. Pumpkin pieces were included in the grinding machine with arrowroot starch added in the ratio of each of: 1:1, 2:1, 3:1, 4:1, and 5:1. Each mixture of pumpkin and arrowroot starch was added with 200 ml of distilled water. The resulting mixture of pumpkin and arrowroot starch was processed using a drum dryer with a variation of the drum dryer rotation speed of 1 and 1.5 rpm at a pressure of 1 bar. The resulting drum dryer process was in the form of a thin slurry of instant slurry, then it was ground and sieved with an 80 mesh sieve.

2.3. Color Testing

The color test in this study used a Chromameter CR 300 Minolta (Japan). Testing was conducted using the Hunter L *, a * and b * color systems. Chromameter before use was calibrated first with the white standard on the device.

2.4. Viscosity Testing

The viscosity test was carried out in this study by using a Brookfield Viscometer tool. The working principle of liquid viscosity testing is to measure the degree of viscosity of liquid samples. The measurement of the thickness of the liquid is useful to know that the frictional force experienced by an

object moving in a fluid is related to the viscosity of the liquid. The thicker a liquid means that it will inhibit the flow of the liquid to move.

3.5. Statistical Analysis

The data were analyzed statistically by one-way variance analysis (ANOVA) at a significance level of 0.05 and the difference in mean values was determined by Duncan's Multiple Range Test (DMRT) ($p < 0.05$) to determine the difference between concentration treatments. For statistical analysis using the SPSS 16, one way anova program.

3. Results and Discussion

3.1. Color

The color of instant porridge of pumpkin and arrowroot starch with variations of pumpkin- arrowroot starch and rotation speed of drum dryer are presented in Table 1.

Table 1. Color of Instant Porridge of Pumpkin and Arrowroot Starch

Pumpkin : arrowroot starch	Rotation speed of drum drier (rpm)	L	a	b
1:1	1	78.66 ± 0.23 ^d	4.36 ± 0.57 ^a	22.46 ± 0.11 ^d
2:1	1	78.70 ± 0.17 ^d	6.36 ± 0.57 ^c	29.10 ± 0.26 ^e
3:1	1	73.70 ± 0.00 ^a	6.13 ± 0.57 ^c	28.43 ± 0.05 ^d
4:1	1	79.36 ± 0.04 ^e	7.83 ± 0.57 ^e	28.20 ± 0.51 ^d
5:1	1	78.00 ± 0.00 ^c	9.00 ± 0.00 ^g	32.70 ± 0.00 ^g
1:1	1.5	80.03 ± 0.46 ^f	5.33 ± 0.57 ^b	25.63 ± 0.28 ^b
2:1	1.5	77.50 ± 0.00 ^b	6.10 ± 0.17 ^c	29.13 ± 0.32 ^e
3:1	1.5	78.23 ± 0.32 ^c	6.73 ± 0.20 ^d	26.70 ± 0.20 ^c
4:1	1.5	80.30 ± 0.00 ^f	8.20 ± 0.00 ^f	29.80 ± 0.00 ^f
5:1	1.5	77.43 ± 0.15 ^b	9.33 ± 0.00 ^h	32.50 ± 0.20 ^g

Values are mean ± standard deviation. Means within the same column with different letters are significantly different ($p < 0.05$).

Based on the color Table 1, it shows that the more the pumpkin ratio added, the more the brightness value decreased. This is because the more pumpkin added the instant porridge color was produced, the color turned into yellow-orange, so the white degree decreased. The lowest level of instant porridge brightness in the ratio of pumpkin and arrowroot starch was 5:1 at 1 or 1.5 rpm drum dryer rotation speeds. As for the redness value (a) shows that there were more pumpkin produced instant slurry which was getting red. This was because the pumpkin contained carotene which gave the red pigment. The yellowish value (b) also had the same tendency as the reddish value, that was, the more pumpkin would produce instant porridge which was getting yellowish. The effect of drum dryer rotation speed on the value of redness and yellowish indicated that the drum drier speed of 1.5 rotations per minute increased the value of redness and yellowish in the instant porridge produced. This was because the faster the rotation of the drum drier did not cause much decrease in the value of the reddish and yellowish color. Carotenoids would decrease due to longer heat contact. Drum dryer rotation at 1.5 rpm was longer than 1 rpm. [11] reported that the higher drying temperature and long drying time caused a decrease in beta carotene levels to reach 56%. [12] stated that the temperature and time of the process of making instant porridge using a drum dryer affected the product produced.

3.2. Viscosity of Slurry Instant Porridge of Pumpkin and Arrowroot Starch

Table 2 shows the viscosity of instant porridge of pumpkin and arrowroot starch before being processed using a drum dryer. The more pumpkin, the viscosity increased. At the pumpkin and arrowroot starch ratio of 5:1, the highest viscosity was 970.8 cP. This was because the water content of pumpkin was greater than arrowroot starch. This was consistent with what was stated by [13] that the total solids in pumpkin was ranged between 7-10%, which meant the water content was between 90-93%. Based on the best instant porridge sensory testing produced by the drum dryer process at a ratio of 5:1 at 1.5 rpm rotation speed, it had a viscosity value of 47.4 cP.

Table 2. Viscosity of Slurry Instant Porridge of Pumpkin and Arrowroot Starch

Pumpkin : arrowroot starch	viscosity (cP)
1:1	140.50 ± 0.70 ^a
2:1	212.00 ± 2.12 ^b
3:1	338.80 ± 1.41 ^c
4:1	549.90 ± 0.00 ^d
5:1	970.80 ± 1.41 ^e

⁴ values are mean ± standard deviation. Means with different letters are significantly different (p<0.05).

4. Conclusion

The treatment ratio of pumpkin and arrowroot starch and rotation speed of drum dryer affected the physical properties of instant porridge of pumpkin and arrowroot starch produced. Variation of pumpkin and arrowroot starch by 5:1 in the drum dryer process in a pressure of 1 bar and a speed of 1.5 rotations per minute produced instant porridge with colors: L: 74.43, a: 9.33, and b: 32.50, and viscosity 47.4 cP.

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