Effect of pre-gelatinization on physicochemical and functional properties of Solenostemon rotundifolius flour

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Abstract. Solenostemon rotundifolius is one of the native tubers from Indonesia that has good potential as a flour source. Unfortunately, this kind of potato has poor quality and undesirable functional characteristics so that underutilized in the food industry. Therefore, the processing of Solenostemon rotundifolius into flour product is needed to be modified to improve the quality, obtain the added value of flour, and enhance food product development using a pre-gelatinization treatment. Pre-gelatinization is a hydrothermal process that initiated with boiling and ended with drying. This study evaluated the effect of pre-gelatinization treatment on the physicochemical and functional properties of Solenostemon rotundifolius flour at optimum temperature and time of process (60°C for 7 minutes). The pre-gelatinization treatment produced 89.58 ± 1.47 % yield of flour, reduced the density (0.55 ± 0.02 g/mL) and lightness of flour (71.30 ± 0.14 L value), and declined the amylose content (18.21 ± 1.22 %) compare to the natural flour, while increased the moisture (8.32 ± 0.31 %), ash (3.95 ± 0.06 %), protein (3.43 ± 0.23 %), fat (0.47 ± 0.01 %), starch content (65.11 ± 0.30 %), and amylopectin (46.90 ± 1.51 %). The differences in physicochemical and functional properties were observed among the pre-gelatinization Solenostemon rotundifolius flour with respect to all of parameters. Thus, Solenostemon rotundifolius flour revealed potency as an alternative flour for food diversification and can be used for substituting wheat flour in the various food products.

1. Introduction
Solenostemon rotundifolius or black potato is one of the native tubers from Indonesia that is not widely known as a common vegetable potato. This black potato is growing wild and spread over Sumatra, Jawa, Kalimantan, Nusa Tenggara, and Maluku [1] and is usually consumed as traditional foods. Black potato contains a high amount of carbohydrate, especially starch content (83%) with amylose content 32% and amylopectin 51% [2]. Thus, starch is a major component of black potato and affects black potato quality. Black potato can reduce the risk of diabetes and obesity diseases because of its low glycemic index, and also well known for high biotin content [3].

Native black potato flour has a good consistency gel thus can be used for substitute rice flour in the making of rice paper, sauce, salad dressing, and mayonnaise [4]. Unfortunately, native black potato flour has less ability on swelling and binding water [5] that make it cannot broader suitable in food product application. Therefore, it needs to be modified to improve some properties to obtain the desired quality, mainly in water binding index and water absorption index.
The pre-gelatinization process is an effective way to increase its physicochemical and functional properties by a modified granule structure [6]. Pre-gelatinization of starch increased solubility and swelling properties [7]. Viscosity, absorption index, and solubility of cassava flour repaired by pre-gelatinization [8]. Pre-gelatinization improved absorption and viscosity of flour in cold water [9] [10]. Thus, by pre-gelatinization, the implementation of starch will be more applicable in the food products. In food application, pre-gelatinization starch is used for thickening agent or filler in instant soup, pudding, sauce, bakery product, and frozen food [11], also applied in flake, powder food, crackers, other snack industry [12].

In this study, we produced native flour from black potato then processed pre-gelatinization to improve its quality. Afterward, we characterized the physicochemical and functional properties of black potato before and after the pre-gelatinization process to characterize its quality. The differences in physicochemical and functional properties were observed among the pre-gelatinization Solenostemon rotundifolius flour with respect to all of the parameters. Thus, Solenostemon rotundifolius flour revealed the potency as an alternative flour for food diversification and can be used for substituting wheat flour in various food products.

2. Material and Methods

2.1. Raw Material

The black potato was harvested during Augustus 2018 from field land in Ngawi, East of Java, Indonesia. The freshly harvested black potato was used for making dried pre-gelatinization flour.

2.2. Methods

2.2.1. Preparation of Native Dried Flour.

The black potato was washed in water flow, peeled and sliced into ± 1mm thickness [13]. Black potato chips soaked in natrium metabisulfite 0.04% for 1 hour, then chips were dried in cabinet drier at 60°C for 7 hours drying process. The dried chips were milled by a blender then passed through 80 mesh sieve shaker. Native black potato flour then stored before analysis.

2.2.2. Pre-gelatinization Process.

Native dried flour of black potato was suspended with water (3:1 w/v) then steam it in water bath shaker at 60°C for 7 minutes, continued with passing the flour slurry into an aluminium tray with ~ 3mm thickness and then dried in cabinet dryer at 45°C for 6 hours. The collected flakes were milled by a blender and passed through 80 mesh sieve-shaker. Dried pre-gelatinization flour was kept in aluminum foil bag until being further analysed.

2.2.3. Analytical methods of physicochemical.

Pre-gelatinization flour was analysed for density [14] and moisture, ash, protein, fat, amylose and amyllopectin content by standard AOAC methods [15]. Colour measurement of pre-gelatinization flour was recorded as L* (lightness) by a colour reader. Total starch was determined with the standard AOAC method [16].

2.2.4. Analytical methods of functional properties

The pasting properties were determined with the Jayakody method [17], while water absorption index (WAI) and water solubility index (WSI) were determined using the method described by Anderson et al. [18].

2.2.5. Statistical analysis

The physicochemical properties of black potato dried pre-gelatinization flour were statistically analysed using Design Expert 7.0 trial version with descriptive.
3. Results and Discussion

3.1. Physical characteristics of flour

Table 1 presents the physical characteristic of dry native black potato flour and dry pre-gelatinized flour, including yield, and density and lightness of native black potato flour and pre-gelatinized black potato flour. After pre-gelatinized in optimum condition 60°C for 7 minutes, it yields 89.58 ± 1.47% of dried pre-gelatinized black potato flour. Bulk density is defined as a mass of particle of a material divided by the total volume they occupy in g/mL [4]. In this study, bulk density decreased after being pre-gelatinized, it is affected by increasing level of starch gelatinization [12] because the starch granule hollow so as to have smaller with the same volume.

| Parameter          | Native       | Pre-gelatinized |
|--------------------|--------------|-----------------|
| Bulk density (g/mL)| 0.62 ± 0.02  | 0.55 ± 0.02     |
| Lightness          | L = 79.25 ± 0.21 | L = 71.30 ± 0.14 |

Color is one of the essential attributes in flour or starch properties, expected to occur bright or white color. Color measurement of pre-gelatinization flour was recorded as L* (lightness), considered the most important and relating flour performance. After being pre-gelatinized, the lightness of dried pre-gelatinized flour color is darker than the native. The differences of flour can be caused by the existence of natural pigment every material while it also formed by the heating process, changing during storage, or affected by other processes [4].

3.2. Chemical properties of flour

Table 2 presents the proximate compositions of dry native black potato flour and dry pre-gelatinized black potato flour. Pre-gelatinized black potato flour presented a higher value of lipid, ash, moisture, and protein content, respectively. Moisture is an essential parameter in the storage of flour, with the highest allowable moisture content of 12% by Indonesian National Standard (SNI) [4] in order to prevent microbial growth and obtain a longer shelf life. In this study, both of flours had moisture content less than 12%; thus, they had a relatively safe, good quality and long shelf life. Protein content, in the food products, gives functional form characteristics like a thickening agent, emulsion, gelling properties, and foaming properties [19]. The presence of lipid content in flour enhances nutritional value in flour, but disrupts swelling properties and absorption properties in its starch [20].

| Parameter       | Native (%) | Pre-gelatinized (%) |
|-----------------|------------|---------------------|
| Protein (%)     | 3.09 ± 0.20 | 3.43 ± 0.23         |
| Lipid (%)       | 0.41 ± 0.01 | 0.47 ± 0.01         |
| Moisture (%)    | 7.37 ± 0.64 | 8.32 ± 0.31         |
| Ash (%)         | 3.33 ± 0.18 | 3.95 ± 0.06         |
| Starch (%)      | 67.44 ± 2.99 | 65.11 ± 0.30        |
| Amylose (%)     | 17.64 ± 0.94 | 18.21 ± 1.22        |
| Amylopectin (%) | 49.80 ± 3.39 | 46.90 ± 1.51        |

Starch content is one of the critical parameters in flour products regarding the quality. Total starch content of dry pre-gelatinized flour was decreased to 65%, which may cause by enzymatic digestion of gelatinized starch. Amylopectin content in pre-gelatinized flour was reduced while the amylose content was increased. Flour with higher amylose content tends to use in hard texture products and suitable to be substituted with other flour in some food snacks.
3.3. Functional properties of flour

Functional characteristic in black potato flour is determined by measure its water absorption index (WAI) and water solubility index (WSI).

| Parameter | Native      | Pre-gelatinized |
|-----------|-------------|-----------------|
| WAI (g/g) | 1.92 ± 0.05 | 2.70 ± 0.04     |
| WSI (%)   | 2.47 ± 0.06 | 8.83 ± 0.56     |

WAI indicates the amount of water taken up by the flour when absorbed in additional water, indicating of starch gelatinization, as native starch did not absorb water without increasing the temperature. WAI content of pre-gelatinized flour was increased compared with the native. It was perceived that elevating temperature with the pre-gelatinization process may increase the WAI of the flours. WSI content indicated the solubility of flour in water. The result showed that pre-gelatinized black potato flour had higher WSI than the native flour. This is reflected that pre-gelatinized flour more likely easy to be homogenized with other food ingredients [21]. Flour with higher WSI tends to use in the baby food products, food powder, cake mixes, and pudding [22].

4. Conclusions

The pre-gelatinization treatment produced 89.58 ± 1.47 % yield of flour, reduced the density (0.55 ± 0.02 g/ml) and lightness of flour (71.30 ± 0.14 L value), and declined the amylose content (18.21 ± 1.22 %) compare to the natural flour, while increased the moisture (8.32 ± 0.31 %), ash (3.95 ± 0.06 %), protein (3.43 ± 0.23 %), fat (0.47 ± 0.01 %), starch content (65.11 ± 0.30 %), and amylopectin (46.90 ± 1.51 %). The differences in physicochemical and functional properties were observed among the pre-gelatinization Solenostemon rotundifolius flour with respect to all of parameters. Thus, Solenostemon rotundifolius flour revealed the potency as alternative flour for food diversification and can be used for substituting wheat flour in various food products.

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