Browning Prevention of Chips from Freshly Harvested Porang (Amorphophallus oncophyllus) Tubers through Immersion in Ascorbic Acid Solutions at Various Times

A C Kumoro\textsuperscript{1}, M Amyranti\textsuperscript{1}, D S Retnowati\textsuperscript{1} and R Ratnawati\textsuperscript{1}

\textsuperscript{1}Department of Chemical Engineering, Faculty of Engineering, Universitas Diponegoro. Prof. H. Soedarto, SH Road-Tembalang, Semarang, 50275, Indonesia

Email: andrewkomoro@che.undip.ac.id

Abstract. Porang (Amorphophallus oncophyllus) tubers contain multifunctional water-soluble heteropolysaccharides, called glucomannan. Therefore, the quality of porang tuber chips is highly depending on its glucomannan content and physical appearance. The presence of considerable amount of carotene, polyphenoloxidases and tannins in these tubers may cause browning of chips and flour during processing. The purpose of this research was to study the effect of anti-browning agent (ascorbic acid) concentrations (2, 5 and 7.5\% w/w) and immersion times (30, 60, 90, 120, 150 and 180 minutes) on the degree of whiteness of porang tuber chips. An increase in the concentration of anti-browning agent solution up to 5\% w/w caused significant increase the degree of whiteness of porang tuber chips. However, further increase in the concentration of anti-browning agent solution exhibited reduction in the degree of whiteness of porang tuber chips. In addition, a longer immersion time also resulted in a higher degree of whiteness of porang tuber chips. The best browning prevention conditions were through immersion of porang tuber chips in 5\% w/w ascorbic acid solution for 120 minutes, from which a highest degree of whiteness was achieved (79.41).

1. Introduction
Porang (Amorphophallus oncophyllus) is a member of the amorphohallus clan, which is belonging to the taro tribe (Araceae). This plant grows well in the tropical and sub-tropical areas. The tuber of this plant is rich in glucomannan, a polymer of D-mannose and D-glucose, with some of the glucose residues being acetylated [1]. Glucomannan exhibits a number of unique properties including being able to form a thick solution in water, large volume expansion ratio, and ability to form a gel. Glucomannan also promotes the development of special taste and texture to food that widens its applications in the food industries, such as emulsifier, thickener, surfactants, dietary fiber and film forming agent [2]. About these superior properties, people have also used glucomannan in the health and medical areas against obesity and some diseases related to gastrointestinal tract disorder [3], stomach ulcers, diabetes and high blood pressure as well as in the drug delivery system through coating, films and membranes, drug carriers [4]. However, the considerable content of calcium oxalate crystals in porang tubers has limited its direct consumption by human because the oxalate may cause itching and trigger the development of kidney stone. In addition to the content of conisine that causes bitter taste, porang tuber also contains carotene about 40 mg/kg FW and small amount of polyphenoloxidases (PPOs) and tannins that may trigger browning of the flour during processing [5].
Commercial extraction of glucomannan from porang tubers required high quality porang flour obtained from micronization of dried porang chips.

The degree of whiteness of the flour is one of the most critical quality factors that play an important role in the enhancement of flour’s appearance and customer’s acceptance [6]. Takigami [5] reported that the whiteness of commercial Japanese porang tuber flour is ranged from 66 to 68; while the whiteness of its purified form should not be lower than 73. Therefore, porang flour producers have to prevent browning, hardening and gelatinization cases to obtain porang flour with premium physical and chemical properties [3]. The occurrence of browning and hardening cases during processing may affect the final color of porang tuber chips. Browning may occur through enzymatic mechanism and non-enzymatic mechanisms (caramelization and/or Maillard reaction) [7]. Enzymatic browning is one of the most important reactions that occur in many fresh-cut fruit and vegetables. This reaction, in which phenolic compounds are oxidized, is related to PPO activity, the amount of phenolics and the presence of oxygen [8]. Some browning prevention efforts have been dedicated to porang chips by soaking of the chips in food grade inorganic anti-browning solution agents, namely the SO2 releasing agents (Na2SO3, K2SO3, Na2S2O5, NaHSO3) at a concentration of 0.25% w/w [3], CaCl2 solution at 0.1 % [9], and 3% H2O2 solution [10]. Zhao et al. [3] also employed organic anti-browning agents, namely 6‰ w/w citric acid to prevent discoloration of porang tuber chips. The inorganic anti-browning agents exhibited excellent protection against discoloration at a concentration of 0.25% w/w. At this concentration, the residual concentrations of sulphurous acid radical in the porang tuber chips were below 4×10⁻⁵ ≤ 40ppm, which complies with the Chinese food standards. Upon treatment with 6‰ w/w ascorbic acid solution, Zhao et al. [3] observed no discoloration and sulphur residue in the porang tuber chips. Widjanarko et al. [10] obtained the highest degree of whiteness (60.38) of porang tuber chips through immersion of the chips in the 3% w/w H2O2 solutions with the assistance of ultrasonic irradiation. Recently, Mawarni and Widjanarko [11] combined the physical and chemical methods to prevent browning in porang flour processing and they successfully achieved the degree of whiteness ranged from 58.76 to 69.65. It is clear that with initial degree of whiteness value of raw Indonesian porang tuber are around 62.72, more browning prevention studies are required to obtain porang tuber chips with commercially acceptable degree of whiteness [11].

Comprehensive studies on the use ascorbic acid as whitening agent for porang tiber chips processing have never been reported in the literature. In this research, the effect of the concentrations ascorbic acid solution and soaking time on the degree of whiteness of porang chips was investigated. The results of this research are expected to be beneficial for porang tuber processors in optimizing their processing methods.

2. Materials and Method

2.1. Materials

The materials used in this study were freshly harvested matured porang tubers (± 9 months old) obtained from farmers under the supervision of PT Perum Perhutani in Kendal Regency, Central Java-Indonesia. The ascorbic acid used in this study was manufactured by Sigma-Aldrich (Singapore) and was purchased at analytical grade (≥ 98.99% w/w purity) from an authorized chemicals supplier in Semarang-Indonesia. They were directly used without prior treatments. The demineralized water used in this study was prepared using a reverse osmosis water purification system in the Department of Chemical Engineering, Faculty of Engineering, Universitas Diponegoro - Semarang.

2.2. Preparation of porang tuber chips

Porang tubers were firstly cleaned from the dirt, washed using flowing water, and peeled to remove the skin. The peeled porang tubers were sliced using a chopper machine to obtain porang tuber chips with 0.5 cm thickness and surface area of about 15-20 cm².

2.3. Anti-browning experiments
Porang tuber chips were soaked in carefully prepared anti-browning solution for 3 hours at 40°C in a series of plastic pans. The anti-browning solutions used were ascorbic acid solution at concentrations of 0%, 2, 5 and 7.5% w/w. The porang chip samples were withdrawn from the systems at every 30 minutes. The wet porang chip was drained by spreading them out of hollow metals pan and further dried using an electric oven at a temperature of 60°C to a moisture content of 14%. The dried porang chips were then subjected to color analysis using the Minolta Chroma Meters CR-400 to measure the value of degree of whiteness.

2.4. Color analysis

Whiteness degree analysis was measured using color analyzer, the Minolta Chroma Meters CR-400. The screen of the equipment immediately showed the values of the parameters $L^*$, $a^*$ and $b^*$, which indicates the lightness or whiteness, redness-greeness and yellowness-blueiness of the sample. Theoretically, a whiter porang tuber flour should exhibit $L^*$ value of close to 100 [12].

3. Results and Discussion

Color is a parameter that affects the economical and aesthetic value of porang tuber flour. High quality porang tuber flour may only be obtained from bright color dried porang tuber chips. A simple browning prevention method through soaking of porang tuber chips in ascorbic acid solution of various concentrations for pre-determined duration has been carried out. The results are summarized as the followings:

3.1 Effect of concentration of ascorbic acid solution

Figure 1 shows that the longer soaking time resulted in an increasing degree of whiteness degree (lightness) of porang tuber chips. Soaking of porang tuber chips in distilled water (0% ascorbic acid solution) exhibited lower value of degree of whiteness due to lowest protection capacity against exposure to free oxygen in the air. The role of ascorbic acid as browning prevention agent appeared as the degree of whiteness of the porang tuber chips slightly increased when 2% w/w ascorbic acid solution was used as the soaking solution. Ascorbic acid treatment reduces browning by reduction of O-quinones to their precursor diphenols. It is suggested that ascorbic acid can reduce color changes arising from enzyme catalyzed browning during tuber processing [13]).

![Figure 1. Effect of ascorbic acid solution concentration and soaking time on $L^*$ (whiteness degree) of porang tuber chips.](image)

An increase in ascorbic acid concentration (2 to 5% w/w) further increased the degree of whiteness of porang tuber chips to a maximum value (79.41) as the soaking time up to 120 minutes and level off.
However, a lower degree of whiteness of porang tuber chips was obtained when the ascorbic acid solution concentration was increased to 7.5%. This phenomenon is reasonable because a higher concentration of ascorbic acid solution facilitated more adsorption of ascorbic acid molecules onto porang tuber chips. Unfortunately, some of the ascorbic acid may degrade during drying, which was reported to follow the first order reaction [14]. This suggests that at a given drying temperature, a higher value of ascorbic acid concentration on the porang chips surface may lead to a faster degradation rate. Drying of porang tuber chips at 60°C may accelerate the thermal degradation of ascorbic acid, which finally reduce the availability of ascorbic acid. At this drying temperature, the PPO activity in the enzymatic browning reaction has been inactivated [15]. It can be assumed that the lower enzymatic browning activity is primarily due to thermal inactivation because the availability of ascorbic acid in the system may not be sufficient to inhibit enzymatic browning.

3.2 Effect of soaking time

Figure 1 presents that for lower concentration of ascorbic acid solution (0 and 2% w/w) a longer soaking time results in a higher value of degree of whiteness. Visually, a brighter porang tuber chips were observed when they were soaked for longer times. The highest degree of whiteness (79.41) was obtained from soaking of porang tuber chips using 5% w/w ascorbic acid solution for 120 minutes. However, prolong the soaking process caused considerable reduction in the degree of whiteness of porang tuber chips when they were soaked in higher concentrations of ascorbic acid solution (5 and 7.5 % w/w). This phenomenon can be explained from the fact that ascorbic acid plays its role as anti-browning agent by reducing O-quinones, produced by PPO-catalysed oxidation of polyphenols, back to dihydroxy polyphenols [16]. Nicolas et al. have suggested that ascorbic acid treatments are temporaries and not significantly effective to inhibit enzymatic browning of fresh-cut apples, because once this acid is totally oxidized to dehydroascorbic acid, the O-quinones cannot be longer reduced and are subsequently accumulated on the porang chips surfaces. As a results, the darkening may happen due to the formation of melanines [17-18].

4. Conclusion

The best conditions for prevention of browning in chips porang with maceration time from 30 minutes to 180 minutes using organic anti-browning agents (ascorbic acid) were obtained at 120 minutes. The effect of adding concentration levels on chips has porang effect on the whiteness degree with the highest level of 5% (79.41).

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