The Influence of Maltodextrin and Final Cooking Temperature on Beta-Carotene and Tocopherol Retention of Granulated Coconut Sugar

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Abstract. Additions of red palm oil in coconut sugar processing is expected to increase their antioxidant and provitamin A content. Objective of this research was to determine the effect of maltodextrin additions and the final cooking temperature on beta carotene and tocopherols retentions of granulated coconut sugar. Factors tested were end cooking temperature (119 °C (T1), 120 °C (T2), and 121 °C (T3)) and maltodextrin levels (0% (M0), 0.2% (M2) and 0.4% (M3)). End cooking temperature of 119 °C had the highest retention of tocopherol and beta carotene (25.27% and 39.44%, respectively) compare to temperature of 120 °C (19.62% and 33.52%, respectively) and 121 °C (14.53% and 29.33%, respectively) ($p < 0.05$). The higher of maltodextrin additions, retention of tocopherol was decreased. In the other hand, beta carotene content increase in line with increasing of maltodextrin addition ($p > 0.05$). The higher the final cooking temperature (end point), in a range of 119 °C-121 °C, the lower the tocopherol and β-carotene contents and retention. Tocopherol content and retention decreased with the increasing amount of maltodextrin, in contrast to the increased β-carotene content and retention. Granulated coconut sugar enriched with red palm oil, a rich source of antioxidant, will increase its functional and competitive value.

Keywords: Beta carotene · Coconut sugar · Maltodextrin · Temperature · Tocopherols

1 Introduction

Granulated coconut sugars is a traditional home-made sugar, was processed by evaporating coconut sap up to supersaturated phase, and than solidified and granulated to get a granular formed sugar.One of the stages in the processing of coconut sugar is the

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addition of vegetable oil to decrease the surface tension (defoaming stage). Replacing vegetable oil with red palm oil which is rich in provitamin A (carotene) and antioxidants (tocopherols and tocotrienols), will improve the functional value of the product. It will increase daily intake of vitamin A and antioxidant which will improve vitamin A status and suppress stress oxidative, a risk factor for degenerative disease.

Red palm oil contains about 500–700 ppm β-carotene [1, 2], lycopene (18.5–38.0 ppm) [3, 4] and vitamin E (560–1000 ppm) which consists of tocopherol (18–22%) and tocotrienol (78–82%) [2, 5]. Vitamin E may exert some health benefits on Metabolic Syndrome patients [6].Tocopherol is a quite potent antioxidant and serves as radical scavenger [2], particularly α-tocopherol which is a radical chain-breaking antioxidant [7]. Tocotrienol is more effective than tocopherol, because unsaturated side chains facilitate better penetration [8]. Animal studies show that palm tocotrienol improves blood glucose, dyslipidemia and oxidative stress in diabetic mice. This can prevent the development of blood wall changes in DM [9, 10].

Previous study showed that the addition of 0,3% of red palm oil in solidified coconut sugar processing with end cooking temperature of 118 °C did not alter the product's sensory characteristics, and the product had 1337–3946 μg β-carotene/100 g [11]. The 2-wk intervention in mice could increase hepatic retinoid stores, an indicator of vitamin A status, above the cutoff point. It also could increase immunoglobulin G levels by nearly 3-fold, which was an indicator of increased immune [12], and had positive response to increased body weight in deficient vitamin A-mice with VAD [13]. Related to vitamin E retention, report that vitamin E degradation in edible palm oil would continously increase in temperatures ranging from 210 °C to 278 °C [14]. However, there has been no study on the addition of red palm oil in granulated coconut sugar, vitamin E (Tocopherol) and β-carotene retention.

Thing that needs to be considered in the development of granulated coconut sugar enriched with red palm oil is the determination of final cooking temperature (end point), which will influence on sucrose crystallization. In processing of granulated sugar was needs a higher end point than solidified sugar. The duration of heating process is also greatly affected by the components in coconut sap or the ingredients added during coconut sap cooking process. Fat and gum contained in red palm oil may affect the end point level. Besides that, an agent is needed to disperse the red palm oil; that is, maltodextrin, which has the ability to homogenize red palm oil (non-polar) into coconut sap (polar). Maltodextrin is a starch hydrolysate with dextrose equivalent (DE) < 20, and it has the ability to bind hydrophobic component in the coil structure which is formed when the linear polymer chains of glucose undergo gelatinization [15]. This ability allows maltodextrin to provide a protective effect to β-carotene and vitamin E (tocopherol) which are non-polar, by trapping them in the coil system. Based on the description above, this study was conducted with the aim to determine the effect of maltodextrin additions and the final cooking temperature on beta carotene and tocopherols retentions of granulated coconut sugar enriched with red palm oil.

2 Materials and Method

The material used in this study was granulated coconut sugar, made from coconut sap and modified by replacing the use of vegetable oil with red palm oil. Coconut sap was

heated to boiling, and then maltodextrin was added, in accordance with the predetermined treatment. The heating process was continued until supersaturated phase, characterized by froth formation. Red palm oil in the amount of 0,3% was then added to the coconut sap with sap's standard degrees Brix of 20 [10]. The heating process was continued until the end point, a final temperature of cooking, was reached, in accordance with the predetermined treatment, which measured by Thermocouple Digital Thermometer 4-Channel −200–1372C.

2.1 Study Design

This study was a factorial experiment with randomized block design, which consisted of two tested factors as follows: a) Final cooking temperature: T1 = 119 °C, T2 = 120 °C, TS3 = 121 °C; b) addition of maltodextrin to total coconut sap: M1 = 0.1%, M2 = 0.3%, M3 = 0.4%. The experiment was repeated three times. Observations were performed on coconut sap (pH and total content of the solids) and the granulated coconut sugar produced; including vitamin E (tocopherol) content (HPLC method), antioxidant (tocopherol) retention, β-carotene content (HPLC) and its retention. The supporting data were also observed such as water content (thermogravimetric analysis), reducing sugar and total sugar contents (by Nelson Somogyi method), and FFA content (volumetric method) [16]. The following formula was used to evaluate antioxidant (tocopherol) retention:

$$\text{Retention of tocopherol}/\beta - \text{caroten} = \frac{\text{Total tocopherol}/\beta-\text{carotene in final product}}{\text{Initial amount of tocopherol}/\beta-\text{carotene}} \times 100\%$$

2.2 Statistical Analysis

Data obtain were analysis by Anova. If there were significantly different, continued by Duncan Multiple Range Test.

3 Result

3.1 Vitamin E Content and Retention

Vitamin E (tocopherol) content in this study ranged from 0.19 mg/g to 0.47 mg/g with tocopherol retention of 12.52%–31.52%. The higher the end point, the lower the vitamin E content of granulated coconut sugar ($p < 0.05$). In line with that, vitamin E (tocopherol) content tended to decrease along with the increasing addition of maltodextrin ($p < 0.05$) (Fig. 1).

Mean values of the tocopherol retention of granulated coconut sugar after the addition of 0%, 0.2% and 0.4% maltodextrin were 23.92%; 19.62%; and 15.89%, respectively. Mean values of the tocopherol content and retention of granulated coconut sugar on end point variation treatment (119 °C, 120 °C, and 121 °C) were 25.27%; 19.62%; and 14.52%, respectively (Fig. 2).

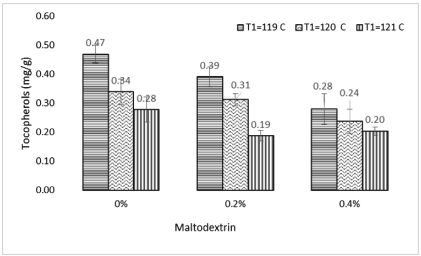

Fig. 1. Effect of maltodextrin addition and final cooking temperature on vitamin E (tocopherol) content of granulated coconut sugar

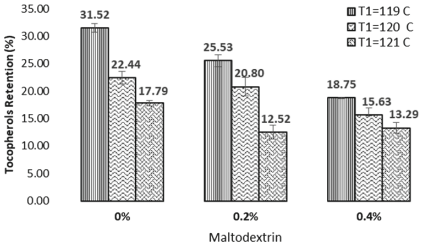

Fig. 2. Effect of final cooking temperature and maltodextrin addition on the retention of tocopherol

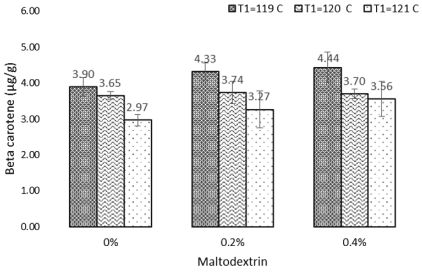

Fig. 3. Effect of final cooking temperature and maltodextrin addition on carotene content of granulated coconut sugar.

3.2 Provitamin A (β-Carotene) Content and Retention

The higher the end point, the lower the caroten content (Fig. 3), and also the lower the retention of caroten (Fig. 4) of granulated-coconut sugar enriched with red palm oil ($p < 0.05$). Meanwhile, the use of maltodextrin had no significant effect although there was a tendency that β-carotene content increased with the increasing addition of maltodextrin ($p > 0.05$).

Mean value of the product's carotene content ranged from 2.97 µg/g to 4.44 µg/g. Mean values of the β-carotene content and retention of granulated coconut sugar after the addition of 0%, 0.2% and 0.4% maltodextrin were 3.51 µg/g and 31.77%; 3.78 µg/g and 34.48%; 3.8 µg/g and 36.03%, respectively. Mean values of the β-carotene content and

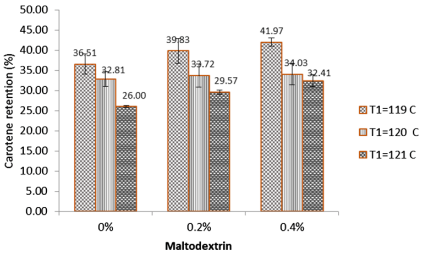

Fig. 4. Effect of final cooking temperature and maltodextrin addition on the retention of carotene

retention in granulated coconut sugar on end point variation treatment (119 °C, 120 °C, and 121 °C) were 4.22 μg/g and 39.44%; 3.7 μg/g and 33.52%; 3.27 μg/g and 29.33%, respectively.

4 Discussion

Vitamin E is a fat-soluble vitamin which has a quite powerful antioxidant activity. Red palm oil added in granulated coconut sugar production contained lycopene (18.5–38.0 ppm) [3, 4] and vitamin E (560–1000 ppm), which consisted of tocopherol (18–22%) and tocotrienol (78%–82%) [2, 5]. Tocopherol is a quite potent antioxidant and serves as radical scavenger [2], particularly α-tocopherol which is a radical chain-breaking antioxidant [7]. Tocotrienol is more effective than tocopherol, because unsaturated side chains facilitate better penetration [8]. Animal studies show that palm tocotrienol improves blood glucose, dyslipidemia and oxidative stress in diabetic mice. This can prevent the development of blood wall changes in DM [9, 10]. The analysis results showed that the red palm oil used in this study contained vitamin E of 11.37 mg/g.

Although vitamin E is a component which is relatively resistant to heat, heating at high temperature and exposure to light and oxygen such as in coconut sugar production will result in the loss of vitamin E [14, 17]. Vitamin E is a powerful antioxidant component; thus, it will protect other components in food system and react with free radicals to form vitamin E radicals. The use of maltodextrin in a larger amount will lead to the greater number of polar components trapped in maltodextrin's coil system, including fat and β-carotene components. Thus, there will be more vitamin E reacting with oxygen, in order to protect the components from oxidative damage. Alpha tocopherol can react with peroxyl radicals or other free radicals, forming hydroperoxide and α-tocopheryl radicals because of the free hydroxyl groups on tocopherol, which can form hydrogen bonds with the electron donor of peroxide and hydrogen peroxide [17].

The higher the final cooking temperature (end point); the exposure to heat, light and oxygen during sugar processing would result in the increasing amount of damaged vitamin E; thus, its retention significantly decreased ($p < 0.05$) (Fig. 2). Similarly, along with the increasing amount of maltodextrin added, the more the fat components or provitamin A being protected (Fig. 3). Therefore, the retention of vitamin E decreased along with the higher concentration of the maltodextrine added ($p > 0.05$). The role of vitamin E as an antioxidant caused it to be more easily damaged and decreased in number; thus, its retention also decreased.

In the red palm oil added in granulated coconut sugar processing, there was a functional component needed by the body, namely carotene. According to previous studies, red palm oil contains 500–700 ppm β-carotene [2]. The analysis results showed that β-carotene content of red palm oil used in this study was 826.11 ppm.

Beta carotene is one of a group of red, orange and yellow pigments produced by plants, with a structure of long carbon chains and conjugated double bonds. It contains substituted β-ionone rings at both ends of the chain, and it is a highly lipophilic component due to its non-polar structure. The oxidation of β-carotene may occur directly due to the exposure to oxygen or indirectly due to the effect of free radicals [18]. The loss of β-carotene may also occur because of the reaction on unsaturated isoprene side chains through autoxidation or geometric isomerization, affected not only by sunlight but also heat and acid. Traditional granulated coconut sugar processing allows the exposure to oxygen, light and heat. The higher the end point, the longer the heating time; thus, the higher the exposure to oxygen, light and heat resulting in high degradation levels and decreased retention of β-carotene.

5 Conclusion

The higher the final cooking temperature (end point), in a range of 119 °C–121 °C, the lower the tocopherol and β-carotene contents and retention. Tocopherol content and retention decreased with the increasing amount of maltodextrin used, in contrast to the increased β-carotene content and retention.

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