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Analysis of Carotene in Biscuits made from Yellow Pumpkin Flour (*Cucurbita moschata Durch*) at Various Heating Temperatures

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Abstract

Yellow pumpkin (Cucurbita moschata Durch) is one of the food ingredients rich in dietary fibers, especially pectin, bioactive compounds, beta carotene, vitamin A, tocopherol, other vitamins including B6, K, C, thiamine, and riboflavin, as well as several types of minerals (K, P, Mg, Fe, and Se). This study aimed to determine the carotene retention of biscuits made from pumpkin flour (Cucurbita moschata Durch) at various heating temperatures. This study's stages included preparing pumpkin flour and biscuits, carotene content, and carotene retention analysis from various heating temperatures. Determination of carotene retention using a UV - Vis spectrophotometer. The results showed that the roasting temperature influenced carotene retention in the preparation of biscuits. Biscuits with retention of 86 % were found at a temperature of 190 °C. The lowest carotene retention of 79 % was found at a roasting temperature of 210 °C.

Keywords: Carotene, retention, temperature

Introduction

Indonesia is a country rich in natural content, especially in plants. This can be seen from the diversity of plants that live in the form of vegetables, fruits, and so on. The abundance of vegetables and fruits is widely used as food ingredients as a source of nutrition that can benefit humans. Nutritional sources in plants include protein, fat, carbohydrates, iron, calcium, potassium, etc. In addition to these nutrients, vegetables and fruits are rich in vitamins, minerals, and other nutrients the human body needs (Fadliya et al., 2018). Some vitamins and minerals in vegetables and fruits are antioxidants that can reduce the incidence of nutrition-related non-communicable diseases due to excess or deficient nutrition (Hermina & Prihatini, 2016).

Many people still lack vitamins in this sophisticated and modern era. One vitamin that is often overlooked is vitamin A. Vitamin A cannot be produced by the body and can only be obtained through food. It is found in many vegetables and fruits. Vitamin A plays an important role not only in eye health but also in overall body health.

Carotene is a provitamin, a vitamin A-forming substance (Hasibuan, 2016). Pumpkin is a food rich in dietary fiber, especially pectin, bioactive compounds, beta carotene, vitamin A, tocopherol, other vitamins including B6, thiamine, and riboflavin, and several types of minerals (K, P, Mg, Fe, and Se) (Rakcejeva et al., 2011). The yellow-orange colour of pumpkin is due to the presence of β-carotene (See et al., 2007). The beta carotene content in raw pumpkin is 4.34 mg / 100 g, which is pro-vitamin A and functions as an antioxidant in the body (Koh & Loh, 2018). Foods containing carotenoids can prevent or treat diseases caused by Vitamin A deficiency, such as xerophthalmia and growth disorders. Beta carotene is a compound that is yellow, orange, or red (Wahyuni et al., 2020)

Vitamin A protects the eyes from eye diseases and can smooth the skin (Yanuwardana et al., 2013). According to Ripi (2011), pumpkin has a reasonably complete nutritional content: carbohydrates, protein, and vitamins. Because of this complete nutritional content, pumpkins can be a potential source of nutrition, and the price is affordable for people who need them. Given some of its advantages and relatively cheap price, pumpkin can be a good fortification material. For this purpose, pumpkin is processed into long-lasting products such as flour. Pumpkin flour is a processed product made from pumpkin fruit that can be used as a composite flour mixture to manufacture food products (Dabash et al., 2017). Pumpkin flour can be used as an alternative to overcome nutritional problems, especially vitamin A deficiency, because of its nutritional content, especially its high beta carotene. Pumpkin flour is excellent for fortification. Fortification is adding micronutrients

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(vitamins and trace elements) to foods. Pumpkin flour gives a distinctive flavor that is slightly sweet because pumpkin contains sugar, so panelists like it (Purnamasari & Putri, 2015). Pumpkin flour can be a companion to wheat flour in various processed food products added to pumpkin flour, which has an attractive colour and taste.

One of the processed products made from pumpkin flour is biscuits. Biscuits are dry products that, during processing, go through a roasting process. Besides, biscuits are a product that people of all ages favor because they have a savory texture; biscuits are also easy to carry because they have a light volume (Yuliani & Mardesci, 2017). Biscuits are one of the foods that can be fortified by carotene. The product is affected by heating temperature. According to Kurniawan (2012), carotene is a natural compound with a very high level of unsaturation that is easily degraded due to oxidation and heating processes. The surrounding environment and other factors influence carotene degradation, such as oxygen and light during processing and product storage (Nurakhirawati et al., 2016). Referring to the stability of carotene to heat, it is necessary to study the carotene analysis of biscuits from processed pumpkin flour at various heating temperatures.

Methods

Tools and materials

The tools used are analytical balance, spectrophotometer, sieve, measuring cup, beaker, Erlenmeyer, volume pipette, funnel, mortar and pestle, shaker, oven, mixer, thermometer, spatula, stirring rod, and tools commonly used in making biscuits.

The materials used were pumpkin, margarine, eggs, baking soda, milk powder, table salt, wheat flour, water, baking powder, filter paper, and hexane.

Pumpkin flour making

Pumpkin flour is made as follows: 2 kg of pumpkin was peeled and cleaned of seeds, then thinly sliced with a knife measuring 0.1 - 0.3 cm. The slices were laid out on a baking sheet and dried using sunlight until dry. The dried pumpkin was mashed with a flouring machine and then sieved (Parayana et al., 2016).

Biscuit making

Making biscuits is as follows: 67.5 g powdered sugar, 32.5 g margarine, 1 g salt, 0.5 g baking soda, milk powder, and one egg were homogenized with a mixer. Then, add a mixture of 45 g pumpkin flour and 55 g wheat flour until a smooth dough is formed. Next, the dough was ground, made into plastic sheets, and molded with biscuit molds. After that, the biscuits were baked in an oven at various temperatures, namely 170 °C, 180 °C, 190 °C, 200 °C, and 210 °C until cooked (Lubis et al., 2019). Furthermore, the carotene content of the cooked biscuits was determined with a visible spectrophotometer.

Carotene analysis

The method used in this carotene analysis is the spectrophotometer: 1 g of biscuit sample was extracted with hexanes as much as 10 mL, then shaken at 250 rpm agitation for 1 hour on a shaker. The extraction was repeated until the extract was colorless. The extract obtained was measured for volume and absorbance at a wavelength of 450 nm. In addition to the biscuit samples, dough samples were taken and analyzed using the same method. The carotene content in the samples was calculated using the following equation:

$$x = \frac{A.Y}{E_{1cm}^{1\%}.100} \qquad (1)$$

Description:
x = Carotene weight (g)
A = Absorbance,
Y = Total volume of carotene extract (mL),
$E_1^{1\,\&}$ cm = Molar extinction coefficient (mL / g).

The calculation results are entered into the equations 1, 2, and 3.

$$\text{Carotene content in the product} = \frac{carotene\ weight\ (mg)}{product\ weight\ (g)\ x\ 100\ (g)} \qquad (2)$$

$$\text{Carotene content in dough} = \frac{carotene\ weight\ (mg)}{dough\ weight\ (g)\ x\ 100\ (g)} \qquad (3)$$

$$\text{Carotene Retention} = \frac{carotene\ content\ in\ biscuits\ (mg/g)}{carotene\ content\ in\ dough\ (mg/g)} x\ 100\% \qquad (4)$$

(Ranonto et al., 2015)

Results and Discussion

Pumpkin flour making

Flour-making technology is one of the recommended alternative semi-finished processes because it is more resistant to storage, easy to mix (made composite), shaped, enriched with nutrients, and faster to cook according to the demands of practical life. Making flour requires relatively little water and is environmentally friendly compared to starch making. Composite flour combines several root flours, sertraline, and grains with or without wheat flour (Indrianti et al., 2019). Pumpkin flour is a processed pumpkin fruit product that can be used as a composite flour mixture to manufacture food products (Dabash et al., 2017). Pumpkin flour has the potential to complement wheat flour in various food preparations so that processed products added with pumpkin flour have an attractive colour and taste.

The process of pumpkin flour is made: 2 kg of pumpkin is peeled and cleaned of seeds, then thinly sliced 0.1 - 0.3 cm in size with a knife; the slices are laid out in a pan and dried using sunlight until dry. Drying is the process of removing or removing some of the water. Drying is one way to preserve perishable or rotten foodstuffs. The purpose of drying is to reduce the water content in the material to inhibit microbial growth and unwanted reactions. The success of drying depends on several factors, one of which is the drying temperature. Drying temperatures that are too low will cause failure in drying, resulting in spoilage of the material. Meanwhile, drying temperatures that are too high cause browning of the material due to caramelization (Dharmapadni et al., 2016). The dried pumpkin was pulverized with a flouring machine. Grinding uses a flour mill machine to simplify the sieving process and then sieved with a sieve. Sifting using a sieve measuring 80 - 100 mesh ensures a smooth flour texture (Muchtadi et al., 2011).

The pumpkin flour obtained passes the sieve, is yellowish-white, and has a distinctive smell of pumpkin—the physical condition of pumpkin flour. When viewed from the physical condition of pumpkin flour, it is greatly influenced by the condition of the base material and drying temperature. The older the pumpkin, the higher the sugar content. Due to the high sugar content of pumpkin, if the temperature used in the drying process is too high, the flour produced will be lumpy and smell caramelized (Meliani et al., 2018).

Biscuit making

Biscuits are dry products that are processed through the baking process. Biscuits are products that people of all ages favor because they have a savory texture; biscuits are also easy to carry because they have a light volume (Yuliani & Mardesci, 2017). Biscuits are usually made from wheat flour or other types of flour, fat or oil, sugar, and eggs (Lubis et al., 2014). In general, biscuit making is preceded by making cream dough. Making cream dough involves mixing additional ingredients: sugar, margarine, eggs, skim milk powder, and flour. In making biscuits, the cream dough is mixed with composite flour, flaking and molding, and baking (Hermayanti et al., 2016).

Making biscuits is as follows: 67.5 g powdered sugar, 32.5 g margarine, 1 g salt, 0.5 g baking soda, milk powder, and one egg were homogenized with a mixer. Mixing or homogenization aims to distribute the ingredients used evenly and obtain a smooth dough. Then, add a mixture of 45 g pumpkin flour and 55 g wheat flour until a soft dough is formed. The comparison of the use of too much pumpkin flour will produce poor biscuit products; this is because pumpkin flour contains higher water content and higher fiber compared to wheat flour. Astarini (2013) states that flour must contain high amylopectin above 70 % to produce a good quality product. Some amylose is needed to provide adequate shatter resistance and acceptable texture. Meanwhile, the amylopectin content in pumpkin flour is relatively low. Purnamasari & Putri (2015) stated that pumpkin flour has an amylose content of 9.86 % and amylopectin of 1.22 %. So, wheat flour is needed because it has a high amylopectin content. Wati (2012) states that wheat flour has an amylopectin content of 72 %. Next, the dough is ground, made into plastic sheets, and molded with biscuit molds. After that, the biscuits were baked in the oven at various temperatures, namely 170 °C, 180 °C, 190 °C, 200 °C, and 210 °C until cooked. Different temperature variations were used to see carotene retention from various temperatures. Roasting is an important part of the processes that lead to a quality product. During roasting, fats melt, sugars dissolve, baking agents continue their activity, structures are formed, liquids are displaced, crust on the surface and colour formation occurs.

Several factors can influence the crispness of biscuits. Factors that affect crispness are the raw materials, namely flour, baking powder, and high temperature. Baking powder is a chemical compound used as a developer to increase the volume and lighten the texture of biscuits after baking (Claudia et al., 2015). The low water content in biscuits affects crispness, which is one of the mandatory attributes of biscuits because the low water content in biscuits will affect the texture and will be preferred by consumers (Jagat et al., 2017).

Carotene analysis

The method used in carotene analysis is using the spectrophotometric method. Spectrophotometric identification is based on the form of absorption and the maximum wavelength value (Mappiratu, 1990). The working principle of a spectrophotometer is that when light (monochromatic or mixed) falls on a homogeneous medium, part of the incoming light will be reflected, partly absorbed in the medium, and the rest will be forwarded. The value that comes out of the forwarded light is expressed in absorbance value because it relates to the concentration of the sample. Carotene has a colour range from yellow to red, so the detection wavelength is between 430 and 480 nm (Kuswardhani, 2007). The maximum absorption wavelength value of carotene in hexane solvent is 450 nm.

A total of 1 g of biscuit sample was extracted using hexanes, as much as 10 mL. The function of adding hexanes is to dissolve the carotene contained in the biscuits. This is because hexane is a non-polar solvent. This happens because the intermolecular forces between similar compounds tend to have the same strength. In terms of toxicity, hexane is also less biologically harmful, and the price is relatively lower than other solvents so that production costs will be lower in terms of industrial-scale research aspects (Kuseno et al., 2018). After that, it was shaken at 250 rpm agitation for 1 hour using a shaker. This serves to stir the mixture of solutions to form a homogeneous solution. The extraction was repeated until the extract was colorless. Extraction is a selective process of taking substances in a mixture using an appropriate solvent (Verdiana et al., 2018). The extraction principle is that the liquid enters the cell cavity containing the active substance and will dissolve because there is a difference in concentration between the active substance solution inside and outside the cell. The active substance will diffuse out of the cell (Estikawati & Lindawati, 2019). Extraction is to separate a substance from its mixture using an appropriate solvent (Zhang et al., 2018). The extract obtained was measured for absorbance at a wavelength of 450 nm.

The absorbance value produced can be used to calculate the retention value of carotene in biscuits, as shown in Figure 1.

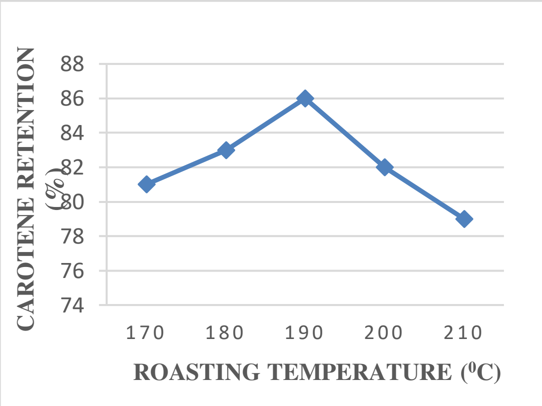

Figure 1. Graph of biscuit retention measurement results at various heating temperatures

Based on the curve above, it can be seen that carotene retention increases from 170 °C to 190 °C, namely 81 %, 83 %, and 86 %, and decreases from 200 °C to 210 °C, namely 82 % and 79 %. Maximum carotene retention was found at 190 °C, which is a good combination because the temperature is lower than 210°C and the time required during roasting is shorter than 170 °C. The 210 °C temperature produced the lowest retention value due to the high roasting temperature, although the time used was shorter. From the data obtained, it can be said that carotene retention depends on the temperature level and the length of time used. However, in this study, variations in treatment time were not carried out. The higher the roasting temperature, the shorter the roasting time, and vice versa (Kurniawan, 2012).

Research conducted by Wardani (2013) explained that carotene retention is influenced by roasting time and temperature. The lowest carotene retention value is found at a temperature of 160 °C, which is 63.22 %, due to the longer roasting time compared to other temperatures. The highest carotene value was found at 190 °C, 94.785 %, the right combination where the temperature is lower than 220 °C and the roasting time is shorter than 160 °C. At 220 °C, the retention value is relatively the same as at 160 °C, namely 65.175 %. This shows that the retention value of carotene decreases in the heating process depending on the temperature level and the length of roasting time. The research was obtained from the findings of Wardani (2013), namely that carotene retention depends on the temperature level and length of roasting time.

The heating process causes the degradation of carotene and degradation products from nonvolatile components that are not carcinogenic (Hastinah, 1996). According to Kurniawan (2012), carotene is a natural compound with a very high level of unsaturation, so it is very easy to degrade due to oxidation and heating processes; this occurs because the number of double bonds is about half of the number of bonds so it is very reactive. Heating at a temperature that is not too high in a short time can cause isomerization of some trans bonds to cis.

Carotenoid compounds are found in the form of trans and cis isomer configurations that are in different levels of cyanidation, depending on the processing method. Erawati (2010) researched the transformation of synthesized carotene and stated that the conditions of the medium influence the resistance of these molecules at high temperatures. Prolonged heating at 180 °C (in the absence of oxygen) only causes slight damage to this molecule, but in foodstuffs (in the presence of constituent components such as starch, fat, etc.) and combined with mechanical mixing will provide an opportunity for O_2 to enter and cause damage to this all trans molecule to a much greater extent. Oxidation of carotenoids will be faster in the presence of light and metal catalysts, especially copper, iron, and manganese. Meanwhile, Goulson & Warthesen (1999) suggested that contact with high oxygen concentrations, heat and light causes beta-carotene decomposition and colour fading.

Several factors cause carotene degradation. The influence of the surrounding environment easily damages provitamin A. Several factors affect the presence of oxygen and light during the process and storage of the product (Nurakhirawati et al., 2016). Drying can damage beta carotene; considerable shrinkage occurs if oxygen is present (Zielinska et al., 2012).

Conclusions

The study's results suggest that carotene retention in biscuit-making is influenced by roasting temperature. At 190 °C, biscuits retain 86% of their carotene.

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