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Tocopherols in cocoa butter obtained from cocoa bean roasted in different forms and under various process parameters

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ABSTRACT

Obtaining good quality chocolate strongly depends on raw material, i.e. cocoa beans. The processing of cocoa beans consists of some important steps, including fermentation, drying fermented beans and roasting. Traditionally roasting is performed on whole beans but currently, roasting crushed cocoa beans or cocoa liquor becomes more and more popular. Many biologically active compounds may be found in the cocoa beans, including tocopherols. This work investigates the influence of the constant or variable roasting process parameters (temperature, velocity and relative humidity of roasting air) on the tocopherol concentration in cocoa butter (CB) extracted from cocoa beans originating from Togo and roasted in two different forms, namely as whole and crushed beans. Whole cocoa beans were roasted to a 2% moisture content and crushed cocoa beans were firstly partially dried which further enables easier dehusking, then ground, dehusked and roasted until their humidity decreased to around 2%. Roasting resulted in lowering the content of individual tocopherols in analyzed material. The degree of degradation of tocopherols in CBs was different, depending on the form of roasted beans from which these CBs were extracted. Higher concentrations were determined in CBs extracted from beans roasted in the form of crushed samples comparing to CBs obtained from beans roasted as a whole. The study investigates different roasting parameters of crushed beans, none of which drastically lowered the concentration of tocopherols in extracted CBs. Their concentration in CBs extracted from whole beans was, on the other hand, influenced by roasting air parameters. In case of whole beans roasted under constant parameters, application of 150 °C proved to be more favorable than roasting at 135 °C, as well as application of "dry" air and 1 m/s roasting air velocity. Discussing the variable roasting process parameters, in case of applied roasting temperature it is more favorable to change it from 150 °C to 135 °C, than the other way round. Changing the relative humidity of roasting air from 5 to 0.3%, lower degradation of tocopherols in CB occurs when the process is conducted at 150 °C. It may be further concluded that a direct dependence between the velocity of roasting air varied during the process and the concentration of tocopherols in extracted CB may not be indicated. In conclusion, it is stated that the temperature of the air applied during the roasting process has the decisive influence on the tocopherol content in CBs extracted from cocoa beans subjected to the process.

1. Introduction

Cocoa seeds of the cocoa tree, *Theobroma cacao* L., are one of the most valuable ingredients of noble confectionery. Cocoa butter (CB) obtained from cocoa beans is an important and one of the most expensive components used not only in chocolate and other chocolate products manufacturing but also in pharmaceutical and cosmetic industries (Liendo, Padilla, & Quintana, 1997; Moazami Farahany, Selemat, Che Man, & Aini Idris, 2008). It has special properties, noncomparable with any other edible fat. CB constitutes the continuous phase for such ingredients like cocoa powder, cocoa liquor, sugar, milk powder and others, used for example in chocolate industry. It is responsible for texture, plasticity, rheology, diffusion of taste and flavor, gloss, snap and melting characteristic in chocolate products and in mouth. CB can exist in six different crystalline (polymorphic) forms, which exhibit different thermodynamic stability and melting properties (Lipp & Anklam, 1998; Lipp et al., 2001; Svanberg, Ahrné, Lorén, & Windhab, 2011). These properties are associated with chemical structure of CB, mainly with fatty acid composition (Liendo et al., 1997). Symmetrical triacylglycerols (more than 90% of triacylglycerol species in CB) and high content of saturated fatty acids are mainly responsible for functionality of this fat (Lipp et al., 2001). CB has a long shelf-life. It is connected with its chemical structure (the favorable fatty acid distribution — low amounts of C18:2 (<3%) and traces of C18:3) as well as the presence of natural oxidants, such as tocopherols and tocotrienols. This provides that CB has a good resistance to oxidation at moderate temperatures (<80 °C) in the absence of light (Pontillon, 1998).

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Tocopherols are a group of chemicals — tocols. They are fat soluble antioxidants with a chromanol ring and a hydrophobic side chain — phytyl. Tocopherols exist in four different congeners, alpha (α), beta (β), gamma (γ) and delta (δ), which differs in the methylation pattern of the benzopyran ring. Each of tocopherol congener has specific biological properties. Their relative ratios are very important. Generally, the most abundant are α-tocopherol, the main contributor to the vitamin E activity, and γ-tocopherol, which shows the highest antioxidant activity in food. Therefore, it is important to know the content of these compounds not only in the raw food products, not subjected to processing, but also in semi-finished and finished products, obtained as a result of technologically reasonable treatment, which often includes use of elevated temperatures. Thermal processes such as roasting constitute an essential element of processing of certain food products, including raw oilseeds such as peanuts, sesame seeds, cocoa beans, and more. Research conducted on the influence of roasting on the physicochemical properties of fats obtained from roasted sesame seeds and perilla seeds indicates that a longer duration of temperature action favors the reduction of tocopherol content, but at the same time, higher temperature of the process was a factor positively affecting a number of compounds of such type. Authors of the study (Koizumi, Fukada, & Namiki, 1996; McDaniel, White, Dean, Sanders, & Davis, 2012; Zhao, Hong, Lee, & Kim, 2012) indicate that the explanation may be, among others, the process of tocopherols release from complex bounds with proteins or phospholipids and formation of Maillard compounds during the roasting process.

Some of the plant materials are a valuable source of tocopherols. Nuts and oilseeds are sources of γ-tocopherol, whereas soybean oil and rice germ oil are particularly rich in δ-tocopherol. Wheat germ is indicated as one of the few good sources of β-tocopherol. Olive oil contains mostly α-tocopherol. Palm oil is a particularly rich source of α-tocopherol and tocotrienols. α- and β-tocopherols are two main tocopherols present in green and roasted arabica and Robusta coffee beans but the presence of γ- and δ-tocopherols is also frequently mentioned (Alves, Casal, & Oliveira, 2010; Rangkadilok et al., 2010; Schwenke, 2002; Yi, Andersen, & Skibsted, 2011). Dominating tocopherol in CB is γ-tocopherol (De Clercq, 2011; Lipp & Anklam, 1998). CB, introduced as an ingredient of chocolate recipe, is in industrial plants obtained by pressing. The addition of 1% of CB extracted industrially is allowed. For analysis of lipids, their composition and substances dissolved therein CB is typically obtained as a result of extraction, generally with petroleum ether with boiling temperature in the range of 40–60 °C or with supercritical fluid extraction (Asep et al., 2008; Budryn et al., 2012; Budryn, Żyżelewicz, Nebesny, Oracz, & Krysiak, 2013; Du & Ahn, 2002; Liendo et al., 1997).

Various methods of conservation and processing of raw materials, including those of plant origin, have been used in food technology. Many of these methods consist of heating under appropriate conditions. Thermally processed foods gain acceptable sensory characteristics like taste, color, aroma, and texture. Also the harmful microflora is reduced by thermal processing. However, apart from beneficial effects, thermal processing may also lead to undesirable reactions and processes that reduce the nutritive value of products. Cocoa beans contain biologically active compounds such as polyphenols and tocopherols that have a positive impact on human organism. Roasting cocoa beans is an essential step of their processing, giving many transformations, such as change in content of water, volatile acids, tannins, phenolic compounds, color, aroma and texture (Krysiak, 2006; Lee, Yoo, Lee, Kwon, & Pyun, 2001; Wollgast & Anklam, 2000). The literature presents data concerning the influence of roasting conditions on the changes in the content of above mentioned indicators of the cocoa bean quality. On the other hand, it lacks in studies on changes in tocopherol content in CB extracted from cocoa beans and crushed cocoa beans roasted under different process conditions, including application of variable conditions during thermal processing, “humid” atmosphere or different velocities of roasting air. Taking into account the above, the objective of this article was to examine the influence of different forms of cocoa beans and roasting parameters on the qualitative and quantitative content of tocopherols in cocoa butters obtained from these beans. Moreover, the influence of roasting process parameters on the selected sensory characteristics of cocoa beans was evaluated. One of them is the fragility of the beans, an important indicator influencing the grinding prior further processing, e.g. extraction of CB. Taking into account that roasting significantly influences the aroma of beans and consequently the aroma of the finished products, presented study also refer to the designated selected aroma components in the examined beans.

2. Materials and methods

2.1. Chemicals and reagents

Standards of α-, δ-, γ-tocopherols (purity 99%, 95.5%, 99%, respectively) and Sylon BFT (bis-(trimethylsilyl) trifluoroacetamide (BSTFA) + trimethylchlorosilane (TMCS) = 99:1) were purchased from Sigma-Aldrich (Bellefonte, PA, USA). Ethanol, ascorbic acid, pyridine (analytical grade), hexane and petroleum ether (boiling point: 40–60 °C) were obtained from CHEMPUR (Piekary Śląskie, Poland).

2.2. Methods

2.2.1. Roasting

Forastero cocoa beans (whole or crushed) from Togo used in the study were convectively roasted in a tunnel roaster (Scheme 1).

Tunnel roaster, made of stainless steel, consists of pipes connected to each other in a closed circuit with adjustable degree of recirculation. Fan (1), with a capacity of 0.13 m^3/s, provides in a measuring section the air velocity in the range of 0.5–4.0 m/s and forces air circulation. The air is heated to a given temperature in the heater (3), and using the heater switches located on the control panel (21) it is possible to regulate temperature in each section. The temperature is maintained at a constant level by the heater (18) installed on the section (7) and controlled by a temperature controller. The heated air flows through a pipe with a circular cross-section to a pipe with rectangular cross-section consisting of several sections of different lengths and functions. The first section is responsible for the control of the air parameters. The next sections are used to even out the velocity profile and to determine the parameters of roasting process. The most important part of the tunnel roaster is the measuring section (8), in which the proper implementation and control of the heat treatment process are conducted.

The air leaving the measuring section (8) flows to the air removing section (12) and then through air off taking pipe into the outside. This is when air is not re-circulated. The tunnel roaster may, however, be also adapted to work when part of the air undergoes re-circulation. To reduce heat losses to the surrounding, the apparatus is covered with a layer of the insulating mat (20) with a thickness of 5 mm. In order to eliminate the impact of vibration on the measurement section and weight readouts, a rubber connection between the fan and tunnel and rubber pads under the load-bearing construction are introduced. Tunnel roaster allows also conducting the roasting process in air with increased humidity. Steam produced in steam generator (25) is led through the main heater (3) and valve (4) serves for adjusting its amount.

2.2.2. Roasting of whole beans. Batches of cocoa beans with length size of 20–24 ± 0.2 mm (around 200 g each) were placed in a roasting chamber and subjected to roasting under variable (temperature — T, air velocity — v, relative humidity of air — RH, time of processing — t) or constant conditions (control). Dosing of beans was performed with use of feeding ports. This method results in the distribution of the material in a single layer without opening the door to the roasting chamber; thus ensuring the maintenance of established process parameters. Process was terminated when moisture of beans decreased to around 2%. Variants of process parameters were as follows: