Effect of Roasting on Physicochemical Properties of Cocoa Beans: An Overview

Youssef, M.M. & Taiseer M. Abo Bakr

Food Science & Technology Dept. Fac. of Agric. Alexandria Univ. Alexandria, El Shatby, 21545, Egypt.

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ABSTRACT

Cocoa beans (*Theorem cocoa*) are the main raw materials used in chocolate manufacture. Roasting is the most important technological process in production of cocoa products. It is the main process in the development of aroma and taste of cocoa beans. Maillard reaction and Strekher degradation take place during roasting process, where the flavour compounds of cocoa are produced. It was found that roasting temperatures at a range from 90 to 110°C were optimum for producing high quality chocolate, by using the Response Surface Methodology (RSM). The desirable flavour components of cocoa beans are developed due to the pyrazines which are produced during roasting process. This process affects the chemical composition (protein, fat, carbohydrates, ash, minerals and vitamins) of cocoa beans. The stability of polyphenols in cocoa beans is influenced by the conditions of the roasting process. Roasting causes a decrease in the polyphenols content of cocoa beans up to 98%. The roasting process of cocoa beans should be optimized (temperature and time) to produce final products of high quality.

Key words: Cocoa beans, roasting, flavour, pyrazines, chocolate.

INTRODUCTION

Cocoa beans (*Theobroma cocao*) are widely used in industrial world. The world annual production of cocoa beans is approximately 3.5 million metric tons. Roasting is a key process in the development of aroma and taste of cocoa beans. It has been agreed that pyrazines are the main compounds responsible for roasted cocoa beans flavour (Jinap *et al.*, 1998, Belitz *et al.*, 2009, Misnawi & Teguh, 2010, Farah, *et al.*, 2012).

During fermentation and drying of cocoa beans, the precursors including the free amino acids, peptides and reducing sugars are developed. During roasting of cocoa beans, Maillard reaction and Strecker degradation take place and produce cocoa flavour compounds such as pyrazines, pyridines, imidazoles, alcohols, esters, furans, aldehdyes and pyroles (Jinap *et al.*, 1998, Puziah *et al.*, 1998, Ramli *et al.*, 2006, Krysiak *et al.*, 2013, Owusu *et al.*, 2013). Despite its key role in the formation process of cocoa bean flavour, Maillard reaction is not the only factor in this respect. Kinetics of non enzymatic browning during roasting of cocoa beans at 125, 135 and 145°C exhibited that non enzymatic browning during roasting is not solely dependent on Maillard reaction (Sacchetti *et al.*, 2016).

Due to its unique properties, cocoa beans are still a subject of scientists' interest. This may be attributed to the importance of these beans as a basic raw material for chocolate and cocoa manufactures (Zyzelewicz *et al.*, 2016). Also, they gained much attention because they have many benefits for human health (Sacchetti *et al.*, 2016).

Obviously, the roasting process is not the only process influencing chocolates flavour formation (Afoakwa *et al.*, 2008, Owusu *et al.*, 2013). In other words, this process is multi factors dependent with roasting being the most influencing factor. Kongor *et al.* (2016) reviewed these factors as: genotype and origin of cocoa tree, post-harvest treatments (pulp pre-conditioning, fermentation and drying), roasting, soil, chemical composition and age of cocoa tree. Consequently, formation of cocoa beans flavour is a complicated process (Fig. 1).

Roasting process helps in removing the undesirable volatile compounds, producing desirable flavour and makes cocoa beans more brittle. Notwithstanding, dimethyl, trimethyl and tetramethyl pyrazines were found to be indicators of the roasting intensity of cocoa beans (Jinap *et al.*, 1998). Pyrazines are considered the main flavour compounds of roasted cocoa beans and formed through the aldol condensation of deoxy intermediate compounds with amino acids (Afoakwa *et al.*, 2008).

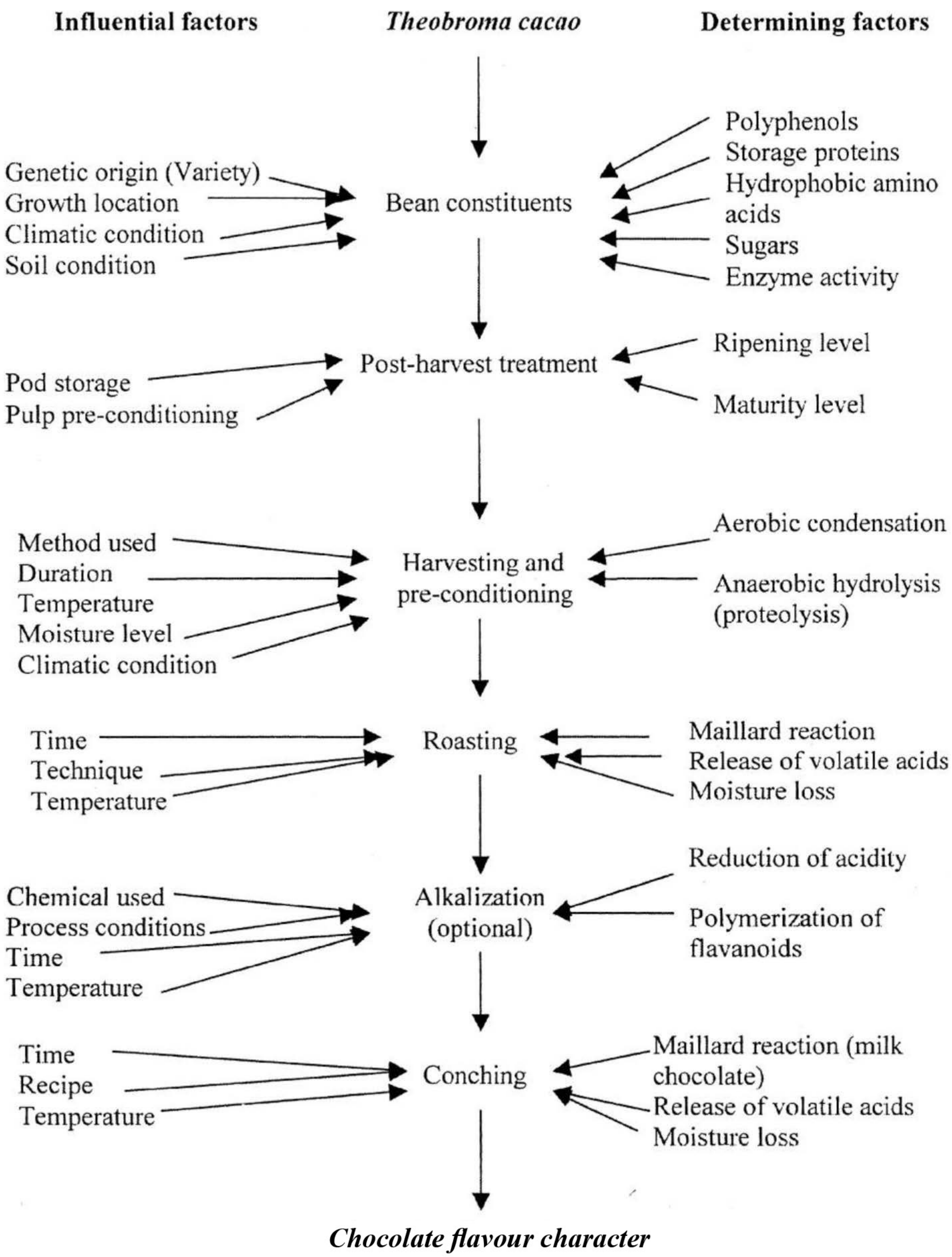

Fig 1. Mechanism of chocolate flavour formation and development process
(Source: Afoakwa *et al.*, 2008)

Methods of Roasting

The most commonly applied method for roasting cocoa beans is the convection method. In this method, a forced flow of hot air is applied at 130-150°C for 15-45 min. (Krysiak, 2002 & 2006, Zyzelewicz *et al.*, 2016). Notwithstanding, microwave roasting of cocoa beans has been investigated (Krysiak, 2011). Data indicated that the microwave roasting promoted oxidation of lipids although the quality of roasted cocoa beans was the best, compared with the convection method.

The Response Surface Methodology (RSM) was applied by Jinap *et al.* (1998) to investigate the effect of roasting time and temperature on volatile component profile during nib roasting of cocoa beans. Data revealed that 53 volatile compounds had been detected in the roasted nib. Higher temperature (>130°C) for longer time (>25 min) resulted in formation of desirable pyrazines. Meanwhile, RSM has been applied to optimize cocoa beans roasting process. It was based on maximum pyrazines and minimum acrylamide (Farah *et al.*, 2012).

The RSM analysis exhibited that roasting at 116°C for 23 min produced high quality cocoa beans. It is worth to mention that to achieve sustainable production of high quality cocoa beans, it is important to understand well factors involved and responsible for variation in flavour of cocoa beans. Such understanding has significant commercial implications (Kongor *et al.*, 2016). On the other hand, Rocha *et al.* (2017) using RSM analysis, investigated the effect of roasting of cocoa beans at temperatures (80, 120 and 160°C) and time (20, 40 and 60 min) on quality of chocolate. The data showed that roasting temperatures at a range from 90 to 110°C regardless of the roasting time were optimum for producing high acceptable chocolate in terms of appearance, flavour and texture.

Numerous drawbacks have been traced for convection roasting of cocoa beans, such as loss of aroma due to long time of heating and variation of temperatures (from 10 to 12°C) between the kernel and the husks of beans and consequently uneven roasting. Meanwhile, roasting of whole cocoa beans results in a significant transfer of cocoa butter from kernel to husk. The latter is a waste and thereby it represents a loss from the economical point of view, as well as the quality of the kernel is also affected (Krysiak, 2011). The aforementioned drawbacks of convection roasting of cocoa beans can be eliminated by alternative microwave roasting (Power M= 700w, F= 2450 MHZ, time T = 5-12 min). Unfortunately, microwave roasting promoted oxidation cocoa butter despite the good quality of beans as compared to their counterparts roasted by convection roasting (Krysiak, 2011).

Physicochemical properties of roasted cocoa beans:

Chemical composition

The characters of the chemical and physical properties which occur in the cocoa beans depend on the roasting parameters such as temperature and the period of roasting. These parameters affect the quality of the final products (Krysiak *et al.*, 2006). Generally, the roasting conditions range from 130 to 150°C and period from 15 to 45 min. Low temperature for roasting is used for milk and some dark chocolates (Afoakwa *et al.*, 2008).

Several studies indicated that roasting process affects the chemical changes occurring inside the cocoa beans. The most reactions affecting the composition of cocoa beans are caramelization, Maillard reactions and lipid oxidation (Arlorio *et al.*, 2008, Kongor *et al.*, 2016). Roasting aimed to conversion the fermented dry beans to be microbiologically clean with a characteristic flavours and proper brittleness (Belitz *et al.*, 2009, Zyzelewicz *et al.*, 2016).

The roasting process helps in formation of many features in cocoa beans such as the brown colour, taste, texture and the desired chocolate flavour "aldehydes and pyrazines" (Oracz & Nebesny, 2019).

During roasting, short chain oligopeptids and amino acids react with glucose and fructose to produce the cocoa flavour (Kongor *et al.*, 2016). The bitter and astringent taste are reduced due to the damage occurs in the polyphenols during roasting.

Roasting of cocoa beans results in significant decrease in each of total protein and reducing sugars whereas, oligosaccharides are brokendown. Meanwhile, polyphenols are oxidized by enzymes during fermentation and roasting (De Brito *et al.*, 2000).

During roasting, the volatile acids are evaporated from the beans causing a reduction in the sourness and bitterness of the cocoa beans. The volatile acids such as acetic acid are reduced as a result of roasting at high temperature. Meanwhile, the less volatile acids (citric, oxalic, succinic, tartaric and lactic) unchanged (Afoakwa *et al.*, 2008, Frauendorfer & Schieberle, 2008, Oracz & Nebesny, 2014).

Roasting process may decrease the nutritional value of the cocoa beans. In other words, it affects its health benefits. High temperature of roasting may cause lipid oxidation, loss in essential fatty acids, loss in essential amino acids and carbohydrates and lead to destruction of vitamins (Ramli *et al.*, 2006, Sacchetti *et al.*, 2016). The traditional roasting results in increasing the peroxide value and thiobarbituric acid of cocoa butter. However, the ash content of cocoa beans increased. The minerals content increased such as iron, phosphorus, sodium and magnesium, while the roasting process reduced calcium content (Djikeng *et al.*, 2018).

The recent studies indicated that roasting process might be optimized in terms of temperature and time to obtain the desired colour of cocoa and content of bioactive compounds and a good quality for the final products (Kongor *et al.*, 2016, Sacchetti, *et al.*, 2016).

Polyphenols

Cocoa beans have been demonstrated to protect the body from heart diseases, free radicals and some types of cancer. This may be attributed to the presence of polyphenols, which are about 12-18% of the dry weight of the bean. It was found that the main classes of polyphenols are simple phenols, phenolic acids, benzoquinones and flavonoids.

The stability of polyphenols in cocoa beans was affected by the roasting process conditions. The phenolic compounds were stable when the beans were roasted in air with high relative humidity (Zyzelewicz *et al.*, 2016, Oracz & Nebesny, 2019).

Ioannone *et al.* (2015) reported that the roasting temperatures caused an increase loss in the flavanols and proanthocyanidins content of cocoa beans. Meanwhile, the use of high temperature for a short time minimizes the loss of proanthocyanidins. Also, it was observed that a reduction in catechin and epicatechin occurred upon roasting.

According to Sabahannur *et al.* (2018), the level of polyphenols and antioxidant activity of cocoa beans are influenced by the interaction of fermentation, drying and roasting process. Such an interaction can decrease the polyphenols content by 98%. Unfermented cocoa beans exhibited very high antioxidant activity (IC_{50}= 7.848 ppm), while fermentation for 3 and 5 days resulted in a strong antioxidant activity (IC_{50}= 35.961 ppm) and moderately activity (IC_{50} = 55.976 ppm), respectively. The IC_{50} (inhibition concentration) is a concentration of an antioxidant substance that gives 50% inhibition.

Cocoa beans along with their content of nutrients (fat, carbohydrates, proteins and minerals) contain considerable amount of biologically active compounds such phenolic compounds (Keen *et al.*, 2002, Zhu *et al.*, 2002, Misnawi *et al.*, 2004, Zyzelewicz, 2016). Condensed tannins constitute about 6% of the total polyphenols content in cocoa beans. Flavonol quercetin and its glycosides, flavon- iso vitexin, phenols-clovamide and deoxyclovamide are the most predominant compounds in roasted cocoa beans (Dreosti, 2000, Wollgast & Anklam, 2000).

Zyzelewicz *et al.* (2016) investigated the influence of the roasting conditions (time, temperature, humidity and flow rate of air) on the polyphenols content in cocoa beans, nibs and chocolate. Data of LC-MS/ MS analysis indicated a degradation of phenolic compounds of cocoa beans and nibs of different particle sizes as a result of roasting. Polyphenols were more stable in beans roasted in air with increased RH. Roasted nibs of sieve mesh from 7 and 10 exhibited the largest degradation of polyphenols.

Numerous studies reported presence of acrylamide in the roasted cocoa beans. This is due to interactions between asparagines and dicarbonyl compounds through Strecker degradation (Maillard reaction) occurs during roasting (Sander *et al.*, 2002, Mottram *et al.*, 2002, Zyzak *et al.*, 2003). The detected level of acrylamide in cocoa products was found to be 909 µg/kg (FAO/ WHO, 2006). The safe limit of acrylamide in these products has to be estimated.

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تأثير التحميص على بعض الصفات الفيزيوكيماوية لبذور الكاكاو: نظرة شاملة

محمد محمود يوسف، تيسير محمود أبو بكر

قسم علوم وتقنية الأغذية، كلية الزراعة

جامعة الإسكندرية، الشاطبي، ٢١٥٤٥، الإسكندرية – مصر

بذور الكاكاو هي المادة الخام الرئيسية في صناعة الشيكولاته ومنتجاتها، وتعتبر عملية التحميص لهذه البذور بمثابة أهم العمليات التصنيعية في إنتاج منتجات الكاكاو.

وتعتبر عملية التحميص بمثابة العملية الرئيسية المسئولة عن إعطاء رائحة وطعم بذور الكاكاو . وخلال عملية التحميص تحدث تفاعلات ميارد وتكسر ستريكر وانتاج مركبات النكهة المميزة لبذور الكاكاو. ولقد تبين باستخدام طريقة مسطح الاستجابة(RSM) أن درجات حرارة التحميص في المدى من ٩٠ إلى ١١٠°م تعتبر الأمثل لانتاج شيكولاتة عالية الجودة.

وتعتبر مركبات البيرازين التي تتكون أثناء عملية التحميص هي المركبات الرئيسية المسئولة عن نكهة الكاكاو. تؤثر عملية التحميص على التركيب الكيماوي (بروتين- دهن- كربوهيدرات- رماد- معادن- فيتامينات) لبذور الكاكاو.

ويتأثر ثبات مركبات عديدات الفينول لهذه البذور بظروف عملية التحميص (درجة حرارة- زمن).

يمكن إنتاج منتجات كاكاو عالية الجودة إذا ما أجريت عملية تحميص البذور عند الظروف المثلى من درجة حرارة وزمن.