EFFECT OF PROCESSING TECHNIQUES ON FLAVOUR AND CHARACTERISTICS OF COCOA PROCESSED AND CHOCOLATE PRODUCTS

Pengaruh Cara Pengolahan Terhadap Citarasa dan Karakteristik Produk Olahan Kakao dan Cokelat

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ABSTRACT *Flavour is important factor and central to acceptability of cocoa products such as chocolate and contributes to determining the quality. The quality of chocolate flavour is influence by several variable factors since in the stage of post-harvest treatments and handling till in manufacturing process. The aim of this paper was review and discuss all relevant studies in relation to cocoa beans and chocolate production, and identify their influence of processing techniques on flavour and characteristics of the cocoa processed products. This information hopefully has potential benefits on the making process of a chocolate manufacture.*
Keywords: cocoa, processing technique, flavour, characteristic, chocolate.

ABSTRAK *Citarasa merupakan salah satu faktor penting dan sebagai salah satu pusat penerimaan produk olahan kakao seperti cokelat dan berkontribusi dalam penetapan mutu. Mutu citarasa produk cokelat dipengaruhi oleh beberapa variabel faktor, sejak pada tahap penanganan pasca-panen hingga tahap proses pengolahan di pabrik. Tulisan ini disajikan bertujuan untuk mengulas dan membahas serta mendiskusikan semua hasil studi yang pernah dilakukan, yang berhubungan dengan biji kakao dan produksi cokelat serta mengidentifikasi pengaruh cara pengolahannya terhadap citarasa dan karaketeristik produk olahan kakao. Informasi ini diharapkan mempunyai potensi yang bermanfaat pada proses pengolahan kakao di pabrik cokelat.*
Kata kunci : kakao, cara pengolahan, citarasa, karakteristik, cokelat.

INTRODUCTION

Cocoa (*Theobroma cacao, L.*) is a crash crop of huge economic significance in the world and the key raw material for chocolate manufacturing (Krahmer *et al.*, 2015; Ho *et al.*, 2015). Chocolate is the generic name for the homogenous products that prepared from cocoa and cocoa materials with sugars, milk products, flavouring substances and other food ingredients (Codex Standard. 87. 1981, Rev. 1 : 2003).

Cocoa beans are obtained from the ripen *Theobroma cacao* pods which commonly planted in the West Africa, South America and some tropical regions around the world like in Indonesia (Ardhana and Fleet, 2003). Cocoa as a food ingredient is fast becoming very popular in the food and confection industry worldwide. It is available in wide variety of forms, colors and flavors and is used in numerous applications (Ndife *et al.*, 2013). For example, cocoaa powder is used in makin beverages with other ingredients such as milk and sugar, while cocoa butter is used for chocolate production..

Chocolate products are desired and eaten, due to their attractive flavours and appearances (Pimentel *et al.*, 2010). The primary chocolate categories are dark, milk and white chocolate (Afoakwa *et al.*, 2007). The widely enjoyed chocolate-flavour, make it a favorite ingredient in bakey, ice cream, beverage, syrup manufacture and as confection in itself (Lecumberri *et al.*, 2007).

Several characteristics of chocolate strongly depend on the process done at the very beginning of the supply chain (Saltini *et al.*, 2013). Another word, quality and flavour of cocoa products strongly depend on the various stages of cocoa processing (Giacometti *et al.*, 2015). These processes begin very early with cocoa farming, storage, fermentation, drying, and packing the cocoa beans and continue with the manufacturing of chocolate (Saltini *et al.*, 2013).

Sustainable cocoa production also involves the production of high quality cocoa beans. Cocoa beans quality is made up of several components such as flavour volatiles, nutritional composition, polyphenolic content and fermentation quality (Kongor *et al.*, 2016). The most important components are the flavour volatiles of the beans as the effect cocoa bean acceptability (Magi *et al.*, 2012; Krahmer *et al*., 2015).

For those reasons, chocolate manufactures have only rough expectations of the qualitative parameters by country of origin as aim at having uniform and constant raw materials to produce chocolate (Saltini *et al.*, 2013). As a consequence of the increased implementation of food quality and food safety in the food industry, so detailed information on how products were handled and treated during production processing could actually be transferred to the producer of the final product and could be used to optimize production operations (Akkerman *et al.*, 2010).

With ever increasing product output, it is essentially important to have a good understanding of the influences of chocolate manufacturing process, as well as the processing conditions, on the quality of the final product (Keijbets et al., 2010). Therefore, this paper aims to review and discuss all relevant studies in relation to cocoa beans and chocolate production, analyzed the different variables investigated and identify their influence of processing techniques on flavour and characteristics of the cocoa processed products.

EFFECT OF POST-HARVEST TECHNIQUES AND TREATMENTS ON COCOA BEAN QUALITY

Before resulting a final cocoa products with a variety of good cocoa processed and chocolate products, the first step processing and production that must be passed through as the key indicators in the processing of cocoa is the post-harvest technique and treatment and handling. Post-harvest techniques and treatments of cocoa involeves all the primary process harvested cocoa pods goes through, before the final dried bean is obtained. These processes include pulp pre-conditioning, fermentation and drying (Kongor *et al.*, 2016). These processes are usually carried out in the country of origin and they play a critical role in the flavour profile of the dried cocoa beans (Krahmer *et al.*, 2015).

Pre-Conditioning

The pre-conditioning involves changing the properties of the pulp prior to the development of microorganisms in fermentation (Afoakwa *et al.*, 2011 b). These changes may be in the form of altering the moisture content of the pulp, sugar content, and volume of pulp per seed as well as pH and acidity of the pulp (Kongor *et al.*, 2016). Removing portions of cocoa bean pulp or reducing the fermentable sugar content has been shown to contribute to less acid production during fermentation, leading to less acid beans (Afoakwa *et al.*, 2012).

Studies have shown that pre-fermentation treatments have significant effects in changing the acidity and polyphenol content of the cocoa beans, and thus, flavour of the beans (Nazarudin *et al.*, 2006; Afoakwa *et al*., 2012). Pulp pre-conditioning can be done in three basic methods prior to fermentation and these are pod storage, depulping (mechanical or enzymatic) and bean spreading (Afoakwa *et al.*, 2011 a).

Pos storage is basically storing harvested cocoa pods for a period of time before opening the pods and fermenting the beans. Pod storage prior to splitting of the beans has been recommended for cocoa beans which are difficult to fermentation or to give chocolate with strong acid flavour (Saltini *et al.*, 2013). Pod storage as studied by Afoakwa *et al.*, (2011 b) appears to have highly beneficial effect on the chemical composition of cocoa beans and subsequent development of chocolate flavour. Results of the studied by Afoakwa *et al.*, (2011 a) also noted that increasing pod storage consistently decreased the non-volatile cidity with concomitant increase in pH during fermentation of Ghanaian cocoa beans.

It is clearly shown in the literature, that pod storage prior to splitting would reduce the sucrose, glucose, fructose, ethanol and acetic acid content, and increase the pH in fermented cocoa beans, improving the flavour of the final chocolate (Saltini *et al.*, 2013). For this reason, pod storage might be beneficial for beans that tend to develop low pH and acidic flavour. On contrast, however, pod storage does not only have benefits. The existing of the amount mouldy beans significantly increases with pod storage, and as a consequence it increses the production waste (Ortiz de Bertorelli *et al.*, 2009).

Fermentation

Fermentation is essential for the development of appropriate flavours from precursors. The approaches used in spontaneous cocoa bean fermentation differs among the producing countries as followed the local preferences; for instance the methods/techniques being used, duration of fermentation, pod or bean selection and post-harvest treatments which will have significant impact on the quality of end products (Camu *et al.*, 2008; Kostinek *et al.*, 2008; Ganeswari *et al.*, 2015).

Fermentation of cocoa beans is very crucial as it promotes dramatic biochemical changes in the type and concentration of flavours precursors in cocoa beans (Kadow *et al.*, 2013; Krahmer *et al.*, 2015). Therefore, the correct fermentation and drying of cocoa beans, which carried out in the countries of origin are essential to the development of suitable flavour and/or flavour precursor (Ho *et al.*, 2014). As consequence, the fermentation method determines the final quality of products produced, especially their flavour.

Different fermentation methods are used for fermenting cocoa beans depending on farmers (Guehi *et al.*, 2010 a), areas and countries (Camu *et al.*, 2008). Platforms, heap, baskets, and boxes are the most used fermentation methods. The platforms method has a quite low fermentation rate, adequate for Criollo beans which require short fermentation, but in appropriate for Forastero which require longer fermentation. This longer fermentation often induces the growth of unwanted molds and consequently off-flavors (Guehi *et al.*, 2010 a).

In general, cocoa beans fermente in boxes show relatively low concentrations of sugar, ethanol and acetic acid, and a high pH. In some cases, the boxes methods has been categorized as a method with low uniformity, which may cause incomplete usage sugars or high presence of defective beans (Guehi *et al.*, 2010 a). Additionally, for this fermentation method, it has been found that the size, shape and construction material of the box also significantly influence pH, tannins, sugar content and presence of purple beans (Wallace and Giuste, 2011).

The fermentation processes is characterized by a well known systematic microbial succession (Saltini *et al.*, 2013). During fermentation, microbiaal succession occur as the micro-environment (temperature, pH, oxygen avaibility) changes (De Vuyst *et al.*, 2010; Illeghems *et al.*, 2015). The changes in pH values during fermentation are very important for microbil activity. Briefly, the initial low pH of the pulp (3.6), presence of citric acid, and low oxygen levels fever yeast colonization which to leads to ethanol production and secracation of pectolytic enzymes within the first 24 hours; after which the process slowly decreases (Saltini *et al.,* 2013).

The remaining conditions favour to growth of lactic acid bacteria (LAB), which reach their peak after 36 hours from the beginning of the fermentation. The main activity of LAB is degrading glucose to lactic acid. The overall pH increases due to to the metabolism of non-acid by product. After 48 hours of fermentation the LAB population decreases giving space to the growth of acetic acid bacteria (Satini *et al.*, 2013).

The duration and method of fermentation are crucial also to the fermentation of flavour compounds and flavour precursors. Based on the study taht conducted by Aculey *et al.*, (2010), it is noted that an increased level of organic acids such as propionic acid, 2-methyl-propanoic acid; 3-methylbutanoic acid and acetic acid after 72 hours of cocoa fermentaion. The increased levels of organic acids are a result of the breakdown of sugars from the pulp surrounding the cocoa beans (Bonvehi, 2005).

Fermentation generates flavour precursors, namely free amino acids and peptides from enzymatic degradation of cocoa proteins and reducing sugars from enzymatic degradation of sucrose (Misnawi, 2008; Afoakwa *et al.*, 2013; Krahmer *et al.*, 2015) from which the typical cocoa aroma is generated during the subsequent roasting process (Fraundoufer and Schieberle, 2008). The theory of fermentation tell us, taht pyrazines precursors (amino acids and reducing sugars) are transformed into pyrazines during roasting process due to the Maillard non-enzymatic browning reactions (Satini *et al.*, 2013). Besides the formation of the flavour precursors, there is also a significant increase in volatile compounds, such as alcohols, organic acids, esters, and aldehyde after fermentation (Magi *et al.*, 2012). The Maillard reaction takes place during roasting process and results in the typical aromatic compounds of chocolate.

Drying

Drying of cocoa beans is a process of heating which reduces the moisture content of the beans to less tahn 7.5% (w/w) (Zahouli *et al.,* 2010) and to prevent mould infestation during storage and also allow some of the chemical changes which occured during fermentation to continue and flavour development (Kyi *et al.*, 2005). Many investigations have been carried out to find the optimal drying methods. Therefore, the drying conditions, temperature and duration of drying, dryng rate, and grade were studied (Giacometti *et al.*, 2015).

Eventhough artificial driers are increasingly popular, natural sun drying is still largely used. Many studies that compare natural and artificial drying methods conclude that natural sun drying give the best result (Zahouli *et al.*, 2010). However, it is believe that artificial drying methods can improve the drying process, and it just requires more research (Saltini *et al.*, 2013). Thus, by knowing the conditions of the drying it woud be possible to predict in real time the ideal duratiob of drying to reach a standardized moisture content.

The drying process of fermented cocoa beans initiates major polyphenol oxidizing reactions catalysed by polyphenol oxidase, giving rise to new flavour components and loss of membrane integrity, inducing brown colour formation. This helps to reduce bitterness and astringency and also the delopment of the chocolate brown colour of well fermented cocoa beans (Saltini *et al.*, 2013). Indicators of well-dried, quality beans are a good brown colour, low astringency and bitterness and on absence of off-flavors such as smoky notes and excessive acidity. Sensory assessment of cocoa beans dried using different strategies; i.e. Sun drying, air blowing, shade drying and oven drying suggested that sun-dried beans were rated higher in chocolate development with fewer off-flavor notes (Kyi *et al.*, 2005; Amoye, 2006).

It is well known that the drying rate during the drying process is of crucial importance for the cocoa beans "final quality". In this case, if the drying rate is too fast or rapid, the beans would tend to retain an excessive amount of acids, including acetic acid, which is deleterious to the flavour. On the contrary, too slow drying rate would results in low acidity, poorer color and high presence of moulds (Zahouli *et al.*, 2010; Rodriguez-Compos *et al.*, 2012; Saltini *et al.*, 2013).

EFFECT OF TECHNOLOGICAL PROCESSING IN COCOA MANUFACTURING ON CHOCOLATE FLAVOUR QUALITY

The flavour of chocolate characteristics originates not only in flavour precursors present in cocoa beans, but also are generated during past-harvest treatments and transformed into desirable odor notes in the maucfacturing process as well (Giacometti *et al.*, 2015). The steps of technological processing in cocoa manufacturing that would be possibly affected to the chocolate flavour quality are identified and known as following, i.e. roasting, alkalization, refining, conching and tempering process.

Complex biochemical modifications of cocoa bean constituents are altered by thermal reactions in roasting and conching as well as in alkalization (Afoakwa *et al*., 2008). Alkalization and roasting are two processes that contribute to the flavour and color of the semi finished products; while refining, conching and tempering are the three process step that contribute to the flavour and quality of the finished products.

Roasting

Roasting is one of the important steps which affects the quality characteristic of cocoa bean during industrial processing (Oracz and Nebesny, 2014). Roasting of fermented cocoa beans is carried out due to mainly two purposes : the removal of undesired compounds with low boiling points, such as acetic acid ; and the formation of typical roasty, sweet odorants of cocoa (Oliviero *et al.*, 2009).

According to Krysiak and Motyl-Patelska (2006) was mentioned that roasting determines the character of chemical and physical processes that occur inside the beans, as well as the quality of the final product. During the roasting process flavour precursors are transformed into flavour compounds. For example, the Maillard reaction (Non-enzymatic browning) and strecker degradation during roasting can produce the desirable flavour compounds such as pyrazines, alcohols, esters, aldehydes, ketones, furans, thiazoles, pyrones, acids, amines, imines, pyrroles and ethers (Arlorio *et al.*, 2008; Misnawi and Wahyudi, 2010). The concentration of pyrazines increased rapidly during the roasting process untill reaching a maximum value, after which these constant values are maintained (Giacometti *et al.*, 2015). The formation yield of pyrazines is known, and reaches the highest yield at high temperature (typically 150 or 170 ^{o}C) (Krysiak, 2006).

Prior to roasting, cocoa bean have bitter, acidic, astringent and nusty flavour. Roasting further diminishes activity reducing concentrations of volatile acids such acetic acid (Granvogl *et al.*, 2006); but not non-volatiles suh as oxatic, citric, tartaric, succinic and lacytic acid (Afoakwa *et al.*, 2008). Another words, during roasting, there is evaporation of volatile acids from the beans causing a reductiob in acidity, hence – reducing sourness and bitterness of the cocoa beans. For this reason, choice of roasting parameters should be determined in order to understand the character of the chemical and physical process that occur inside the bean.

When looking directly at the flavour acceptability, several studies investigate the best combination of time and temperature of roasting (Saltini *et al.*, 2013). Several studies also revealed that temperature and duration of roasting substantially affect the chemical and physical changes occuring in cocoa beans (Farah *et al.*, 2012). It is needed to be attention and well known, that if cocoa beans are carried out an inproper roasting procedure generates undesirable flavour compounds; while , if the cocoa beans are not roasted enough, the resulting chocolate products would be very bitter; and alternatively, if the beans are over roasted , burned and off-flavour will be developed (Bonvehi and Coll, 2002; Saltini *et al.*, 2013). In general, the literature agrees that the higher the roasting grade is, the better flavour profile will be, until an over roasting point is reached.

Usually, cocoa beans roasting conditions was carried out at range from 15 to 45 minutes with temperature from 130 – 150^{o}C (Krysiak *et al.*, 2013). Time and temperature of roasting process depend on several factors, such as cocoa material (beans, nibs and liquor roasting), final cocoa product (dark or milk chocolates) and type of cocoa (Kothe *et al.*, 2013). Based on this information, it is clear that the optimal roasting parameters strongly depend on the raw material processed and type of chocolate products.

Alkalization

Alkalization is a treatment that addressed to cocoa nibs or liquor of cocoa with solutions of alkali, and it is carried out primarily not only to change color but also influence the flavour of cocoa powder (Afoakwa *et al.*, 2008). Originally, performed to make for cocoa products such as drink to enhance solubility or in baking or coating (Whitefiled, 2005), and also performed to make the powder not agglomerate or sink to the bottom, when it was added to milk or water-based drinks (Giacometti *et al.*, 2015).

Cocoa beans are often alkalized with potassium carbonate or sodium hidroxide in order to improve the microbiological conditions (De Muijnck, 2005). Many studies report that increasing the pH from 5.7 to 7.5 is deleterious to the flavour acceptability (Noor-Sofialina *et al.*, 2009); so it is suggested that cocoa with high acidity and low chocolate flavour could be achived a good flavour development by alkali teratments. The conclusion was that chocolates from alkalized had better flavors than non-alkalized nib roasted chocolate (Afoakwa *et al.*, 2008).

It was established that alkalization caused a progressive reduction of polyphenols as well as their antioxidant activity (Miller *et al.*, 2008). Reduction of the polyphenol antioxidant activity was mentioned to be triggered by heat and alkali synergistically (Sulistyowati and Misnawi, 2008). Recently, a sudy by Payne *et al.*, (2010) found that compared to natural cocoa powders, alkalization caused a loss in both epicatechin (up to 98%) and catechin (up to 80%). Another study that has been conducted by Andres-Lucueva *et al.*, (2008) was hshown a decrease in epicatechin and catechin of 67% and 35%, respectively, as a result of the alkalization of cocoa powders.

In general, changes occuring as the results of alkalization treatment could be attributed to the oxidation of phenolic compounds under basic pH conditions, leading to the brown pigments that are polymerized to different degrees. In particular, secondary reaactions involving ortho-quinones preveiously formedd during fermentation stage by polyphenol oxidase are probably involved in further reactions responsible for the browning developed during alkalization (Miller *et al.*, 2008).

Refining

Refining is a step processing of cocoa or chocolate which produce a smooth texture by reducing the size of the particles of cocoa mass from about 80 – 90 microns to about 30 – 40 microns (Payne *et al.*, 2010). At this point, the chocolate, which has the required ingredients mixed, still has rough texture, because it is a form of chocolate paste or chocolate liquor. The rough is not ideal since may hinder the conching process that will be explained later. Therefore, refining is necessary to turn the roughness into smoothness.

In addition, the cocoa liquor is mixed with cocoa butter and sugar and this is further refined by reducing the particle size of the added milk powder solids and sugar down to the desired fineness (Pugh, 2014). As described by Afoakwa *et al.* (2007), the addition of milk fat to milk chocolate results in a lower melting point, a slow setting or solidification and a soften texture. The smoother the chocolate desired, the more rolling milling required. Because of that, in order to ensure that its products qualities meet their expectations, it refines its chocolate paste to 19 micrometers while other major markets refine their chocolate to only 40 micrometers. The smaller micrometers they have are beneficial to the overall texture of the chocolate.

The refining process has a certain parameters that can be changed that might alter the flavour. Refining is also will determine the size reduction of a chocolate mass as it is being manufactured. Whether a product is fine, medium or coarse ground will determine the pallete's flavour perception. The particles will be coated with fat, which the flavour carrier. When these particles enter the mouth, the melt, sweetness and mouthfeel, and all will influence how the product tastes (Stauffer, 2000).

Conching

Conching is a step of cocoa processing in the manufacture to produce chocolate with superior aroma and melting characteristics. This process strongly affects the final flavour and texture of chocolate (Pugh, 2014). The conche is a surface scraping mixer and agitator that evenly ditsribute cocoa butter within chocolate, and acts as a "polisher" of the particles. The conches have heavy rollers that can produce different degrees of agitation and aeration, so that the conching process redistributes into the fat phase of substance from dry cocoa that creates the flavour (Pugh, 2014).

The function of the conche is to remove unwanted flavour but at the same time retain the more desirable one. A goal in conching is also to obtain the optimum viscosity (flow properties) at the lowest practical fat content (Stauffer, 2000). As consequence, residual volatile acids and moisture are removed, angulur sugar crystals and viscosity are modified, and their color changed due to emulsification and oxidation of tannins (Reineccius, 2006; Afoakwa *et al.*, 2007). Based on the above information, key elements in this goal would be moisture reduction, input of energy, and control of superfines and amount of free fat available.

As described by Stauffer (2000) based on her research sudy, It was mentioned that the chocolate data from her study shows that physical characteristics are definitely different between conched and unconched chocolate. The results of the sensory panel also found that the conched sample to have more chocolate, more caramel and more diary notes with about the same levels of sweetness as the unconched sample. The unconched sample was found to have moderate nutty notes not present in the conched sample.

Based on the study, it was mentioned that temperature and time of conching or conching conditions are the main influence factors of conching process in order to produce a good flavour chocolate. The results of the study revealed that there were interactions between time and temperature (Afoakwa *et al.*, 2008). Generally, higher temperature leads to a shorter required processing time. For example, conching conditions for crumb milk chocolate are 10 -16 hours at 49 - 52^{o}C ; but 16 – 24 hours at 60^{o}C for milk powder chocolate; however if the temperature above 70^{o}C lead to changes in cooked flavour (Awua, 2002; Beckett, 2003; Whitefield, 2005), while, up to 82^{o}C for dark chocolate (Awua, 2002).

Meanwhile, effect of the conching temperature was mentioned by Stauffer (2000), that high-temperature sample (74^{o}C for 12 hours) had a more pronounced caramel note with slightly less perceivable chocolate notes. In contrast, however, the flavour perception of a low temperature (64^{o}C for 12 hours) shows a well rounded sample, with milky, chocolate notes, very even.

Tempering

Tempering is a technique of controlled precrystallization employed to induce the most stable solid form of cocoa butter, a polymorphic fat in finished chocolates (Afoakwa *et al.*, 2008). Tempering process refers to a controlled melting and cooling of chocolate in order to achieve at the correct crystalline structure of the constituent cocoa butter among the six existing polymorphic forms, namely the form V (Schenk and Peschar, 2004). Tempering is also mentioned as the final critical step for the chocolate that it must be tempered to deter large crystalls from forming. Because chocolate would have a gritty texture and a dull appearance and/or the cocoa butter would separate from the mixture without tempering taking place (Pugh, 2014).

The primary purposed of tempering is to assure that only the best form is present or to develop the correct polymorphic form, and in order to do so the chocolate is cooled from 45^{o}C to approximately 30^{o}C (depending on the type of chocolate, e.g. milk or dark chocolate) (Keijbets *et al.*, 2010). Consequently, for the best possible finished product, proper tempering is all about forming the most on type V crystalls (34^{o}C) with characteristics appearance glossy, firm, best snap, melts near body temperature (37^{o}C). This will provide the best appearance and mouth-feel and creates the most stable crystals; so the texture and appearance will not degrade over time (Leffer, 2014).

After the tempering stage, the liquid chocolate is deposited into polycarbonate moulds and cooled. Objective of this cooling phase is the solidification the fat phase of the tempered chocolate mass with the correct crystalliation, as this will lead to contraction of the chocolate and easy removal of the solidified chocolate from the mould during the subsequent demoulding process (Keijbets *et al.*, 2010).

The process of tempering consist shearing chocolate mass at controlled temperature to promote crystallization of triacylglycerol (TAG) in cocoa butter to effect good setting characteristics, form stability, demoulding properties, product snap, contraction , gloss and self-life characteristics (Afoakwa *et al.*, 2008). This is a delicate process that involves slowly heating and cooling the chocolate repeatedly to the temperatures between 41^{o}C and 29^{o}C. This stabilizes the product and achieve the smooths, shinny texture, pleasant mouth-feel and sops the chocolate becoming crumby as it hardens (Pugh, 2014).

To produce the right number and size of stable form V crystals, agitation is one important variable. As a results, some means of mixing or agitation must be part of any tempering machine. Another factor related to agitation is shear, because to a carefully defined shear has been recently recognized as the key factor in the success of tempering process (Donshi and Stapley, 2006). In a tempering machine, shear take places where there is scraping against the cooling surface (Sofia, 2013).

Temperature is perhaps the most critical variable of tempering. As the different polymorphic forms have different melting ranges, the trick to tempering is to carefully control the temperature of the melted chocolate (Debaste *et al.*, 2007). Therefore, by choosing the appropriate temperature throughout the tempering process, we can induce crystal formation, maintain a constant crystal population and melt away undesirable crystals (Sofia, 2013).

The control of tempering process is important for the quality of the product, as well-tempered chocolate is shiny, even-colored, snap, and smooth tasting; while badly-tempered chocolate is chewy (not knocking), chalky and grainy, within the form of an unattractive, dull brown mass because of fat blooming (Debaste *et al*., 2007). Based on the study by Debaste and his collegeaus (2007) was also mentioned that the quality of product obtained by their tempering process will depend on several operating parameters, such as the ratio between the mass of the particles and the mass of melted chocolate; the size of the particles, their initial temperature, the temperature of the melted chocolate at time 0, the temperature of ambient air; and the temperature of the walls during cooling.

CONCLUSION

The technological and processing techniques of cocoa to produce chocolate was influenced by some variable factors, since the beginning in the post-harvest treatments and handling of cocoa up till to the manufacturing process. Some variable factors that influence in the post-harvest and handling of cocoa were included pre-conditioning, fermentation and drying; while some variable factors that influence in the manufacturing process were included roasting, alkalization, refining, conching and tempering.

Fermentation and drying process were identified as a key role in flavour formation ana character in cocoa and chocolate. Fermentation generates flavour precursors and promote biochemical changes in the type and concentration of flavour in cocoa beans. Drying reduce bitterness and astringency and also the development of chocolate brown colour. Those process were impact and affected to the quality of cocoa flavour in the final product of chocolate and its derived.

Roasting, conching and tempering were identified also as the key important roles in the chocolate manufacturing process and affected on the final flavour and characteristics of chocolate. Roasting is determines to the character of chemical and physical process that occur inside the beans like Maillard reaction and strecker degradation, and a reduction in acidity, sourness and bitterness. This process was influenced by roasting conditions such as time and temperature of roasting process.

Conching process was known as a marker to produce chocolate with superior aroma and melting characteristics. This process was functioned to remove unwanted flavour and was influenced by the variable factors of temperature and time of conching.

Tempering is the final critical process in manufactured of cocoa to assure that only the best form namely the form V crystals (the most stable crystals). This process should be controlled by choosing the appropriate temperature in order to obtain well-tempered chocolate.

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