Production of Chocolate Bars from Palm Fractions

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INTRODUCTION

Chocolate is a type of confectionery besides sugar and flour confectionery. It is one of the most desired and craved foods in the world. It is enjoyed by people from all walks of life, from children to the elderly, regardless of gender and socioeconomic level. This is partly due to the satisfying and 'feel good' sensation one gets when indulging in chocolate. Seligson *et al*. (1994) found that in many north European countries, the per capita consumption of chocolate confectionery approximated 7-10 kg yr^{-1}. The history of chocolate confectionery started back in the 19th century after the invention of the cocoa press resulted in the first commercial production of dark chocolate. Milk chocolate was then invented by the Swiss. However, before the 19th century, chocolate beverages were the only consumable product of cocoa. Nowadays, chocolate confectionery is one of the top-selling products in the food and snack industries. Chocolate bar, chocolate spread, chocolate filling, chocolate coating and baking chocolate are some of the popular types of chocolate confectionery in the market. This article will focus on the production of chocolate bars from palm fractions.

A chocolate bar is a bar-shaped chocolate manufactured in a snack size, and is eaten as is. In America, the chocolate bar is also referred to as a candy bar. Chocolate bars are normally classified into three categories, namely milk chocolate, dark chocolate and white chocolate, based on the amount and type of ingredients used. Plain chocolate normally falls under the dark chocolate category. Most countries in the world have their own regulations and legislation for their cocoa products which include the chocolate bar. In the United States of America, for example, in order to be labeled as milk chocolate, the product must contain more than 10% cocoa liquor (produced from fermented, fried, roasted and ground cocoa beans) and more than 12% milk solids. Dark chocolate should be formulated with more than 35% cocoa liquor and less than 12% milk solids. White chocolate on the other hand must contain more than 14% milk solids, less than 55% sugar/sweetener, more than 20% cocoa fat and more than 3.5% milk fat (Food and Drug Administration, 2016).

Typically, chocolate bars are made of vegetable fat together with sugar, cocoa powder, emulsifier and flavouring. Chocolate bars may contain other ingredients such as fruits, nuts and nougat to provide value addition and variation in the product. *Cadbury, Godiva, Lindt, Hershey's* and *3 Musketeers* are among the top brands of chocolate bars. In 2016, 1939 chocolate bar products were launched in markets worldwide. Germany launched the highest number of chocolate bar products followed by the United States, United Kingdom and France. Malaysia is among the top 15 countries that launched chocolate bar products (Innova Market Insight, 2017).

ROLE OF FAT IN CHOCOLATE BAR PRODUCTION

Lipids are molecules consisting of hydrocarbons. They are non-polar and therefore are not soluble in water. One of the examples of lipids is fat. Fat is an essential raw material in food products, including chocolate confectionery. Fats are composed of triacylglycerols (TAGs), having a molecule of glycerol and three molecules of fatty acid which generally make up about 90%-99% of the composition. The remainder is composed mostly of diacylglycerols (DAGs), monoacylglycerols (MAGs), free fatty acids (FFAs), phospholipids, sterols and other minor components. TAGs are the most important component of fat in chocolate but DAGs can play a significant part too. Confectionery fats, or what are often called specialty fats, are usually solid at room temperature.

Chocolate is a suspension of solid particles (cocoa powder, sugar and milk) in a fat phase. These ingredients (solid particles and fat) provide flavour, aroma and colour to the chocolate. Although sugar comprises about half of the chocolate content, the fat component influences and controls the overall quality of chocolate mostly through its crystallisation, the most crucial step in chocolate making (Rios *et al.*, 2014). Crystallisation

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changes the liquid phase of the chocolate to a solid phase. During crystallisation, a random collection of molecules without order in the liquid phase begin to line up to form an ordered pack until a solid phase is obtained. The processes of crystallisation include nucleation and crystal growth. Fat has the ability to crystallise into different crystalline forms, depending on the processing conditions, and this is called polymorphism. β is the most stable polymorph in chocolate fat followed by β' and α. γ on the other hand is the least stable polymorph. As β is the most stable polymorph, it has the highest surface energy and highest heat of crystallisation compared with the other polymorphs (Timms, 2003). Desired characteristics of chocolate are obtained through proper control of crystallisation. These quality characteristics include melting properties, glossiness, 'snap' ability, mould contraction, blooming (discoloration) as well as flavour release of the chocolate (Beckett, 2009). For example, a steep melting property at 30°C-35°C is desired for chocolate to completely melt in the mouth while maintaining solid, and to have the ability to snap brittlely at ambient temperature (Alander *et al*., 1993). The cooling sensation when chocolate melts completely in the mouth is due to the energy absorbed by the fat crystals from the tongue (www.perfectfuel.com, 2011).

PALM OIL FRACTIONS IN CHOCOLATE BAR

There are four types of fats that are commonly used in the production of a chocolate bar. They are categorised as cocoa butter and cocoa butter alternatives (CBA). Palm fractions are the most common CBA used for the production of chocolate bars due to their reliable supply and competitive price. Oil palm being harvested all year around produces a continuous supply of palm oil and palm kernel oil which are the raw materials for the production of palm-based CBA. These fats are attractive as they are bland in flavour. CBA from palm fractions are called cocoa butter equivalent (CBE), cocoa butter replacer (CBR) and cocoa butter substitute (CBS).

1. The traditional fat used in the production of chocolate bars is cocoa butter. Cocoa butter is derived from cocoa beans which have been fermented, dried, roasted, ground and pressed. Its prominent fatty acids are palmitic, oleic and stearic, resulting in about 70% of its TAGs coming from the 1,3-dipalmitoyl-2-oleoyl glycerol (POP), 1(3)-stearoyl-2-oleoyl-3(1)-palmitoyl glycerol (POS) and 1,3-distearoyl-2-oleoyl glycerol (SOS) types (Naik and Kumar, 2014).

2. CBE has similar physical and chemical properties as cocoa butter. CBE is produced by blending palm mid fraction (PMF) which is rich is POP with other vegetable fats that are rich in POS and SOS fractions (such as shea butter, illipe butter and others). It has complete compatibility with cocoa butter and has excellent organoleptic properties (flavour release and mouth feel) as cocoa butter. As CBE has similar chemical properties as cocoa butter, it requires tempering to form stable polymorphs (Samsudin and Rahim, 1996).

3. CBR has similar physical properties as cocoa butter but has different chemical properties. Currently, low and zero-*trans* CBR have been the choice of many chocolate manufacturers as *trans*-fat produced from partial hydrogenation is detrimental to health. As CBR has different chemical properties from cocoa butter, it does not require tempering. Low and zero-*trans* CBR show better compatibility with cocoa butter (Smith, 2012). Although CBR can be used in the production of chocolate bars, its usage is more prominent in chocolate coating.

4. CBS is a lauric oil type fat. Similar to CBR, CBS has comparable physical properties to cocoa butter but with distinct chemical properties. CBS is normally derived from palm kernel oil and coconut oil. Chocolate compounds with CBS should contain a limited amount of cocoa butter in the fat phase due to the eutectic effect. CBS does not require tempering and this is advantageous in saving processing time (Ulberth and Buchgraber, 2003; Pease, 1985).

Fats for the production of chocolate are selected based on requirements. Cocoa butter and CBE are used when a strong chocolate flavour is required. It is to be noted that both cocoa butter and CBE require tempering. Nonetheless, CBR has better compatibility with cocoa butter compared with CBS when a strong chocolate flavour is still required. CBS has less unsaturated fatty acids and is more stable. Therefore, it is suitable for chocolate that requires good oxidative stability. CBS should be avoided in the presence of live enzymes as it can give a soapy off-taste due to hydrolysis. Hardness, melting properties and rate of crystallisation are among other factors that have to be considered in the selection of chocolate fats (Smith, 2012).

PROCESS OF CHOCOLATE BAR PRODUCTION

There are generally seven common steps in the production of chocolate bars. These steps include mixing, refining, conching and tempering. The tempered chocolate is then molded into various shapes as desired, followed by cooling and stabilising at designated temperatures and times before packing. These chocolate production processes influence the

physical and chemical properties of the end products.

Mixing is an act of putting together melted fat, cocoa powder, sugar and milk powder to produce chocolate paste. White chocolate does not contain cocoa powder. The chocolate paste is then refined using a roll refiner to obtain the desired smoothness that is critical for rheological and sensory properties (Afoakwa, 2016; Afoakwa *et al*., 2007). Chocolate paste is typically refined until 80% of its particle size distribution is between 20 and 30 µm to avoid grittiness in the chocolate. The smaller the particle size, the larger will be the total surface area. As a consequence, more fat is required to cover the surface area which leads to thickening of the chocolate (Timms, 2003; Minifie, 1982).

Conching will then take place for a few hours. It is carried out to turn the refined chocolate paste into a free-flowing chocolate liquid. Conching temperature is dependent on the type of chocolate being made. Milk chocolate has a lower conching temperature. Conching develops the chocolaty flavour, reduces undesirable flavours (*e.g*. acidic flavour) and results in a moisture content of less than 1% of the chocolate. After leaving the concher, the chocolate contains no nuclei or other crystals (Timms, 2003; Minifie, 1982).

Tempering is an act of supercooling the conched chocolate to induce crystallisation, and then warming it up to a point above the melting point of all the unstable crystals. The purpose of tempering is to induce the most stable solid form of cocoa butter, a polymorphic fat in finished chocolates (Afoakwa *et al*., 2008). Tempering is only for chocolate containing cocoa butter and CBE. CBR and CBS type of confectionery fats do not require tempering as both fats will be able to form stable polymorph easily (Timms, 2003; Minifie, 1982). The tempered chocolate is then poured into a mould to form a particular shape (*e.g*. rectangular bar). The temperature of the moulds should be about 2°C-5°C lower than the mass. The chocolate is then cooled in a cooling cabinet at 5°C-12°C for not more than 45 min. The finished products are stabilised at 18°C-20°C for at least 24 hr to complete crystallisation (Malaysian Palm Oil Council, 2010).

CONCLUSION

Fats from palm oil and palm kernel oil fractions are comparable to cocoa butter and can be applied as cocoa butter alternatives (CBA). These CBAs have similar chemical, physical, or both chemical and physical properties as cocoa butter, and thus would be able to produce good quality chocolate at a competitive price.

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Tocotrienol-rich Fraction: An Emerging Nutrient in Cardiovascular Health

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TOCOTRIENOLS – A NOVEL, SAFE AND EFFECTIVE VITAMIN E

Vitamin E, an essential vitamin, is not synthesised by the human body; thus, it has to be obtained from diet. Lack of vitamin E can cause nerve damage, blood disorders and infertility. In 2010, the USA Food and Drug Administrative (FDA) granted 'Generally Recognised as Safe' (GRAS) status to palm-derived vitamin E, making it safe to be incorporated into foods and beverages. Scientific research has shown that tocotrienols possess unique biological properties with greater anti-oxidation activity and additional health benefits compared with the more commonly known α-tocopherol (Sen *et al.*, 2006).

BIOLOGICAL PROPERTIES

It is believed that tocopherols and tocotrienols are nature's way of protecting the plant's seeds and seedlings from being damaged by ultraviolet (UV) light and oxidation. Tocotrienols have been shown to possess up to 60 times higher anti-oxidative activity compared with α-tocopherol (Serbinova *et al.*, 1991). In addition, tocotrienols exhibit anti-inflammatory and cholesterol-lowering activities, not demonstrated in tocopherols (Wong *et al.*, 2015). Tocotrienols' distinct chemical structure gives them more fluidity, facilitating better cellular uptake in biological systems which is up to 70 times higher than for α-tocopherol (Saito *et al.*, 2004).

CARDIOVASCULAR HEALTH-PROMOTING PROPERTIES

Cardiovascular disease (CVD) is the leading global cause of death, accounting for 17.3 million deaths per year. This number is expected to reach 23.6 million by 2030 (Laslett *et al.*, 2012). Tocotrienol is a nutrient with well-documented cardiovascular health-promoting properties (Qureshi *et al.*, 1991; Baliarsingh *et al.*, 2005; Zaiden *et al.*, 2010; Yuen *et al.*, 2011; Zhao *et al.*, 2014).

i. Dyslipidemia (loss of lipid balance)

Tocotrienols can alleviate hyperlipidemia and hyper-cholesterolemia which are key independent risk factors in CVD. Research has shown that they can reduce low density lipoprotein-cholesterol (LDL-C) and total cholesterol levels by up to 20% and 25%, respectively (Qureshi *et al.*, 2002). Davos Life Science, in collaboration with leading researchers in Malaysia, Australia, China and Japan, has published evidence in peer-reviewed journals on the cardiovascular health benefits of tocotrienols supplementation in tissue culture systems, rodent models as well as human studies (Laslett *et al.*, 2012; Wong *et al.*, 2015). In these studies, tocotrienols reduced the production and transport of triglycerides in cells, rodents and humans, reducing triglyceride levels by 28% (*Figure 1*).

Tocotrienols lower LDL-C by suppressing the production of HMG-CoA reductase, the key enzyme essential for cholesterol production (Pearce *et al.*, 1992). Currently, statins remain the primary pharmacological standard for the treatment of dyslipidemia. While efficacious and effective, statins at higher doses have unfavourable side-effects. Tocotrienols, on the other hand, inhibit cholesterol biosynthesis by lowering the expression of the proteins, resulting in less enzymes being available

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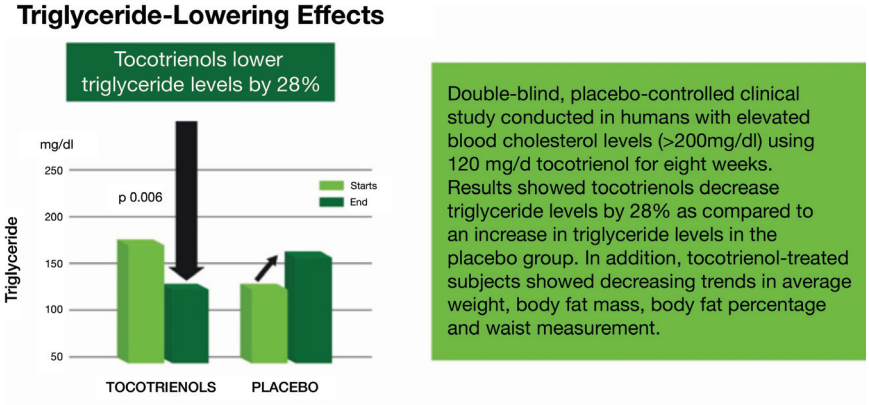

Figure 1. Triglyceride levels in tocotrienol and placebo groups after 8 weeks of supplementation.

at a given time for cholesterol biosynthesis (Baliarsingh *et al.*, 2005; Leonard *et al.*, 2007; Heng *et al.*, 2013; Naci *et al.*, 2013). Thus, tocotrienols are unlikely to cause the same side-effects as statins.

ii. Atherosclerosis and blood vessel health

Atherosclerosis is a disease in which atheromatous plaque builds up inside the blood vessels. Plaque build-up leads to the narrowing of the lumen of coronary blood vessels and is a cause of angina. Plaque rupture is also a major mechanism in heart attacks. One of the major constituents of plaque build-up is LDL-C level. Tocotrienols not only lower LDL-C and TG, but also delay plaque formation in blood vessels (Kooyenga *et al.*, 1997). Plaque build-up also leads to up-regulation of inflammation processes (Packard and Libby, 2008). Tocotrienols have well-researched anti-inflammatory properties, a property not seen in the more widely available α-tocopherol (Pearce *et al.*, 1992).

In a study involving human subjects, the narrowing of the lumen of neck blood vessels regressed in 32% of patients given a tocotrienol-rich fraction formulation for two years, suggesting that tocotrienols may delay plaque formation (atherosclerosis) in blood vessels (Kooyenga *et al.*, 1997).

Prolonged and uncontrolled hypertension and diabetes can disrupt the lining of blood vessel walls. In pre-clinical studies, tocotrienols improved blood vessel function when administered in hypertensive animal models (Muharis *et al.*, 2010).

iii. Heart health

Davos Life Science, in a collaborative study with scientists from Singapore and Australia, presented evidence that tocotrienols can improve cardiac hypertrophy, reduce inflammatory cell infiltration and improve cardiac contractility in rats fed a high fat diet (Wong *et al.*, 2015).

Reperfusion injury happens when there is normalisation of blood flow following significantly reduced tissue perfusion. In this complex process, key proteins such as c-Src are activated, and proteasome necessary for 'clean-up' of damaged proteins in affected tissues is reduced. Tocotrienols have been shown to inhibit c-Src as well as maintain proteasome integrity (Das *et al.*, 2008). Thus, tocotrienols are able to confer health benefits in various aspects of cardiovascular health, from lowering lipid levels to preventing plaque formation in the blood vessels.

For in-depth scientific information, please visit **www.tocotrienolresearch.org**

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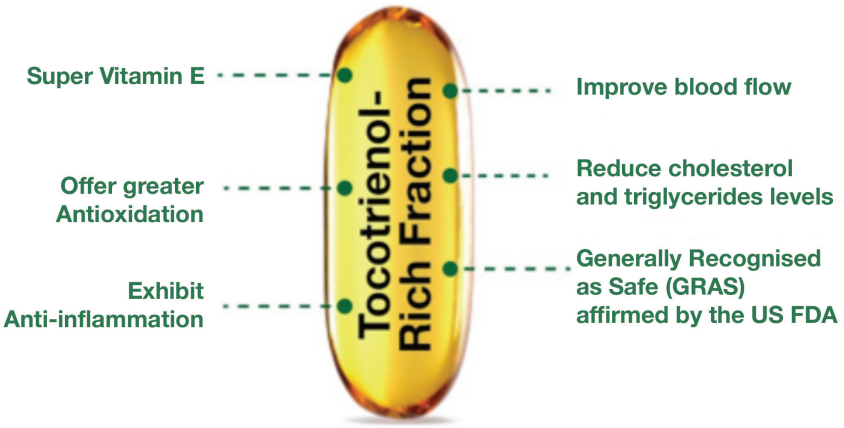

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