STORAGE STABILITY OF REDUCE CALORIE MILK CHOCOLATE

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ABSTRACT - *A storage study was conducted for reduced calorie milk chocolates. Reduced calorie milk chocolates were produced by incorporating cocoa butter emulsion (CBE) into chocolate formulation. Chocolates were analyzed for melting property using differential scanning calorimeter (DSC), solid fat content (SFC) using a pulsed-nuclear magnetic resonance (p-NMR) spectrometer, sensory evaluation, proximate analyses and then compared to original milk chocolate. Proximate analyses showed that moisture content increased to 1.7% (sample A) and 1.5% (sample B) compared to control, 1.2%. Fat content was slightly reduced in both samples A and B compared to control. A minimal change in melting temperatures does not affect significantly the melting time and behavior of the chocolates. The finding also indicates solid fat content of chocolates with CBE was similar to original milk chocolate. The sensory attributes of all samples showed not significant different except for smoothness where samples A and B were significantly less smooth than control. The energy value of each sample was 371kcal/100g (A), 380 kcal/100g (B) and 521kcal/100g (control). Energy value was reduced by 29 and 27 % in each sample respectively. Storage stability of both reduced calorie milk chocolates indicated that these chocolates can be stored at ±16 °C for about one year. If stored at room temperature the moisture content and hardness increased and glossiness reduced compared to control samples.*

Keywords: Chocolate; cocoa butter emulsion; reduced calorie; storage.

INTRODUCTION

Chocolate can be consuming as high energy food during activities that need more energy such as mountain climbing, marathon, swimming competition and sport activities. Chocolate is considered a non-Newtonian fluid, pseudo plastic, and its rheological behavior determines the process conditions adopted industrially (Volt & Beckett, 1997). In sixteen centuries, it was first enjoyed as a spiced drink called ‘choclatl’ by Aztec and Mayas in Mexico. Chocolate was first made in 1847 in England by Fry using cocoa powder, cocoa butter and sugar. In 1876, chocolate was produced using condensed milk by Daniel Peter in Switzerland. Then chocolates were producing commercially by Switzerland Company, Nestle’ (Nazaruddin and Suriah, 2005). As progress, today many types of nutritious chocolates were available such as dark chocolate containing high polyphenol, chocolate enriched with omega, chocolate fortified with inulin, herbals chocolate, sugarless chocolates and many types of functional chocolates.

Beckett *et al*. (2001) patented a process for manufacturing milk chocolate containing up to 30% water (by weight), which involved mixing a dark chocolate material with a water-in-oil emulsion and mixing to disperse the water (to below 10 µm), without creating a continuous phase. Hugelshofer (2000) investigated this method in depth. The water-in-oil emulsion was unstable in the presence of solid particles. However, Hugelshofer (2000) suggested that it is possible to produce dark chocolate containing10–15% water with sensorial properties similar to conventional chocolate. A similar method was patented by Traitler *et al*. (2000) who added a water-in-oil emulsion (with droplets of approximately 2 µm) to molten chocolate, with the intention of distributing the water in droplets throughout the chocolate mass, resulting in a chocolate with 1–40% water (by weight). However, if water is introduced in the form of an emulsion (i.e. by making stable droplets and preventing water migration), calorie content could be greatly reduced. A number of patents describe processes or products which attempt to introduce water into chocolate. Baba *et al.* (1992) patented a method of creating water-containing chocolate by directly mixing a chocolate mix with an aqueous ingredient after rolling and conching, emulsifying with a nut paste to make a water-in-oil type emulsion. Schlup and Lioutas (1995) patented a process for the production of a water-containing milk chocolate containing 1–16% water (by weight), in which the cocoa and aqueous ingredients were mixed independently and then blended to form a uniform mixture. The product made is a solid with desirable gloss, snap and hardness, and can be remoulded well.

As societies concern of reduced weight, obesity and reliant on low calorie food, dieting and physical exercise are the mainstays of treatment for obesity. Obesity leads to an increment of death cause diseases such as heart diseases, diabetes, certain types of cancer, osteoarthritis and others (Barnes *et al*., 2007). These are the main preventable cause of death worldwide and the most important public health problems of this century. Obesity results from an energy imbalance (i.e. energy intake exceeds energy usage) with most excess calories stored as triacylglycerol (TAG) in fat tissues. To avoid obesity, lowering the total fat consumption and carbohydrate are recommended, especially saturated fat and to balance the types of fat in the diet. Although many kinds of food with fat substitutes have been available on the market, consumers do not seem to be willing to compromise taste for health. Reduced calorie chocolate is suitable for weight reduction and maintenance, and allowing us to enjoy eating chocolate with fewer calories but with the same unique characteristics of original chocolates.

Production of chocolate products with low calories and high nutritional value can increase products varieties and consumption of chocolates among Malaysian, therefore enhances the economic contribution to the country. Besides that, these products can replace high calorie chocolate and reduce obesity among children and can be introduced in schools. By introducing these products to chocolate entrepreneurs and cocoa industries such as SME or SMI, can improve their income and also as ways to enhance cocoa markets and Malaysian economy. Finally contributes to the fourth element of the National Key Results Area (NKRA)

Product development is one of major and important part in chocolate research and cocoa industry. The physical properties, sensorial behavior and perception of chocolate are influenced by its ingredient's composition, particle size and processing techniques. To develop new product with additional values and same quality of original chocolate can be enhanced with additional ingredients, and manipulation to modify physical properties, rheological characteristic, sensorial attributes and storage stability.

This paper reports on production of reduced calories of milk chocolate incorporated with cocoa butter emulsions. Storage study up to 1 year was conducted to observed stability of the newly developed reduced calorie chocolates.

MATERIALS AND METHODS

Materials

Cocoa butter and cocoa liquor were obtained from local grinder, Barry Callebaut Malaysia Sdn. Bhd., Klang, Selangor. Emulsifier, sugar, milk powder and vanilla were purchased from local shop in the vicinity. All chemicals used were food grades and purchased from local chemical suppliers.

Preparation of cocoa butter emulsion

Cocoa butter emulsion (70 % water, 28% cocoa butter and 2 % emulsifier) was homogenized at 10,000 rpm for 2 minutes using a high shear homogenizer. Rotor–stator systems and high pressure homogenizer is commonly used for producing emulsion (Schubert and Armbruster, 1992). These emulsions were kept frozen (-4 °C) for chocolate production.

Production of reduce calorie milk chocolate

A portion of cocoa butter was mixed with cocoa liquor, refined sugar, and milk powder in a lab scale (1 kg capacity) mortar and pestle mill (Pascal, U.K) for 20 minutes at 45ºC to form paste. The paste was refined with a three roll refiner (Pascal, U.K) to get a particle size of less than 35µm measured by a micro screw meter (Mitutoyo, Japan). The mass was then transferred back into the mortar and pestle mill with the remaining portion of the fats blend and emulsion for a conching process of 6 hours at 55ºC. Two hours before the end of conching process, lecithin and vanillin were added. The portion of emulsion (15% and 20%) was added at the final stage of conching process. Finally, the process was followed by manual tempering on a marble slab at 28ºC to 29ºC and transferred into chocolate mouldsand cooled to set at 16ºC for 40 minutes. The chocolates were stored at 16±2ºC in a chiller before further analyses. Storage study was also done to evaluate the stability of the product at different temperature and condition for about one year. Formulation of chocolate was adopted from Beckett (1994).

Moisture content analyses

The moisture content of emulsions and chocolate samples was determined using HR73 Halogen moisture analyzer (Metler Toledo, Malaysia). Chocolate was cut into small pieces and then approximately 5mg of sample was placed on the pan and heated to 105ºC until constant weight was achieved.

Fat content analyses

The fat content of chocolate was determined using the Soxhlet procedure. Approximately 5mg melted chocolate sample was subjected to acid digestion and a 4 hours Soxhlet reflux in petroleum ether of boiling range 40-60ºC. Weight of fat extracted was recorded and percentage of fat was calculated.

Crude Protein

Crude protein was determined according to IOCCC (1999). The chocolate was defatted and the casein was extracted from the fat free residue, using sodium oxalate. The casein was then precipitated with tannin and nitrogen in the precipitate determined by the Kjeldhal method. The crude protein was calculated from nitrogen value.

Carbohydrate and energy value

Carbohydrate was calculated by subtracting the sum of the moisture, crude protein, fat and ash from 100%. Factor of 4, 9 and 2 were used for calculating energy from crude protein, fat and carbohydrate.

Ash content

Ash content was done according to AOAC, 13.005(1984), approximately 5g of samples was heated at 550 to 600°C in a muffle furnace. Heating procedures was done for 2 hours and moistens cooled ash with alcohol and then dried on sand bath. Then further re ash at 600°C overnight. Different in weight before and after ash was calculated as the concentration of ash present in sample. The ash content was expressed in percentage on dry basis.

Melting Profiles

Melting profile was measured using a differential scanning calorimeter 8000, Serial number: 534N2080801. The method used was based on Md Ali and Dimick (1994). The samples were melted at 50ºC in a ventilated oven. Approximately 3 to 5mg of sample was hermetically sealed in an aluminum pan. The sample was heated at 60ºC for 30 min. and cooled at 0ºC for 90 min. It was then transferred to an incubator at 26ºC for 40 hrs for stabilization. The sample was cooled again at 0ºC for 90min before it was transfer to a DSC chamber and held at -25ºC for 5 min on the DSC head. The melting profile of the fat was measured at a heating rate of 20ºC/min from -25ºC to a maximum of 50ºC.

Solid Fat Content

Solid fat content was determined using a Pulsed-Nuclear Magnetic Resonance (p-NMR) spectrometer, Newport analyzer Mark 3 (Newport Parnell, England). Method used was as described by Nilsson (1986). NMR tubes were filled 3-4cm with samples and melted at 80ºC and then held for 60ºC for 25 min. It was then cooled at 0ºC for 90min. The samples were stabilized for 35 minutes at each measuring temperature of 10ºC, 20ºC, 25ºC, 27.5ºC, 30ºC, 32.5ºC, 35ºC and 40ºC prior to measurement of SFC.

Particle size

The particle size of chocolate was measured using Malvern particle size analyser (Mastersizer Micro Version 2.19, Malvern, UK), which applied the laser diffraction particle size analysis that based on the phenomenon that all particles scatter light at a range of angles, which is a characteristic of their size.

Sensory evaluation

Flavor profile of CBE chocolates were measured by quantitative descriptive analysis (QDA) with scale of zero (low intensity) to ten (higher intensity). The attributes tested were texture (hardness), glossiness, odor and smoothness, melting behavior (rapidness of melt in the mouth), melting time (time taken of complete melt), and overall acceptance. Method of sensory evaluation was adopted from Aminah (2000). Fifteen experienced panelists were participated in this sensory evaluation. Sensory evaluations were done in three cycles coded with three digit numbers.

Statistical Analyses

All experiments were conducted in triplicates. Analysis of variance (ANOVA) was done using MINITAB version 14 software.

RESULTS AND DISCUSSION

Proximate analyses of chocolates containing CBE were compared with pure milk chocolate (control). Table 1 shows the nutritional properties of reduced calorie milk chocolate. Sample A is chocolate with 20% CBE and sample B is 15% CBE whereas sample C is pure milk chocolate as control without CBE. It shows that moisture content increased from 1.2% in control to 1.5% and 1.7% for both chocolates in cooperated with CBE. Fat content slightly reduced in both samples compared to control. Energy calculated for sample A was about 371.2 kcal per 100g and sample B was 379.5 kcal per 100g compared to control 520.6 kcal per 100g. Therefore, the total calorie reduction was about 29 and 27% in each sample respectively. Incorporating CBE in chocolate is a new strategy for producing chocolates with fewer calories. Addition of 20 % CBE can only reduce the calorie by 8 to 10 %. More reduction in calorie can only be obtained if sugar is substitute with sugar alcohol such as isomalt, maltitol and xylitol. Cocoa butter emulsion was produced from 28% of water, 2% emulsifier and 70% of cocoa butter. This emulsion can only be substitute into chocolate formulation up to 20%. Sugar substitute can affect the rheological, particle size and sensory properties of chocolates. Therefore, adding sugar substitute into chocolate formulation has limitation.

Table 1: Nutritional properties of reduced calorie milk chocolate

Samples	A	B	C
Moisture(g/100g)	1.7	1.5	1.2
Ash(g/100g)	1.4	1.4	1.4
Crude protein(g/100g)	4.8	5.0	5.2
Fat(g/100g)	24.0	25.0	26.2
Carbohydrate(g/100g)	68.1	67.1	66.0
Energy(kcal/100g)	371.2	379.5	520.6

The melting profile analysis indicated that the onset temperature for samples A is slightly higher than control (C) and samples B and C are not significant different. However, there was no significant difference in peak and end set temperatures for all samples. However, an enthalpy value is slightly higher in sample A compared to B and C (control). This value is not very high to influence the sensational melting characteristic in mouth. Melting properties of chocolate is one of the major criteria for chocolates that determined for best quality chocolate.

Table 2: Melting properties of reduced calorie milk chocolate

Samples	**Onset Temp. ± Std**	**Peak Temp. ± Std**	**End set temp. ± Std**	**Enthalphy ± Std**
A	28.14 ± 0.29b	32.58 ± 0.11a	33.41 ± 0.40a	28.53 ± 0.70b
B	26.81 ± 0.18a	31.14 ± 0.17a	33.22 ± 0.03a	27.31 ± 2.34a
C	26.60 ± 0.18a	32.09 ± 0.12a	33.20 ± 0.42a	27.07 ± 0.71a

Flavor profile of reduced calorie chocolates is shown in Figure 1. The sensory attributes of all samples showed no significant different except for smoothness where samples A and B were significantly less smooth than control (C). Addition of 15% or 20% CBE did not affect other physical properties of chocolates significantly accept for smoothness as stated in Table 3. Addition of more than 20% CBE could cause grittiness in texture of the chocolates and harden the chocolate paste during conching. It also causes difficulty in tempering and moulding process. However, if more CBE is added then it is more suitable to create other types of products such as chocolate filling or chocolate sauce.

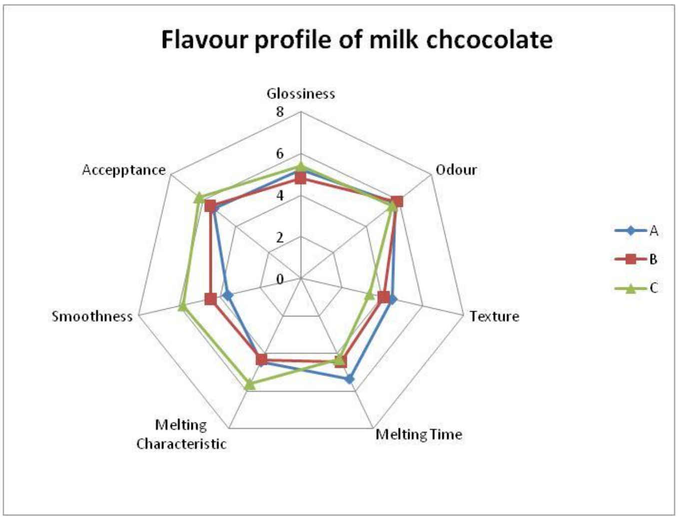

Figure 1: Flavor profiles of reduced calorie milk chocolate

Table 3: Mean score for sensory evaluation of reduced calorie milk chocolate

Sampels	**Glossiness**	**Odour**	**Texture**	**Melting Time**	**Melting Characteristic**	**Smoothness**	**Accepptance**
A	5.200 ± 1.646 [a]	5.811 ± 1.253 [a]	4.4778 ± 0.8829 [a]	5.3333 ± 0.8292 [a]	4.422 ± 1.306 [a]	3.578 ± 0.710 [a]	5.333 ± 1.225 [a]
B	4.811 ± 1.603 [a]	5.911 ± 1.171 [a]	4.0889 ± 1.1107 [a]	4.4556 ± 1.0163 [a]	4.311 ± 1.422 [a]	4.422 ± 1.47 [ab]	5.556 ± 0.882 [a]
C	5.422 ± 1.362 [a]	5.611 ± 1.318 [a]	3.3667 ± 0.7483 [a]	4.2778 ± 0.9718 [a]	5.611 ± 1.616 [a]	5.811 ± 1.149 [b]	6.222 ± 1.202 [a]

Statistical results for ANOVAs (one-way). Mean value followed by the same alphabet in the same column are not significant at $p>0.05$.

Figure 2 shows the solid fat content in chocolates with CBE from temperature 10 to 50°C. Solid fat content indicates the amount of solid present in the product at particular temperature. However, addition of 15% and 20% CBE into chocolate formulations did not affect the solid fat content profiles of chocolate produced compared to control.

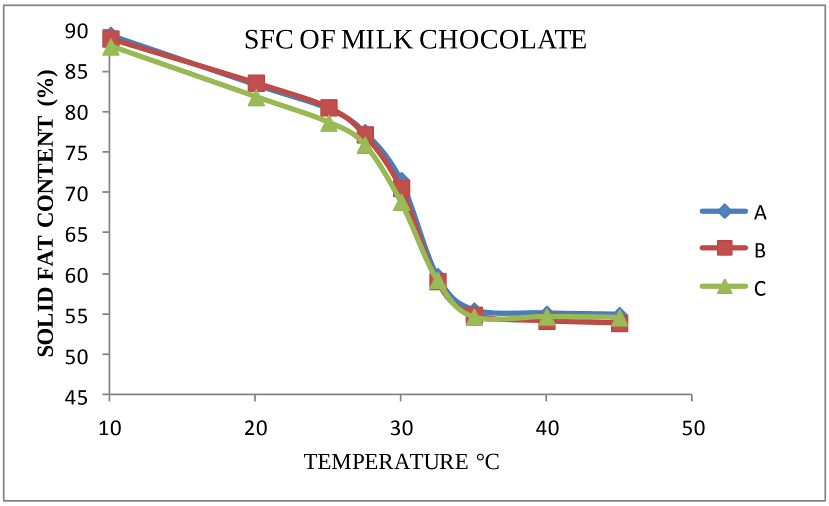

Figure 2: Solid Fat Content of milk chocolate.

The distribution of chocolate's particle size was measured using Malvern particle size analyser and the size was taken as the largest size presence in 90% of the particles. In other words, 90% of chocolate particles are having a size of less than the value recorded (Figure3). Incorporation of CBE into chocolates resulted in higher particle size in sample A and B compared to control.

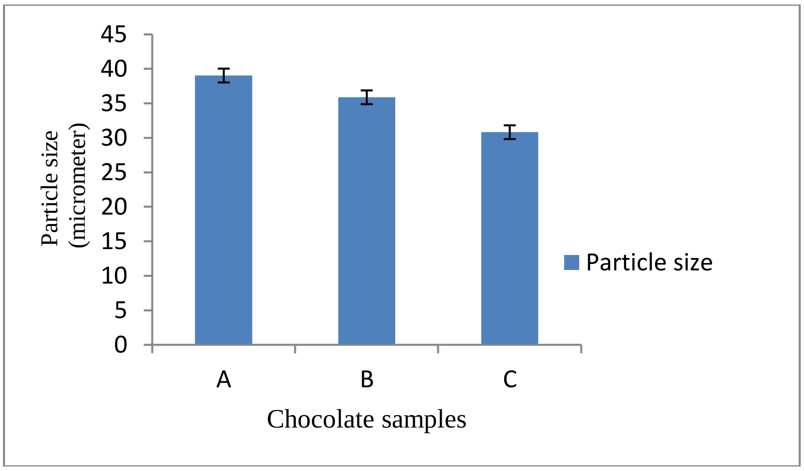

Figure 3: Particle size of milk chocolate

Affective method is used for consumer preference test. Consumer acceptance study of reduced calorie milk chocolates were carried out using 7 hedonic scales where a scale of 1 to 7 was used to describe the level of acceptance of the chocolates. The scale of '7' indicates extremely like, '6' means like it very much, '5' means like, '4' means neither like nor dislike, '3' means dislike, '2' means dislike very much and finally '1' means extremely dislike. Result of analysis was obtained from 63 numbers of respondents in state of Selangor and Negeri Sembilan, were from age of between 20 to 52 years old. Result is as shown in Figure 4. The results indicated that there are no significant different ($p>0.05$) among samples and control in reduced calorie milk chocolate for acceptant scores.

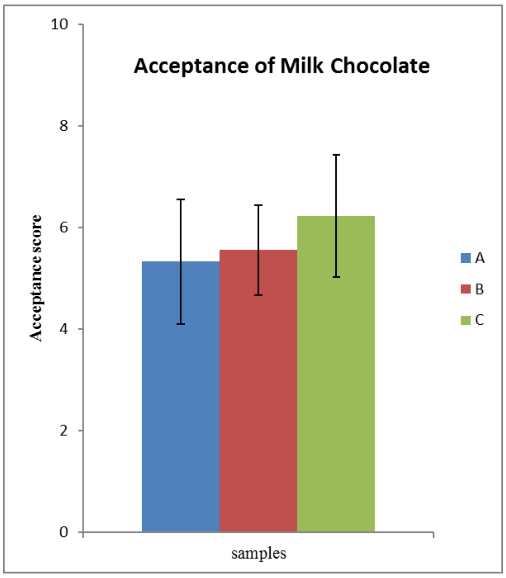

Figure 4: Acceptance score of milk chocolate by random consumers

Quality assessment upon storage

Reduced calorie milk chocolate was kept for up to one year for the purpose of storage stability study. Quality changes upon storage were carried out on moisture content; hardness (breaking force and penetration); glossiness; odour, texture, smoothness, melting time, melting characteristic and overall acceptance score (Figure 5 to 20.). Studies on quality changes on chocolates upon storage were carried out in two conditions, i.e.; room temperature and chiller. For room temperature the study lasted for about 9 months and for chiller it was completed for about 12 months.

The average temperatures of the chillier were 13.7 ± 0.3 ºC (Minimum), 15.2 ± 0.4 ºC (maximum) and average relative humidity (R.H) of 61.1± 9 % (minimum) and 71.8 ± 5% (maximum) respectively for a duration of 12 months. Whereas for room temperatures condition, the average temperature was 26.7 ± 6 ºC (Minimum), 30.5 ± 0.4 ºC (maximum) and average R.H. of 67.7 ± 6 % (minimum) and 86.1 ± 4 % (maximum) respectively for a duration of 9 months. Temperature and R.H. were well maintained during storage study.

Moisture content of chocolates stored at room temperature and chiller increased compared to control (Figure 5 and 6) but for chiller of temperature ±16ºC, the moisture is still below 2.5% and chocolates stored at room temperature the moisture reached almost 4.0%. Therefore, it is advisable to store the reduced calorie chocolates at temperature below ±16ºC in a chiller. Once the moisture content exceeded 2.5% and more the storage study was ended. With higher moisture content the chocolate is prone to mold growth.

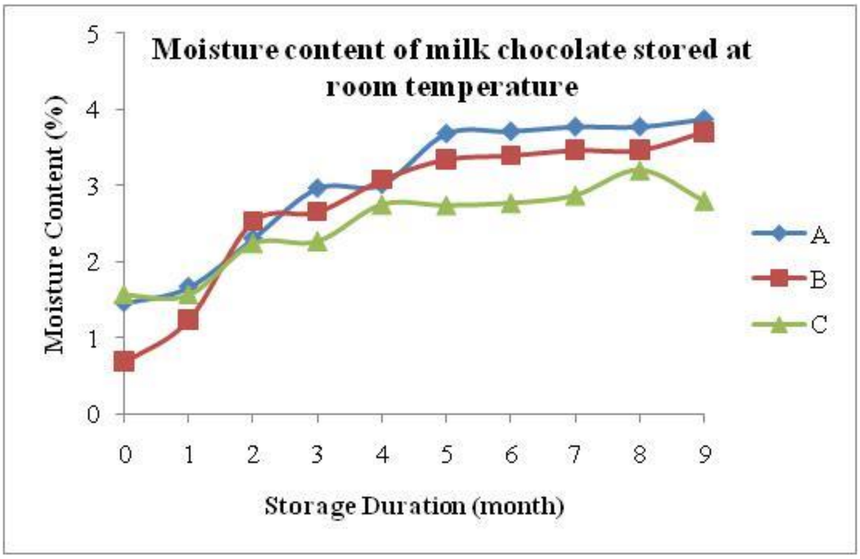

Figure 5: Moisture content of milk chocolate stored at room temperature

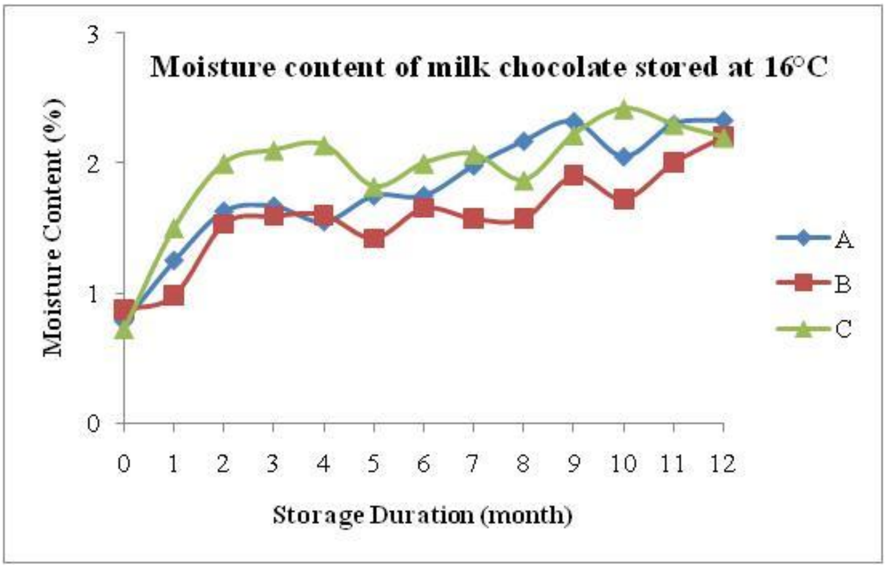

Figure 6: Moisture content of milk chocolate stored at ±16°C

The rheology of chocolate is the study of the relation between the stresses (force per area) applied to chocolate and the ensuing strain (relative deformation) as function of time during which the stresses are applied. The Casson yield value is the force required starting flow of chocolate and the Casson plastic viscosity is the force required to maintain a constant flow in chocolate, also referred to as "shear thickening factor". This simply means that viscosity is the internal resistance of liquids to flow during a flowing process. The more viscous the fluid is, the more resistance to flow. The yield value is the minimum force needs to be applied in order to start the flowing process. Below this minimum force no flow occurs. Therefore, in this study adding emulsion, CBE into chocolates formulation is monitored by the viscosity of the new products developed compared to control.

The rheology of melted chocolate (at 40°C) was measured at 5 different speeds of spindle (RPM) and the responding viscosity, shear stress and rate of shear are as recorded. The plot of viscosity (Cp) versus RPM (Figure 7) shows that the viscosity pattern of reduced calorie milk chocolates for both samples are very close and are higher than the viscosity of control chocolate. The viscosity patterns of both chocolates are very similar. The viscosity (Cp) increased in both samples (A and B) compared to control (C), additional of emulsion increases the viscosity of the products.

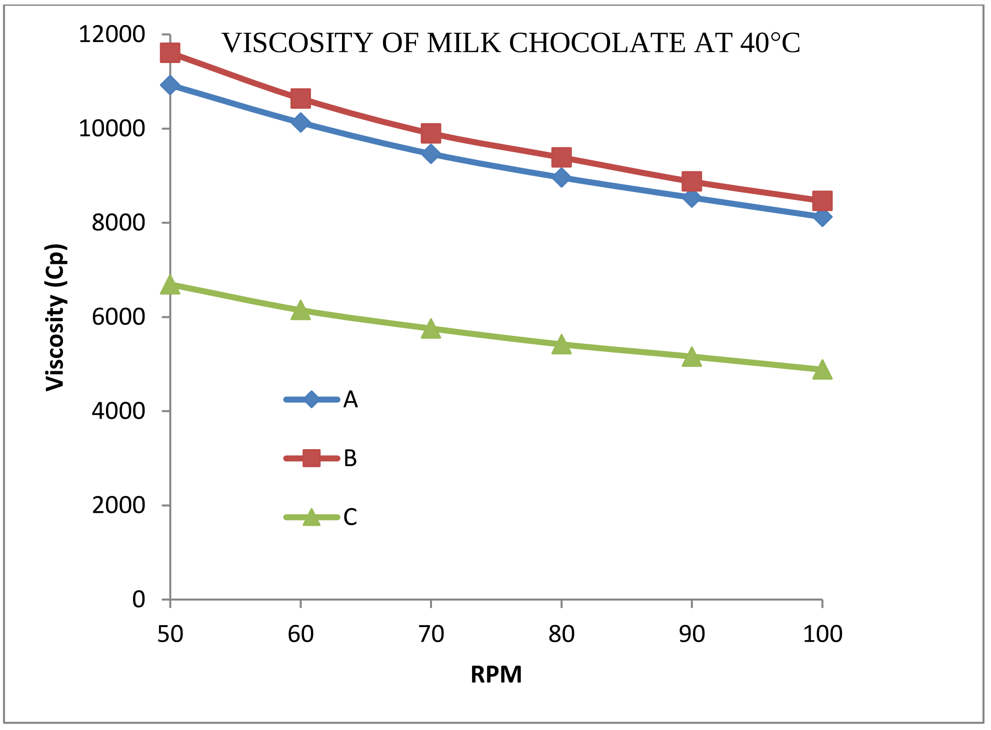

Figure 7: Viscosity of milk chocolate at 40°C

Hardness (penetration force and breaking force) for milk chocolates stored at ±16 °C increased in all samples compared to control. However, milk chocolates stored at room temperature indicated that the penetration and breaking force increased gradually from 0 month to 9 months in all samples and it is significantly different in samples and compared to control (Figure 8 and to 11). Changes in quality of chocolates storing in room temperature is more prominent compared to chocolates stored in chillers. To preserved quality and prolong storage duration it is suitable storing chocolates in chillers.

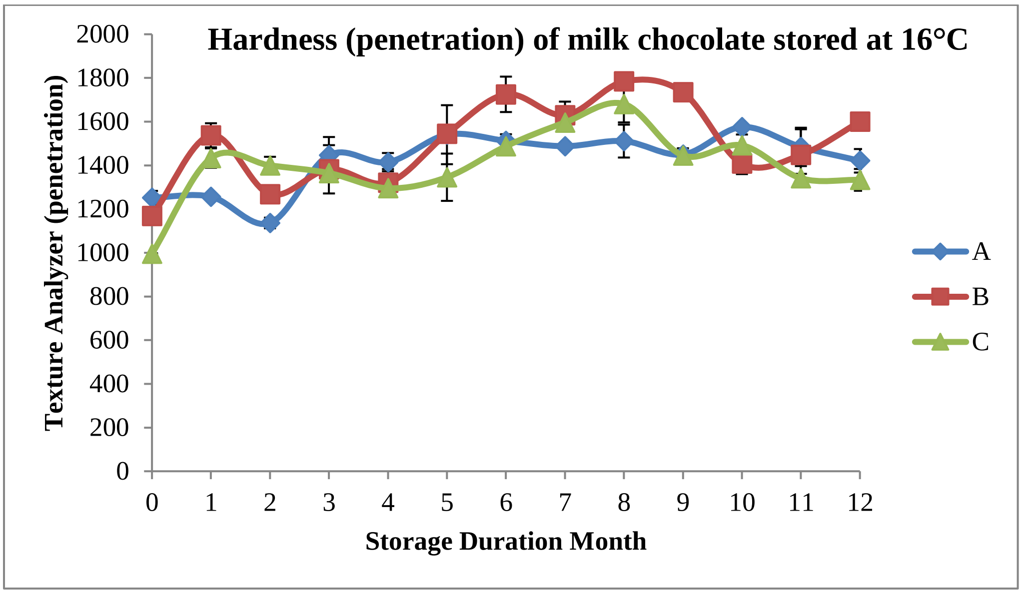

Figure 8: Hardness (penetration) of milk chocolate stored at ±16 °C

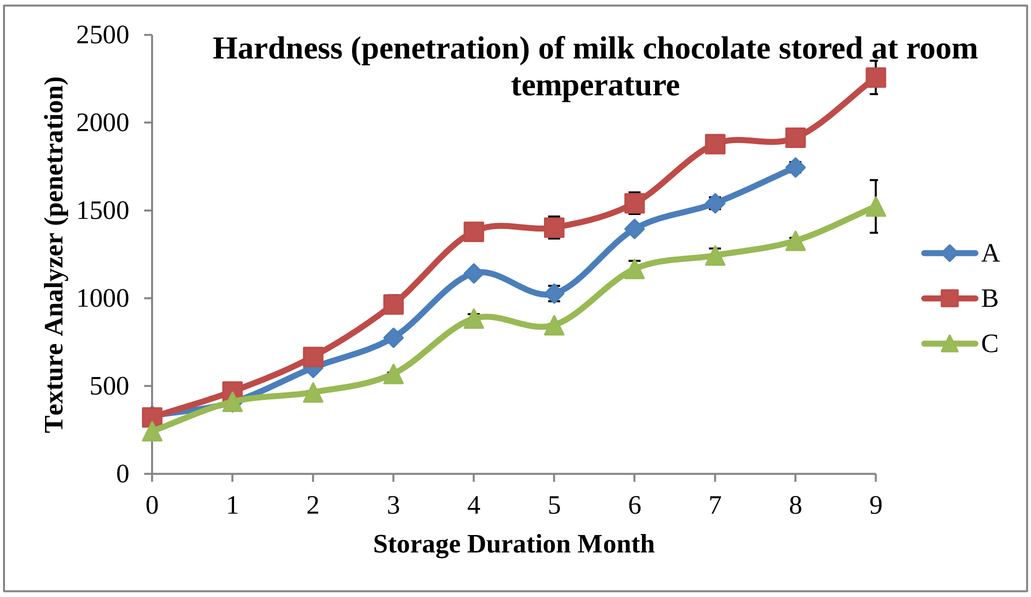

Figure 9: Hardness (penetration) of milk chocolate stored at room temperature

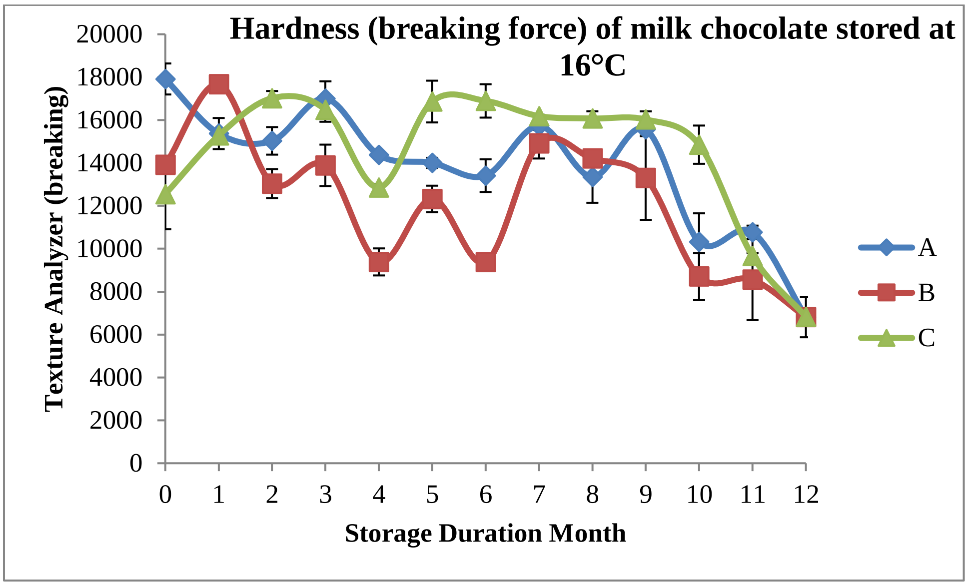

Figure 10: Hardness (breaking force) of milk chocolate stored at ±16 ºC

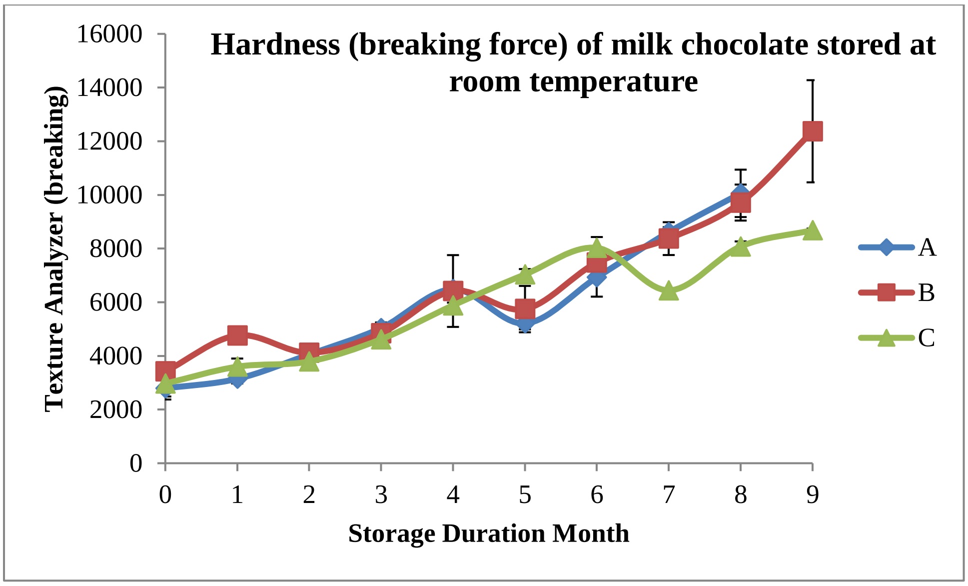

Figure 11: Hardness (breaking force) of milk chocolate stored at ±16 ºC

Result for surface glossiness of chocolate stored at room temperature and at ±16°C are shown in Figure 12 and Figure 13 respectively. The glossiness measurements were taken at 85°angle. Results showed that the glossiness of chocolates stored at room temperature and chillers' decreases with time until end of storage. Glossiness of chocolates stored at both places drop tremendously from beginning at month 0 to 3rd months (stored at ±16ºC) and to 5th month (stored at room temperature) and then remain almost constant. Glossiness of all chocolates drop over time when stored at room temperature and chillers.

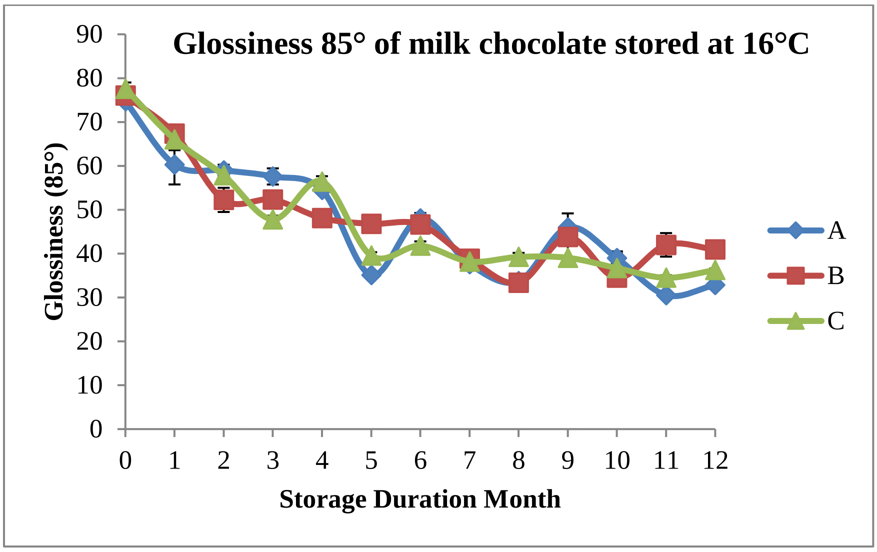

Figure 12: Glossiness of less calorie milk chocolates upon storage.

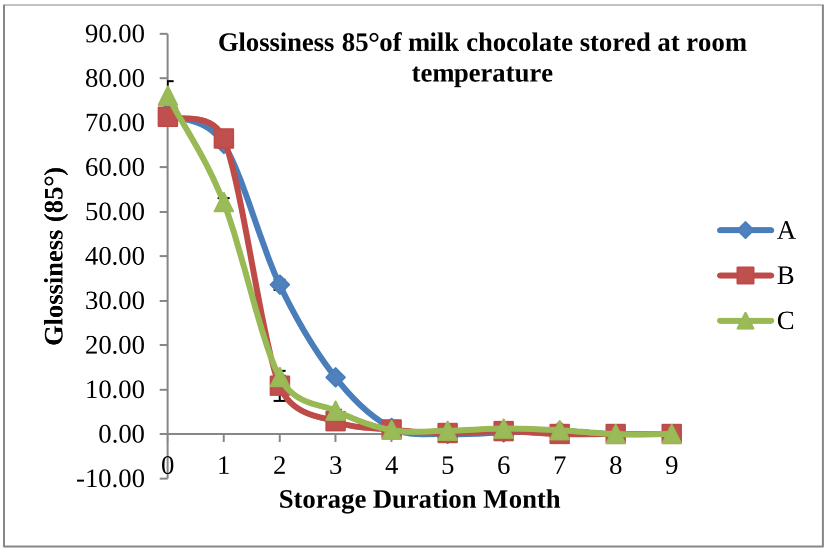

Figure 13: Glossiness of less calorie milk chocolates upon storage.

Figure 14 to 20 show sensory evaluations carried out using trained panellist on reduced calorie chocolate stored at temperature of ±16ºC. Sensory attribute that used were glossiness, odour, texture, smoothness, meting time, melting characteristics score, and overall acceptance. The results indicated that all samples were in good condition for a period of one month upon storing in chillers. Evaluation using sensory panels compared to using instrument shows slight drop in glossiness in month 0 to month 5 (Figure 12). Whereas hardness (penetration) increases from month 0 to month 6 (Figure 8). Measurement using instrument is considering fast and more accurate. Observing using naked eye in sensory evaluation can used to support data collected using instruments, however it is important that both evaluation should be used to calculate shelf life of product developed.

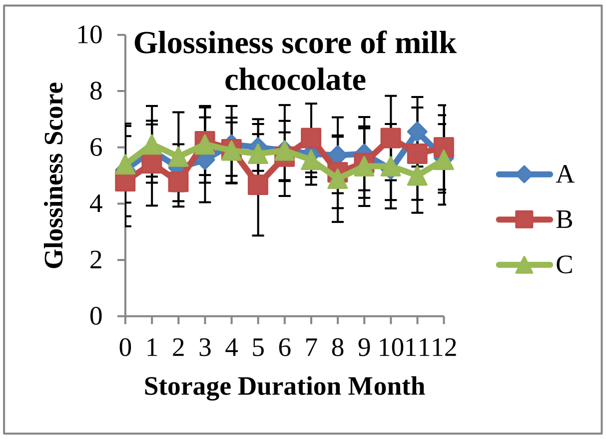

Figure14: Glossiness score of milk chocolate

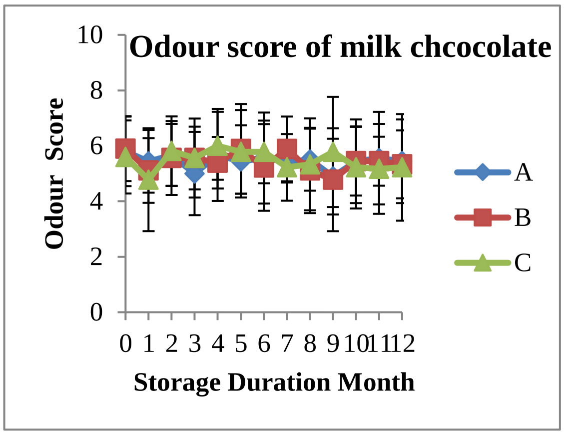

Figure15: Odour score of milk chocolate

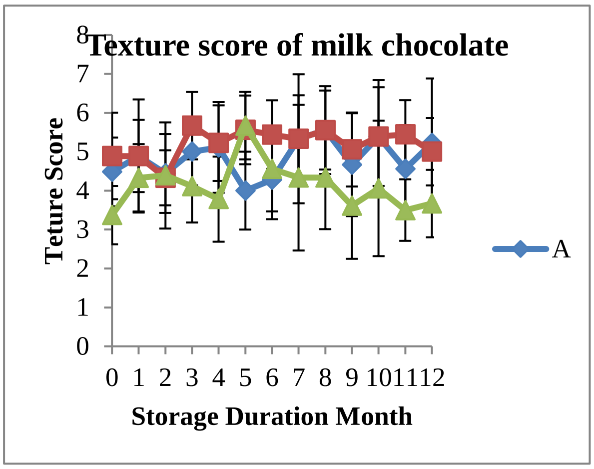

Figure 16: Texture score of milk chocolate.

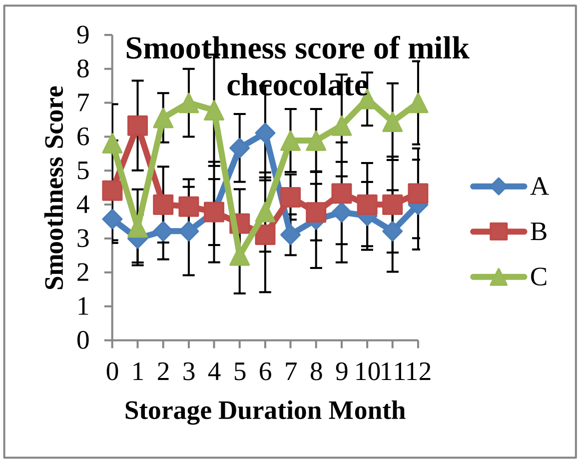

Figure 17: Smoothness score of milk chocolate

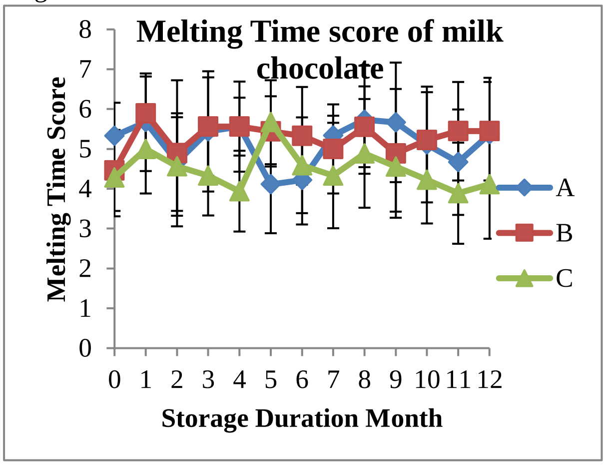

Figure18: Melting time score milk chocolates.

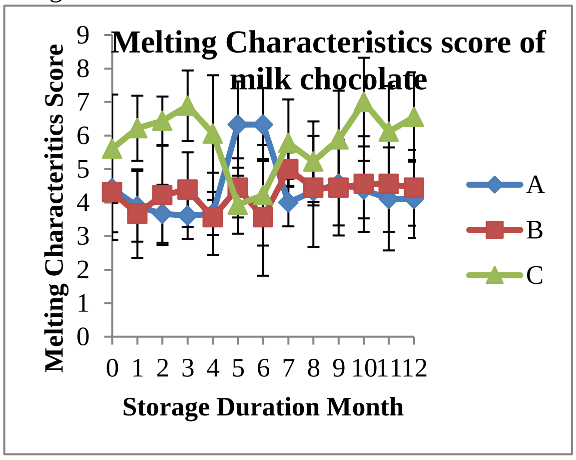

Figure19: Melting characteristic for less calorie milk chocolates.

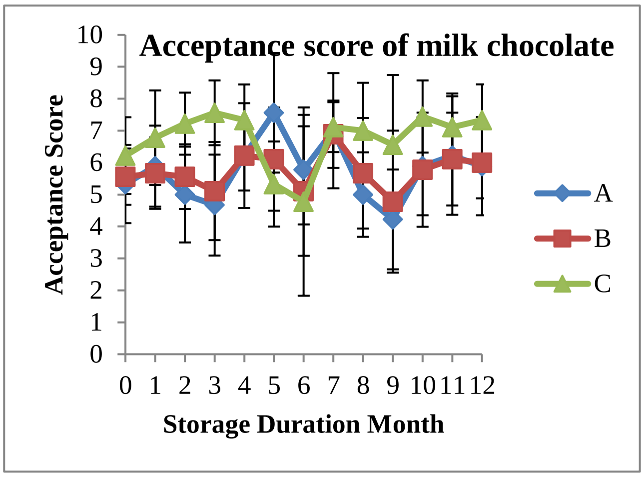

Figure 20: Acceptance score for less calorie milk chocolates.

CONCLUSIONS

Application of cocoa butter emulsion was found to be one of the most effective methods in reducing calorie of milk chocolate. Addition of CBE has limitation; therefore, formulation has to be revised and tailored with method of conching and adding ingredients. In this experiment, incorporating CBE with some modification of ingredients into chocolate formulation can reduce calorie content of the product by 27 to 29%. The properties of the chocolates remain almost similar to original milk chocolate and the acceptability score is not significantly different compared with control chocolate. Both samples were accepted by consumers regardless of the amount of CBE addition. Quality deterioration upon storage in normal room temperature condition is faster than samples chocolates stored in chiller at temperature ±16°C. Quality assessment using instrument and sensory evaluation can both be used in product development and determining the shelf life. Minimum temperature for storing chocolates is about ± 16ºC; if higher then this it could have shorter shelf life. At room temperature the moisture content tends to increased more than 2.0%, this could incur mold development and insect's infestation for chocolate contained fruits and nuts. Storing chocolate in improper and unsuitable temperature and relative humidity can shorten shelf life.

Currently, reduced calorie chocolate produced by this method is not commercially available in Malaysia; therefore, this product has potential for commercialization. For further development, production of reduced calorie milk chocolate can be tested in pilot plant scale.

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