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Improving heat stability along with quality of compound dark chocolate by adding optimized cocoa butter substitute (hydrogenated palm kernel stearin) emulsion

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ABSTRACT

Conventionally manufactured chocolates demonstrate the poor melting resistance during storage and transportation in tropical regions or summer seasons. In the conventional technologies, all heat-resistant chocolates obtained have problems of quality parameters being unsuccessful as commercial products. To resolve this issue, an optimized CBS (cocoa butter substitute) emulsion (CBS: polyglycerol polyricinoleate: water: gum Arabic: invert syrup) was developed and mixed at different concentrations in the molten chocolate mass of standard recipe. Prepared formulations of chocolate mass were evaluated for their molding suitability. Prepared chocolate bars were evaluated for their color, pH, hardness, shape retention index (SRI), moisture, water activity and sensory attributes. Optimized CBS emulsion increased moisture and fat content but reduced aw of dark compound chocolate bars. Addition of CBS emulsion up to level of 60 mL/L led to decrease viscosity of molten chocolate mass and surface whiteness of chocolate bars; and improve sensory attributes. However, at level of 80 mL/L CBS emulsion maximum hardness was observed at higher temperature (36 °C and 40 °C) but fat bloom was appeared due to temperature fluctuation and scores of sensory attributes were decreased. Consequently, optimum dosage of CBS emulsion was 60 mL/L in order to produce good quality heat resistant compound dark chocolate bars.

1. Introduction

Chocolate is a nutritious premium snack food with good digestibility and quick metabolism. Sensory attributes comprise a snap (brittleness) when the chocolate is broken; a shiny gloss on the surface and smoothness that becomes obvious only when the chocolate liquefies in the oral saliva (Figoni, 2007). It usually melts down at 33.8 °C due to liquefaction of solid cocoa butter. Conventional chocolate becomes semi-liquid or even runny at higher temperatures often faced in tropical countries or summer seasons. It inclines to stick to the wrapper and fall apart with the removal of wrapper (Steinburg, Bearden and Keen 2003).

Three main approaches to develop heat resistant chocolate have been recognized: addition of an oil binding polymer, network microstructure enhancement, and the use of fats having high-melting point or increase in melting point of the fat phase (Stortz & Marangoni, 2011). However, addition of oil binding polymers increased the viscosity of the subsequent chocolate mass made it hard to mold and pump. Addition of polyols and gelled water for network microstructure enhancement requires hardening time that would be a costly practice. The utilization of enzymes is exclusively overpriced in any case. Use of fats and emulsifiers having high-melting point provides waxy mouth feel (Stortz, 2014).

For sugar network structuring in chocolate, when water is added directly to melt chocolate, it leads to a drastic increase in viscosity of chocolate mass, microbiological instability and reduction in snap ability of chocolate bars (Norton, Fryer, Parkinson and Cox, 2009). The water must be in small amounts and in a stable enough form to allow complete mixing before reaction with the sugar particles. This would allow for the development of an even sugar skeleton. Likewise, water-in-oil emulsions have been shown to be a good form of controlled water addition to chocolate (Killian, 2011).

Compound chocolate is a “cocoa product containing low-cost solid vegetable fats as an alternative of cocoa butter”. It can

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deliver cocoa flavour at a greatly reduced cost and it does not need to be tempered (Raoufi, Tehrani, Farhoosh, & Golmohammadzadeh, 2012). Palm kernel stearin based CBS is appropriate for the production of solid or hollow-moulded items with excellent mould discharge, great snap, sharp melting attributes, resistance to fat bloom and good flavour release (Rector, 2000).

In the conventional technologies, all heat-resistant chocolates obtained have problems of quality being unsuccessful as practical products. Therefore, present study has been planned to develop compound dark chocolate bars with improved melting resistance and quality parameters by adding optimized CBS (hydrogenated palm kernel stearin) emulsion (w/o) containing CBS, PGPR, water, gum Arabic and golden syrup. These components of CBS emulsion are selected for their typical characteristics to avoid quality problems observed in previously made heat-resistant chocolates using emulsions.

Invert sugar, microbiologically stable syrup, can be mixed with sucrose to produce products that not only have low water activity but that also will not crystallise. PGPR is an emulsifier that is used to reduce the viscosity of molten chocolate. Addition of PGPR increases the continuous phase portion and links left over water present in chocolate leading to make it unavailable for hydration and swelling of solid units (Rector, 2000). Kanouni, Rosano and Naouli (2002) found that polymeric emulsifiers (e.g. PGPR) created stable W/O emulsions. Two important functions of gum Arabic in a range of products are: to inhibit sugar crystallization and to emulsify fat to keep it uniformly dispersed all through the product (Kenyon, 1995).

2. Materials and methods

Procurement of raw materials and testing of product: Cocoa powder (CP) was purchased from BT & KLK, Malaysia. Skim milk powder (Dairy America $_{TM}$) was purchased from FRESNO, CA 93711-USA. CBS (Cargill® Super Socolate Special™) and soy lecithin was purchased from Cargill Palm Products SDN, BHD. PGPR emulsifier was purchased from Far eastern impex (Pvt) Ltd. Golden syrup purchased from Innovative Productions, Industrial estate Multan, Pakistan. Sugar was purchased from MSM (Pvt) Ltd, Pakistan. All reagents were procured from Merck (Merck KG$_a$A, Darmstadt, Germany) and Sigma-Aldrich (Sigma Aldrich, Tokyo, Japan). Product testing was performed at National Institute of Food Science and Technology, Faculty of Food, Nutrition and Home Sciences, University of Agriculture and Ayyub agricultural research institute, Faisalabad.

Production of optimized CBS emulsion: Different trials were conducted to discover the optimum composition of CBS emulsion. Flow behaviour of chocolate mass and heat stability of chocolate bars improved by adding the optimized CBS emulsion. Heat stability of chocolate bars has shown an inverse relationship with concentration of CBS and PGPR in CBS emulsion. However, flow behaviour of chocolate mass has direct relationship with concentration of CBS and PGPR in CBS emulsion. Optimized CBS emulsion was prepared using CBS (544 mL/L), PGPR (96 mL/L), golden syrup (180 mL/L) and gum Arabic solution (180 mL/L) following the method described by Zhang (2011) with some modifications. Gum Arabic (GA) is highly water soluble polymer that gives relatively low viscosity as compared to other gums (Anderson, Brown Douglas, Morrison and Weiping, 1990). Therefore, gum Arabic (GA) powder was easily dissolved at higher concentration of 200 g/L in water at room temperature. Then GA solution and golden syrup were mixed well together to create an aqueous phase. PGPR and CBS were mixed at 50 °C for 30 min using a stirring rod for the production of continuous phase. Then CBS emulsion was produced by adding 360 mL/L aqueous phase at constant speed in 640 ml/L continuous phase with continuous but gentle stirring. Mixing of both phases was carried out at 50 °C.

Assessment of emulsion stability: Emulsion phase separation was visually noticed as described by Bouyer, Ghozlene, Nicolas, Veronique and Florence (2013). Prepared emulsion was stored at room temperature in dark for 24 h. Next day of emulsion preparation, phase separation was visually noticed after maintaining its temperature at 50 °C in water bath.

Slip melting point of CBS (Capillary tube method): Slip melting point of CBS was determined through capillary tube method following the method of AOCS (2001).

Preparation of chocolate formulations: CP (110 g/kg), SMP (138 g/kg), icing sugar (460 g/kg) and 260 g/kg CBS were mixed in conch at 50–60 °C for 16–18 h. Lecithin (2 g/kg) and remaining CBS (30 g/kg) were mixed at final stage of conching. CBS is a lauric fat that produces stable crystals in compound chocolate on fast cooling without tempering. Then CBS emulsion at level of 20, 40, 60 and 80 ml/L was mixed with prepared chocolate mass. The chocolate without CBS emulsion was used as control. All formulations of dark compound chocolate mass were moulded into bars through pouring at 50 °C into moulds of desired dimension (60 × 32 × 6 mm), cooled at 7 °C in freezer for proper de-moulding of solidified bars, packed in polythene bags through heat sealing and then stored at room temperature (28 °C).

Moulding suitability of prepared formulations: Moulding suitability was judged visually during stirring and pouring at 50 °C. Viscosity of the all treatments was also determined in triplicate at 50 °C using Brookfield DV-1 viscometer coupled with spindle # 4 at 20 rpm following the method described by Aryanaa and McGrewa (2007) with some modifications. Each sample was heated at 50 °C for 1 h prior to analysis. The constant reading of viscosity was taken in Pa. s after 15 s of initial reading.

2.1. Physico-chemical analysis of chocolate bars

All physico-chemical tests were performed in triplicate and mean values of their results were calculated. Calculations of fat content (mL/L) in chocolate formulations were made by using specific gravity of CBS (0.925) and chocolate mass (1.250).

pH: The pH of the compound dark chocolate was measured by a digital pH meter (Arwa, AD 111 CE, Hungary) following the method described in AOAC (2005). First of all, pH meter was calibrated with buffers at pH 7.01 and pH 4.01. Then 10 g chocolate was dissolved in 90 ml of boiling water using the stirrer. Then filtered using filter paper and cooled the filtrate to 25 °C. Then electrode was dipped immediately to determine the pH. After few seconds stable and constant reading of pH was showed on display of pH meter.

Color: The colour measurement of formulated chocolate bars (60 × 32 × 6 mm) was determined by using ColorTec-PCM™ spectrophotometer (Accuracy Microsensors, Inc. Pittsford, New York, USA) in accordance with the method of Raoufi et al. (2012). The bars of dark compound chocolate were placed on the top side of spectrophotometer confronting the light beam. The colour was expressed in terms of L*, a* and b*. To express the colour of a food product, most often the CIEL*a*b-system is used. This system uses three spatial coordinates a* (+a* red -a* green), b* (+b* yellow −b* blue) and lightness L* (0 black–100 white).

Hardness Analysis: Hardness analysis was performed according to Piga et al. (2005) with some modifications by using texture Analyser (TA-XT Plus, Stable Microsystems, Surrey, UK) interfaced with a computer after keeping compound dark chocolate bars at 28, 32, 36, and 40 °C for 1 h in an oven (IFE 550, Memmert, Germany). The hardness of the chocolate was assessed by using 2 mm Needle Probe (P/2N) attached to 5 kg load cell moving at pre-test speed of 1.5 mm/s, test speed of 2.0 mm/s and post-test speed of 10.0 mm/s.