LWT - Food Science and Technology 87 (2018) 177–185

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Developing functional white chocolate by incorporating different forms of EPA and DHA - Effects on product quality

Omer Said Toker [a], Nevzat Konar [b, *], Haniyeh Rasouli Pirouzian [c], Sirin Oba [d], Derya Genc Polat [e], İbrahim Palabiyik [f], Ender Sinan Poyrazoglu [b], Osman Sagdic [a]

[a] Yildiz Technical University, Chemical and Metallurgical Engineering Faculty, Food Engineering Department, İstanbul, Turkey
[b] Siirt University Faculty of Architecture and Engineering, Department of Food Engineering 56100, Siirt, Turkey
[c] Department of Food Science, College of Agriculture, University of Tabriz, Tabriz, Iran
[d] Amasya University, Suluova Vocational School, Department of Food Processing, Amasya, Turkey
[e] Tayas Food, R&D Department, Gebze, Kocaeli, Turkey
[f] Namik Kemal University, Agricultural Faculty, Food Engineering Department, 59030, Tekirdağ, Turkey

ARTICLE INFO

Article history:
Received 21 April 2017
Received in revised form
22 August 2017
Accepted 24 August 2017
Available online 1 September 2017

Keywords:
White chocolate
Omega-3
Microalgae
Casson model
Hardness

ABSTRACT

In the present study, white chocolate was enriched with different forms (encapsulated form, microalgae containing form) of Eicosa-Pentaenoic-Acid (EPA) and Docosa-Hexaenoic-Acid (DHA). EPA/DHA sources were added after conching process. Main EPA/DHA percentage of the sources changed between 5.80-38.7 and 8.50–70.5 g/100 g, respectively in total fatty acid content. EPA and DHA contents of the chocolate samples increased to 226.8 and 54.3 mg/25 g chocolate, respectively, in a consequence of enrichment. Water activity (0.290–0.340), hardness (5.31–7.97 N), yield stress (2.09–3.87 Pa), plastic viscosity (1.06 –1.62 Pa s), T_{end} (31.4–33.6 °C), energy required for complete melting (ΔH) (9.53–11.3 J/g) properties of the samples were affected significantly ($P < 0.05$), however these effects were tolerable and in narrow ranges. The use of EPA/DHA in different forms and origins affected the colour saturation, after taste and overall acceptance of the samples ($P < 0.05$). The findings of this study showed that it is possible to produce white chocolate fortified with EPA/DHA from microalgae origin and in free flowing powder form with desired quality. According to the results, it can be concluded that white chocolate can be used as a carrier of bioactive substances which are heat sensitive.

1. Introduction

Primary chocolate categories are known as dark, milk, and white which mainly differ in the content of cocoa solid, milk fat and cocoa butter present in the formulation (Afaokwa, 2010, p. 275). Main ingredients of white chocolate are sugar, milk solids and cocoa butter (Rousseau, 2007). Chocolate products are manufactured by application of different processes which are pre-mixing, refining, conching, tempering and moulding. The quality of all chocolate products depends on the amount and type of the ingredients and production procedures applied. Melting, textural, colour and sensory characteristics of the chocolate products are main criterion determining consumer acceptability of the products. Chocolate products with desired quality characteristics are widely consumed by people of all ages worldwide. After being understood of the relation between health and diet, the physicochemical and sensory characteristics of the chocolates are not accepted as only determinant in terms of consumption of the products.

Driving force determining consumer acceptability of food products have changed especially in the last 20 years. Healthful characteristics of foods play an important role in purchasing behaviour as well as sensory and physicochemical properties and cost. The presence of functional compounds in the product have at least positive impact on purchasing decisions (Harwood, 2013, p. 123; Konar, Toker, Oba, & Sagdic, 2016) since people are clearly aware of the direct relevance between health and diet.

In the development of products including bioactive compounds, selection of "carrier" foodstuffs with widespread consumption may be advantageous for reaching larger consumer groups. Chocolate and chocolate-derived foodstuffs are potentially such bioactive ingredient carriers, although these foodstuffs have a negative

* Corresponding author. Present address: Siirt University, Department of Food Engineering, 56100, Siirt, Turkey.
E-mail address: nevzatkonar@hotmail.com (N. Konar).

http://dx.doi.org/10.1016/j.lwt.2017.08.087
0023-6438/

perception due to proportions of fat and sugar in their composition.

Functional food development studies associated with white chocolate are very limited, which is important since functionality of white chocolate is low compared to the other types since cacao is not present in the white chocolate. Maillard and Landuyt (2008) produced probiotic milk, dark and white chocolate by incorporating *Lactobacillus helveticus* and *Bifodibacterium longum* encapsulated with fatty acids using spray drying. In another study, potential of functional food and hypercholesteraemic properties of white chocolate including ergosterol-enriched extracts obtained from *Agaricus bisporus* were studied by Gil-Ramirez, Ruiz-Rodriguez, Marin, Reglero, and Soler-Rivas (2014).

Various bioactive compounds can be used in the development of functional foods. Soluble and insoluble fibers, prebiotics, vitamins and minerals, herbal extracts and other phytochemicals are the main ingredients which can be used as substitutes or enrichment agents (Konar et al., 2016) for chocolate. Essential fatty acids may also be among these bioactive components. Most of the bioactive compounds, e.g. fatty acids, carotenoids, tocopherols, polyphenols, phytosterols, oil soluble vitamins have hydrophobic nature (Marsanasco, Marquez, Wagner, Chiaramoni, & Alonsi, 2015). Omega-3 fatty acids, an important member of bioactive compounds, belong to the family of polyunsaturated fatty acids (PUFAs) (Kaushik, Dowling, Barrow, & Adhiraki, 2015). Omega-3 fatty acid is an essential nutrient because the body cannot synthesize them (Johannessen, Skagestad, & Bergkaasa, 2011). The relationship between omega-3 fatty acids and health outcomes has been the topic of numerous population-based studies (Hanson et al., 2016; Huang, 2010; Vannice & Rasmussen, 2014). EPA and DHA proved to be beneficial in the prevention and treatment of certain medical conditions including coronary heart disease, blood platelet aggregation, abnormal cholesterol levels and several carcinomas (Fogliano et al., 2010). Recommendations of EPA + DHA intake from national and international authorities range, e.g. WHO 200–1000 mg/day, American Heart Association (AHA) 430 mg/day, The Food Standards Agency of the UK 450 mg/day, The French Authority 500 mg/day, The Netherlands 450 mg/day, The European Food Safety Agency (EFSA) 259 mg/day (Lopez-Huertas, 2010), ISSFAL (International Society for the Study of Fatty Acids and Lipids) more than 250 mg/day (Molinari et al., 2014).

The aim of this study was to determine the effects of omega-3 fatty acids addition in different forms; powder, microencapsulated powder, oil and triglyceride form from different origins (microalgae and fish) on the quality characteristics of white chocolates such as physical, physico-chemical, thermo-gravimetric, rheological, textural and sensory properties.

2. Materials and methods

2.1. Materials

For the preparation of functional white chocolate samples containing EPA and DHA, cocoa butter (Altinmarka, İstanbul Turkey), sugar (SMS Kopuz, Istanbul, Turkey), whole and skimmed milk powder (Besel, Konya, Turkey), soy lecithin (Brenntag Chemistry, Istanbul, Turkey), polyglycerol polyricinalate (PGPR) (Palsgaard, Zierikzee, Netherland) and the EPA/DHA sources, as the following;

Life'sDHA®S17-P100 (MAP): Free-flowing powder derived from microalgae containing 170 mg/g DHA.

Life'sDHA®S35-O300 (MAO): Nutritional oil derived from algae containing min. 350 mg/g DHA,

MEG-3®30% H Powder (TGM): Microencapsulated powder based on fish gelatin, minimum 54 mg EPA, 35 mg DHA (Min 150 mg – Max 220 mg EPA + DHA) and 180 mg total Omega-3 per g MEG-3® 30% 8a.

Food Oil (TGO): Triglycerides, minimum 250 mg – maximum 320 mg EPA + DHA, minimum 300 mg total Omega-3 per g (DSM Nutritional Products, Istanbul, Turkey).

Were used in the present study (DSM Nutritional Lipids, 2017).

2.2. Sample preparation

The formulation was adjusted considering EFSA advice which suggests 250 mg EPA and DHA consumption per a day. Depending of the serving size of the chocolate as 25 g/day, the required amount of EPA/DHA sources was calculated. For achieving the required level, MAP, MAO, TGO and TGM were added to the chocolate samples 5.97, 2.88, 4.04 and 6.78 g/100 g chocolate product, respectively (Table 1). Production flow chart of the white chocolate sample is presented in Fig. 1.

Each sample group was prepared in lots of 10 kg batch. For this purpose, the melted fat components (comprising 20% of the total cocoa butter) and the dry powders (sugar, whole and skimmed milk powders) were mixed until homogeneous mixture formed while being heated to 40 °C. At the end of the mixing and warming, the chocolate mass was first pre-refined on a pilot-scale 3-roll refiner (Lehmann, Aaelen, Germany) and then mixed again and warmed to 50 °C. To achieve a mean particle size of 20–25 μm, the gap size/pressure between the rollers of the 3-roll refiner was adjusted and particle size distribution values were measured as described in Section 2.5. After measuring the particle size, dry conching BSA Schneider Anlagentechnik, Aachen, Germany) was performed for 45 min, and the remaining cocoa butter (80% of the total), soy lecithin and PGPR were added. The total conching time was 360 min at 60 °C.

After conching, EPA and DHA sources were added to chocolate mass at 32–33 °C. Then the mass was mixed nearly 5 min. Afterwards, a three-stage tempering process (33–35, 24–25 and 25–26 °C) was implemented by using pilot-scale tempering equipment (Aasted, Farum, Denmark). Temper index was in the range of 5.50–6.00 which was measured by a temper meter (Chocometer, Aasted Farum, Denmark). Subsequently, the moulding and vibration process were conducted at 27–30 °C. After 20 min of cooling at 5 °C, the process was completed. Samples were stored at temperatures between 13 and 15 °C and kept away from light and heat prior to analysis.

2.3. Determination of fatty acid contents

The GC-MS technique was used to identify fatty acid distribution of chocolate samples (Morato et al., 2015) using GC-MS-QP2010 SE (Shimadzu, Columbia, USA) equipped with mass selective detector and Rtx-5MS GC column (30 m, 0.25 μm film thickness 0.25 μm). Injection temperature was 250 °C. Column temperature was increased from 90 to 270 °C at 4 °C/min heating rate and hold at 270 °C for 4 min. Carrier gas was Helium and flow rate and injection volume was 1 mL/s and 1 μL, respectively. Split rate and pressure was set to 50:1 and 69.1 kPa, respectively. Standard mixtures of Supelco 37- C4-C24 (Bellefonte, PA, USA) and fatty acid methyl esters (FAME) were used for quantifying the fatty acid composition. Calibration curves were created by preparing a set of standard solutions with known concentration (125 μg/mL, 250 μg/mL, 500 μg/mL and 1500 μg/mL) of the analyte (FAME).

2.4. Colour

Colour parameters of chocolate samples were determined using colorimeter (Chroma Meter CR-400, Konica Minolta, Tokyo, Japan). Chroma (C^*), hue (h^*), whitness index (WI*) values were calculated