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Physicochemical, functional and sensory properties of mellorine enriched with different vegetable juices and TOPSIS approach to determine optimum juice concentration

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ABSTRACT

In this study different concentrations (2.5%, 5%, 10%) of beetroot, red cabbage and broccoli juices were added to mellorine to increase its bio-functional properties. Some physicochemical (brix, pH) and bio-functional properties (total phenolic and flavanoid content and DPPH activity) of the juices were determined and total phenolic content of broccoli, beetroot, and red cabbage juices were found to be 419.8, 570.6 and 1131.9 mg/L, respectively. The rheological, physicochemical properties of mellorine mixes and functional and sensory properties of mellorine enrinched with vegetable juices in different concentrations were investigated. All mixes showed shear thinning behavior. The apparent viscosity and consistency index values (K) decreased with increase in vegetable juice concentration. Total phenolic, total flavonoid and DPPH radical scavenging activity increased with increasing all vegetable juice concentration added to the formulation. Regarding sensory properties, among the samples containing vegetable juice, broccoli juice containing sample in concentration of 5% had the highest scores considering colour and appearance, body and consistency and taste and colour properties. TOPSIS (Technique for order preference by similarity to ideal solution) was performed to determine optimum vegetable juice type and concentration regarding bio-functional and sensory properties. According to TOPSIS, the mellorine including 10% red cabbage juice was found as the best sample when considering determined conditions.

1. Introduction

Mellorine, mainly composed of milk, vegetable oil, sugar, emulsifier and stabiliser, is one of the ice cream products or frozen desserts (Clarke, 2004) and it has a complex structure similar to the dairy ice cream (Goff, 2002). Unlike dairy ice cream, in mellorine formulation, all or some proportion of dairy fat is substituted with vegetable based oils (Clarke, 2004; Keeney, 2012). Using vegetable oils in the production of mellorine does not negatively influence sensory profiles of mellorine, even they contribute to a positive effect on human nutrition since they contain remarkable amount of

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unsaturated fatty acids (Anonymous, 2013; Hyvönen, Linna, Tuorila, & Dijksterhuis, 2003; Nadeem, Abdullah, & Ellahi, 2010). Mellorine is consumed by people of all age throughout worldwide as an alternative product to ice cream (Karasu, Doğan, Toker,& Doğan, 2014); therefore, increasing functionality of the product is important for human health since mellorine is poor in terms of natural phytochemicals such as phenolics (O'Connell & Fox, 2001). Bio-functional properties of mellorine or dairy ice cream can be improved by adding biologically active compounds or substances containing these compounds to ice cream formulation. For this reason, in recent years, a variety of researches has been conducted to fortify ice cream formulation with phenolic compounds by adding some fruits (Karaman et al., 2014; Sun-Waterhouse, Edmonds, Wadhwa, & Wibisono, 2011), fruit pulp (El–Samahy, Youssef, & Moussa–Ayoub, 2009), herbal tea (Karaman & Kayacier, 2012) and some phenolics (Sagdic, Ozturk, Cankurt, & Tornuk, 2012) to ice cream mix in different concentrations.

Fruits and vegetables are rich in phenolic compounds which contribute to colour and taste of the product (Blasa, Gennari, Angelino, & Ninfali, 2010). Furthermore, plants contain a variety of antioxidants such as phenolics and flavonoids, which have a protective effect against some diseases, for instance cardiovascular diseases and some types of cancer caused by free radicals, especially reactive oxygen species (Fraga, 2010; Keller, 2009). Broccoli and red cabbage are among *Cruciferous* vegetables, which have attracted much interest in recent years due to a number of compounds with high antioxidant activities, such as phenolics, predominantly kaempferol and hydroxycinnamic acids derivates, and cyanidin derivates, respectively (Chun, Smith, Sakagawa, & Lee, 2004; Heimler, Vignolini, Dini, Vincieri, & Romani, 2006; Wu and Prior, 2005). They are also a good source of glucosinolates, known as sulphur-containing substances which have cancer-protective properties. The sulphur-containing substances have been studied to understand their functional specifications in cancer research in vitro and vivo studies (Higdon, Delage, Williams, & Dashwood, 2007; Podsedek, 2007). One of these researches, Boivin et al. (2009), studied the antiproliferative and antioxidant activities of common vegetables, and those vegetables were divided into four groups (little, intermediate, high, and very high) according to their effects on certain types of cancerous tumour cells. According to this classification beetroot, broccoli and red cabbage were classified in high group; therefore usage of these vegetables for improving functionality of the product is beneficial for human health.

Increasing the bio-functional properties of the product alone is not sufficient for the acceptability of the product (Gurmeric, Dogan, Toker, Senyigit, & Ersoz, 2013). Therefore, sensorial analysis was performed to determine consumer's acceptance or rejection of a new product. Although sensory analysis is useful for determination of the formulation of the product, it is very difficult to interpret the results since as one sample might be preferred regarding one sensory property (such as taste), the other sample might be preferred considering the other sensory property (such as odor). Obtaining one score from different sensory properties, which might be carried out by multi-criteria decision techniques, is facilitative for interpretation or decision. Multi-criteria decision techniques can deal with decision problems considering a number of decision criteria simultaneously (Pohekar & Ramachandran, 2004). They can be used for the evaluation of alternatives based on the determined criteria by using a number of qualitative and/or quantitative criteria (Ozcan, Celebi, & Esnaf, 2011). One of the multi-criteria decision techniques is the TOPSIS (technique for order preference by similarity to ideal solution) which provides a decision hierarchy and requires pairwise comparison between criteria (Balli & Korukoglu, 2009). According to the TOPSIS method, the best alternative is nearest to the positive ideal solution and farthest from the negative ideal solution (Benitez, Martin, & Roman, 2007; Lin, Wang, Chen, & Chang, 2008). Although there have been many studies about the application of multi-criteria decision making techniques in different areas, we have found only two studies, one of them is related to application of different multi-criteria decision techniques on sensory properties of the prebiotic pudding sample (Gurmeric et al., 2013) and the other one is about combination of sensory properties and bioactive properties of persimmon enriched ice cream with TOPSIS method (Karaman et al., 2014), about this subject in the food bioscience field.

The aim of this study was to determine how different vegetable juices at different concentrations affect the bio-functional, rheological and some physicochemical properties of mellorine mix, and to determine the optimum concentration by the TOPSIS technique considering bioactive and sensorial features.

2. Material and methods

2.1. Material

Skimmed milk powder, vegetable oil (sunflower oil), sugar, potable water, broccoli, red cabbage and red beetroot were purchased from a local market in Kayseri, emulsifier (mono- and di-glyceride) was obtained from Safiye Cikrikcioglu Vocational College, in Erciyes University and xanthan gum was obtained from Sigma. Methanol, sodium carbonate, Folin-Ciocalteau reagent, sodium nitrite, aluminium chloride and sodium hydroxide were obtained from Merck Co. and DPPH was obtained from Sigma Co.

2.2. Preparation of mellorine

Broccoli, red cabbage and red beetroot were washed and then pressed to prepare their juices after they were cut small parts. Vegetable juices pasteurised at 90 °C for 1 min with magnetic stirrer prior adding to mellorine mix. The mellorine mix (basic mix) was prepared according to method described by Karaman and Kayacier (2012) with some modifications. The mix formulations contained 14% sugar, 11% skimmed milk powder, 7% vegetable oil, 0.3% emulsifier and 0.2% xanthan gum. Ingredients were added to the drinking water in the following order: vegetable oil at 30 °C, skimmed milk powder at 40 °C, sugar at 50 °C, dry mixture (remained sugar+ emülsifier+xanthan gum) at 70 °C. The mixture obtained was heated to 85 °C and held for 30 s at this temperature for pasteurisation. The pasteurised mix was cooled to 4 °C and then aged for 22 h at 4 °C. Pasteurised vegetable juices