DEVELOPMENT AND PHYSICOCHEMICAL EVALUATION OF FRUIT-FLAVORED FREEZER POPS BASED ON WHEY PROTEIN ISOLATE

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Abstract

In this study, four formulations of fruit-flavored freezer pop (FPk, FPma, FPme, and FPo) were prepared using whey protein isolate, water, sugar, and different fruits (kiwi, mango, melon, and orange). Whey protein isolate was purchased from Redis CO SRL (Bucharest, Romania). Kiwi, mango, melon, orange, and sugar were procured from local supermarkets. All the prepared formulations were subjected to a consumer test in order to identify the most preferred one. Formulation with 11% whey protein isolate, 65% water, 11% sugar, and 13% mango (FPma) was selected as preferred by panelists; the addition of mango, significantly ($p < 0.05$) changed the appearance of freezer pops and thus this formulation showed the highest score for overall acceptability (7.3 points). The chosen formulation was further subjected physicochemical analysis to determine its composition and energy value. This assortment contains 10.2 g protein, 0.1 g fat, and 11.4 g carbohydrates per 100 g product that gives an energy value of approximately 87 kcal (364 kJ). Thus, FPma is a low-calorie product (less than 200 kcal/100 g product) characterized by high-protein content, very low-lactose and fat content.

Key words: fruit-flavored freezer pops, whey protein isolate low lactose, physicochemical evaluation, sensory evaluation

Freezer pops (also known as ice pops, popsicles, ice lollies, and paletas) are frozen sweets on a stick whose main ingredient consists of water or dairy products (e.g., milk, cream or its derivatives) and are included in the class of edible ices (Mosquim, 1999; Contreras *et al.*, 2012). Edible ices are food obtained by the freezing process, under continuous of agitation or not, with base mix pasteurized and homogenized or fruit prepared composed of dairy products or not, sugars, dyes, flavoring agents, stabilizers, emulsifiers and other additives (Gajo *et al.*, 2017).

Lately, whey and whey derivatives have gained attention among producers in the food industry due to their nutritional (e.g., high content of essential amino acids), functional (e.g., gelation, foaming, and emulsifying agent), and biological properties (e.g., antimicrobial, anticarcinogenic, and immunomodulatory activities). Whey is the liquid remained after the precipitation of casein and curd removal during cheese manufacture (Ramos *et al.*, 2016). It contains more than half of the solids present in the original whole milk, including whey proteins (20% of the total protein) and most of the lactose, water-soluble vitamins and minerals (Mollea *et al.*, 2013). Whey protein fraction is mainly constituted by beta-lactoglobulin (*β*-Lg), alpha-lactalbumin (α-La), immunoglobulins (IGs), bovine serum albumin (BSA), lactoferrin (LF), and lactoperoxidase (LP) (Ramos *et al.*, 2016). Whey protein isolate (WPI) is obtained by the removal of sufficient non-protein constituents from whey so that the finished dry product contains not less than 90% protein on a dry matter basis. It is produced by membrane filtration processes and/or ion exchange (ADPI).

Even though there is a wide variety of freezer pops on the market, our literature survey revealed that there are few studies published on this topic. Some authors have focused on the determination of chemical composition of water and milk based ice pops produced by a microindustry in Hidalgo, Mexico (Contreras *et al.*, 2012). Other researchers have investigated the physical and sensorial parameters of frozen dessert made with concentrated whey obtained through a nanofiltration process in total replacement of water and an ideal combination of hydrocolloids (Gajo *et al.*, 2017).

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To the best of our knowledge, this would be the first study that investigates the use of whey protein isolate as an ingredient in the manufacturing of freezer pops. The aim of the current study was the development of a frozen dessert rich in protein but with low-lactose and fat content. To this purpose, four formulations of freezer pops were prepared using 11% whey protein isolate, 65% water, 11% sugar, and 13% fruits (kiwi-FPk, mango-FPma, melon-FPme, and orange-FPo). The current study was conducted to determine the formulation preferred by consumers, its chemical composition, and nutritive value.

Table 1

Formulations for the preparation of fruit-flavored freezer pops based on whey protein isolate

Ingredient (%)	FPk	FPma	FPme	FPo
Whey protein isolate low lactose	11	11	11	11
Water	65	65	65	65
Sugar	11	11	11	11
Kiwi	13	-	-	-
Mango	-	13	-	-
Melon	-	-	13	-
Orange	-	-	-	13

Note: FPk - freezer pops with kiwi; FPma - freezer pops with mango; FPme - freezer pops with melon; FPo - freezer pops with orange.

Table 2

Overall acceptability and attribute ratings for fruit-flavored freezer pops

Attribute	FPk	FPma	FPme	FPo	Significance
Appearance	5.8 ± 1.62^{b}	7.5 ± 0.85^{a}	6.9 ± 0.99^{ab}	7.4 ± 1.71^{ab}	*
Color	6.6±1.96	7.7±0.67	7.1±0.88	7.5±1.65	NS
Texture	6.1±1.79	7.0±1.05	6.7±1.16	6.9±2.13	NS
Smell	6.0±1.41	7.2±1.40	6.9±1.52	7.1±1.60	NS
Taste	6.0±2.36	7.1±1.10	7.9±0.88	7.4±1.84	NS
Overall appreciation	6.4±1.58	7.3±0.95	7.3±0.67	7.5±1.65	NS
Consumers acceptance	FPk	FPma	FPme	FPo	Significance
Overall acceptability	6.2±1.62	7.3±0.88	7.2±0.89	7.3±1.71	NS

Note: FPk - freezer pops with kiwi; FPma - freezer pops with mango; FPme - freezer pops with melon; FPo - freezer pops with orange. Values are expressed as mean. Different letters within the same line denote statistically significant differences (Tukey's test, $p < 0.05$) between the freezer pops; Significant differences are denoted by asterisks: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; $p \geq 0.05$, non-significant (NS).

MATERIAL AND METHOD

Materials. Whey protein isolate-Prolacta 95 LL Instant Low Lactose (95% protein, 3% minerals, 0.4% fat, and 1.6% carbohydrates of which 0.2% lactose) was purchased from Redis CO SRL (Bucharest, Romania). Kiwi, mango, melon, orange, and sugar were procured from local supermarkets.

Preparation of fruit-flavored freezer pops. To obtain the four formulations (FPk, FPma, FPme, and FPo) whey protein isolate was reconstituted with warm water (35°C). Then, sugar was added and the composition was blended till its dissolving. The fruits were washed thoroughly with tap water, peeled, cut into pieces, and crushed. The obtained liquid base was pre-frozen and whipped in an ice cream freezer for 30 minutes and then gently mixed with the crushed fruits. The resulted formulations were poured into molds prior to freezing at -18°C for 24 hours. *Table 1* shows the usage level (%) of ingredients in the four formulations. Samples were kept frozen until their analysis.

Method for sensory evaluation. Fruit-flavored freezer pops were served at freezing temperature on white plastic plates to 40 panelists (15 men and 25 women), with a mean age of 24. The appearance, color, texture, smell, taste, and overall appreciation were evaluated using a 9-point hedonic scale (1=dislike extremely, 9=like extremely). Panelists were required to rinse their

mouth with water before and between each sample.

Methods for physicochemical evaluation. The total solids content was determined using the method described in ISO 3728 (2004). Fat content was determined by extraction from total solids using a solvent extractor Velp SER 148/6 (Velp Scientifica, Milano, Italy). Protein content was determined using the method described in ISO 8968-1 (2014). Ash content was determined by incineration of the sample in a muffle furnace (L3/11/B170, Nabertherm GmbH, Bremen, Germany). Total carbohydrates were calculated based on the following formula (1) from the content of moisture, protein, lipid, and ash (Nagy *et al.*, 2017):

(g/100g) Total carbohydrates = 100 - (*g* moisture + *g* protein + *g* lipid + *g* ash) (1)

Energy value was calculated based on the following formula (2) from the content of protein, carbohydrate, and lipid using the energy factors (Nagy *et al.*, 2017):

(kcal/100g) Energy value = 4 x (*g* protein + *g* carbohydrate) + 9 x *g* lipid (2)

Statistical analysis. To perform the statistical tests, Minitab software (version 16.1.0; LEAD Technologies, Inc., Charlotte, NC, USA) was used. The one-way analysis of variance (ANOVA) on the whole set of sample data was assessed. Tukey's honest significance test was carried out at a 95% confidence level ($p < 0.05$).

RESULTS AND DISCUSSIONS

Table 2 lists the hedonic scores for sensory attributes (appearance, color, texture, smell, taste, and overall appreciation), as well as for overall acceptability of fruit-flavored freezer pops based on whey protein isolate. The only statistically significant difference among samples was found to be between the hedonic scores of appearance ($p < 0.05$). The freezer pops with mango (FPma) were the most appreciated by panelists in terms of appearance, followed equally by freezer pops with melon (FPme) and freezer pops with orange (FPo), then by freezer pops with kiwi (FPk). Considering that there were no significant differences between the mean overall acceptability scores of the four formulations, the selection of consumer's preferred sample was done based on appearance. Therefore, the formulation with 11% whey protein isolate, 65% water, 11% sugar, and 13% mango was further analysed to determine its composition and energy value.

The results obtained shows that the product contains 77.9 ± 0.14 g water, 10.2 ± 0.14 g protein, 0.1 ± 0.0 g fat, 11.4 ± 0.28 g carbohydrates, and 0.5 ± 0.0 g minerals per 100 g product that gives an energy value of approximately 87 kcal (364 kJ). One hundred grams of traditional freezer pops contains 19.2 g total carbohydrates from which 13.7 g sugar, 0.2 g fat, and 0.0 g protein (SND). Their energy value, 79 kcal (331 kJ)/100 g product, is mainly due to the carbohydrate content. In comparison to traditional freezer pops, the FPma formulation has approximately a 25% lower carbohydrate content and approximately a 10% higher protein content.

CONCLUSIONS

This work indicates the potential of using whey protein isolate and fruits for the preparation of freezer pops. The formulation obtained in this study, a low-calorie mango-flavored freezer pop (less than 200 kcal/100 g product), is characterized by high-protein content, very low-lactose and fat content. Being a dietetic product but at the same time nutritious due to the contribution of proteins, this frozen dessert is destined for persons with an active lifestyle, with lactose intolerance, or those that follow a diet.

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