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Extended Abstract

A Comparison of Physicochemical and Sensory Characteristics of Ice Cream made from Cow's Milk and Soy Milk with Ice Cream made from their Mix Powder

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Abstract
In this research, in the preparation of ice cream, cow's milk and/or soy milk at a ratio of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50 were substituted. Then, characteristics such as pH, viscosity, overrun, melt resistance and sensory properties were tested. The results indicated that by increasing the cow's milk replacement with soy milk, viscosity and melting resistance significantly increased; however, pH and overrun decreased ($P<0.05$). The taste and overall acceptability were reduced without the use of vanilla flavor, though no significant difference was observed after adding one percent of vanilla to 40% of the replacement level. The ice cream mixes were spray-dried in a pilot plant spray dryer. The powders were reconstituted and converted into ice cream and their physicochemical and sensory properties were measured and compared with primary mixes. The results showed that the pH, viscosity, overrun and melting resistance of the powder samples compared to the primary specimens significantly decreased, although significant changes in sensory features were not observed when using vanilla ($P<0.05$).

Keywords: Ice cream, Sensory properties, Spray drier, Viscosity

Introduction
Ice cream is a complex, multiphase system consisting of ice crystals, air cells and fat globules embedded in a highly viscous, freeze-concentrated matrix (Arbuckle, 1986). Although dairy fats are mostly used in the preparation of ice cream, the replacement of cow's milk with soy milk can increase the nutritional value of the product given that the latter is a rich source of indigestible fibers, unsaturated fats, lecithin, vitamins, minerals, and bioactive organic polyphenols (phenolic acids, isoflavones, tannins, and saponins), (Wangcharoen, 2008). Vega, Kim, Chen, & Roos (2005) were the first to spray dry ice cream mixes using a spray dryer. This study aimed to compare the ice cream made from cow's milk or soy milk with that prepared from their mix powders in order to understand both the effect of substituting soy milk with cow's milk as well as the impact of spray-drying on the product's physicochemical and sensory characteristics.

Materials and methods

The ice cream mixes were formulated to contain 10% milk fat, 14% sugar, 11% milk solid nonfat (MSNF), 0.2% carboxy methylcellulose (CMC) and 2.0% lecithin. First, lecithin and CMC were mixed with sugar. Homogenized and pasteurized milk (3% milk fat) and cream (30% milk fat) were then mixed together and warmed up to 50 °C, before being added slowly along with skim milk powder to the mixture. Mixing was performed using a Moulinex mixer (Model R10, Moulinex, Ecully Cedex, France). Next, the samples were pasteurized at 80 °C for 30 s (HTST), cooled immediately to 4 °C, and then stored at that temperature for 12 h. After aging, concurrent with physicochemical tests on 1 kg out of the 3 kg of the samples, freezing (25 min) was carried out in a batch soft ice cream maker (Feller Ice Cream Maker, Model IC 100, Feller Technologic GmbH, Dusseldorf, Germany). It should be noted that in order to prepare the different samples, soy milk was first prepared using the method of Yeganehzad, Mazaheri Tehrani, Shahidi, & Zaerzadeh (2007) before the percentage of replacement of cow's milk with soy milk was calculated and applied during the aforementioned production steps. The final products were collected in 70 mL plastic containers that were subsequently covered by lids, coded, and placed in a chest freezer for one week. Meanwhile, the remaining 2 kg of the samples were transferred to a factory for drying. The ice cream mixes were spray-dried in a pilot plant spray dryer (China). The rotation of the rotary cup atomizer was set at 12000 rpm; the inlet and outlet temperatures were 170-180 and 75-80 °C, respectively. The powders were reconstituted and converted into ice cream, and their physicochemical and sensory properties were measured and compared with the primary samples.

Results and discussion

The results showed that in the production of ice cream, by increasingly replacing cow's milk with soy milk, the pH, viscosity, and melting resistance significantly increased, but the overrun fell (P<0.05). At high replacement levels, an increase in the pH of the samples could be due to the pH of soy milk. Ahsan *et al*. (2015) also achieved similar results in the production of soy ice cream. Moreover, the increased viscosity of the ice cream mixes could be due to the unique properties of soy proteins, including the excellent water absorption, fat absorption, emulsion stabilization, mixing ability, and foam stabilization (Barać, Stanojević, Jovanović, & Pešić, 2004). Razavi, Habibi Najafi, & Nsyebzadeh (2001) reported that cow's milk proteins, like soy milk proteins, do not have the power to absorb water. However, unlike soy carbohydrates, cow's milk lactose lacks the ability to form gels. As a result, a direct and positive relationship was observed between soy milk percentage in the ice cream formulation and viscosity. A direct relationship also prevailed between viscosity and melting resistance. The best explanation for the drop in overrun is that cow's milk casein is able to create a uniform network within which air is trapped, while soy proteins do not have this ability. As a result, replacing cow's milk with soy milk can reduce the overrun of the product (Pourahmad & Ahanian, 2015). Although taste and overall acceptability scores significantly dropped in the absence of vanilla flavoring, no significant changes occurred in these parameters for up to 40% soy milk replacement in the presence of 1% vanilla. The evaluation of the reconstituted powder samples elucidated significant differences in physicochemical and sensory characteristics compared with the primary ice cream (P<0.05); significant drops in pH, viscosity, overrun, and melting resistance were recorded in these powders. Samples that included more soy milk had a greater pH reduction than samples that contained less soy milk, which can be explained by the presence of high unsaturated fatty acids in soy milk. Unsaturated fatty acids (soy milk) are oxidized more than saturated fatty acids (cow's milk) when in contact with the heat inside the dryer tower. On the other hand, the high temperature in the dryer tower leads to the denaturation of both soy milk and cow's milk proteins. Protein denaturation reduces water absorption and thus viscosity (Table 1). In addition, denatured proteins cannot create a uniform network for air trapping, and ultimately reduce overrun. Fazaeli, Yarmand, & Emam-Djomeh (2018) also reported that the high temperature in the dryer tower causes the denaturation of the proteins in the primary feed. As a result, after reconstructing the produced powder and preparing ice cream, decreased viscosity and melting resistance were observed.

Table 1. Some of the physicochemical properties of ice cream samples

T	Cow milk	Soy milk	pH		Viscosity		Overrun	
			PI	IMP	PI	IMP	PI	IMP
1	100	0	6.32±0.10^{a}	6.28±0.00^{b}	147.10±2.02^{a}	141.30±1.79^{b}	68.70±0.17^{a}	61.30±0.12^{b}
2	90	10	6.32±0.03^{a}	6.28±0.01^{b}	145.70±2.60^{a}	133.60±2.08^{b}	65.10±0.29^{a}	58.10±0.15^{b}
3	80	20	6.32±0.02^{a}	6.26±0.02^{b}	156.30±1.90^{a}	142.60±2.02^{b}	65.30±0.21^{a}	60.40±0.18^{b}
4	70	30	6.32±0.06^{a}	6.25±0.01^{b}	168.40±1.21^{a}	153.10±1.61^{b}	61.60±0.16^{a}	57.50±0.19^{b}
5	60	40	6.34±0.01^{a}	6.25±0.00^{b}	174.80±1.01^{a}	155.70±2.25^{b}	62.10±0.13^{a}	56.70±0.17^{b}
6	50	50	6.34±0.03^{a}	6.22±0.00^{b}	175.20±1.08^{a}	163.20±1.02^{b}	61.50±0.10^{a}	56.50±0.17^{b}

PI: Primary ice cream; IMP:Ice cream made from powder

The numbers in each horizontal column with the same words don't have significant difference (P<0.05).

Conclusions

The results showed that the replacement of cow's milk with soy milk affected the physicochemical properties of ice cream, but significant changes in sensory features were not observed when using vanilla in the formulation (P<0.05). Another important aspect of this study was that the ice cream mixes were successfully spray-dried in a pilot plant spray dryer. The powders were reconstituted and converted into ice cream, and their physicochemical and sensory properties were measured and compared with the primary mixes. Although the pH, viscosity, overrun, and melting resistance of the powder samples decreased significantly compared to the primary specimens, these reductions did not alter the overall quality of the final ice cream products. Hence, it is possible to industrially convert ice cream mixes into powders that can be reconstructed when desired.

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