Agr. Nat. Resour. 54 (2020) 521–528

AGRICULTURE AND NATURAL RESOURCES

Journal homepage: http://anres.kasetsart.org

Research article

Effect of pumpkin on quality, nutritional and organoleptic properties of ice cream

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Article Info

Article history:
Received 2 January 2020
Revised 24 February 2020
Accepted 18 March 2020
Available online 30 October 2020

Keywords:
Antioxidant,
β-carotene,
Physical attributes,
Pumpkin ice cream,
Sensory quality

Abstract

The physical attributes, antioxidant properties and sensory quality were evaluated of developed pumpkin ice cream products. Milk-based ice cream containing 25% pumpkin had the highest sensory score compared to bases using coconut milk or soy milk and so was selected for further study. In addition, various added increments of pumpkin mash (0-40%) were expected to increase the health benefits derived from the milk-based ice cream products. The pumpkin ice cream products had approximately 1,108-2,866 µmole Trolox equivalent/100 g oxygen radical absorbance capacity, 604-1,207 µg/ 100 g *β*-carotene and 1.4-2.4 g/ 100 g dietary fiber, along with less fat (8.0-10.5 g/ 100 g) and protein (1.5-2.2 g/ 100 g), though they were higher in total solids (27-30 g/ 100 g). Increasing the amount of pumpkin mash resulted in a significant ($p < 0.05$) reduction in overrun (62-84%) and pH (6.8-7.0), increased the viscosity (2.04×10^4-3.03×10^4 mPa.s) and delayed the melting rate. The overall liking score for all pumpkin ice cream products was moderate (7.2-7.4), which was slightly higher than for the control sample (7.1). This preference was most likely due to the sweet flavor, odor, smooth texture and the vivid yellow color of the pumpkin ice cream products, which positively influenced consumer liking. The products were safe for consumption since they were free of any pathogenic or microbial contamination. Consequently, pumpkin could be used successfully to produce a healthier ice cream with a distinctive pumpkin color, aroma and flavor.

Introduction

Studies have shown that consuming foods containing antioxidants, bioactive compounds and fiber may reduce the risk of cancer and non-communicable diseases (Penny et al., 2002; Dauchet et al., 2006). Currently, a growing number of people are becoming concerned about their health, which has increased the demand for healthy foods (Wijesinha-Bettoni and Mouillé, 2019)

Pumpkin (family Cucurbitaceae) is a healthy low-fat food rich in *β*-carotene, phytochemicals, vitamins, minerals, pectin and dietary fiber (Dutta et al., 2006). The *β*-carotene can convert to vitamin A in the body, which can play a crucial role in preventing chronic diseases and reducing the risk of cancer (Bendich, 1989; Deshmukh et al., 2017). Other potential benefits include slowing the aging process, reducing the risk of developing cataracts and preventing tumor growth. In addition, phenolic phytochemicals (α-amylase and α-glucosidase inhibition) and protein-bound polysaccharides in pumpkin flesh have anti-diabetic properties that can reduce blood glucose, increase insulin levels and improve glucose tolerance (Quanhong et al., 2005; Kwon et al., 2007). However, the variety, cultivation conditions and

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https://doi.org/10.34044/j.anres.2020.54.5.09

maturity stage may affect the nutrient compositions and quality of pumpkin (Yadav et al., 2010; Kim et al., 2012; Muenmanee et al., 2016). Nonetheless, the consumption rates of pumpkin and its related products have increased steadily due to the potential health benefits gained from antioxidants and phytochemicals, including pumpkin's fiber-rich nature (Dreosti, 1993; Quanhong et al., 2005; Kwon et al., 2007). Popular dishes containing pumpkin include soups, steamed and stir-fried foods, as well as snacks, such as puddings, pies, cakes and fried snacks (Nikolić et al., 2018).

To date, however, limited research has been done on the use of pumpkin to make ice cream products, which could be very popular among all age groups. In addition to health benefits, these products could increase add value to pumpkin and have a positive socioeconomic impact, including using surplus pumpkin supplies to produce ice cream pumpkin products, rather than simply discarding them.

Ice cream is generally accepted as a popular frozen dessert that is typically eaten as a snack and its taste sensation, richness of flavors, smooth quality and creamy texture can influence consumer preference. Dairy milk (whole milk, whipped cream, milk powder) and sugar (sucrose, glucose syrup) are the main ingredients used for making a basic ice cream (Goff and Hartel, 2013; Krahl et al., 2016). Minor food ingredients, such as hydrocolloids and emulsifiers, are also added to stabilize the foam, improve the creamy texture and provide good melting properties and structure (Muse and Hartel, 2004; Méndez-Velasco and Goff, 2012). Adding fruits or vegetables to the ice cream products can increase their potential health benefits and add value.

Technically, ice cream is a complex frozen food colloidal system consisting of ice crystals, air cells and partially coalesced fat droplets dispersed in a continuous freeze-concentrated aqueous phase containing polysaccharides (sucrose and lactose), proteins and minerals (Goff and Hartel, 2013). Changes in the quantities of fat, protein, non-solid fat content, fiber and other ingredients are related closely to body structures, ice crystals, appearance, ice cream melting point and product acceptance (Syed et al., 2018). Consequently, the addition of pumpkin mash (or coconut milk or soy milk replacements) in ice cream may influence the quality and preference for ice cream products.

A few studies have been conducted on pumpkin ice cream products and their potential health benefits. Kulkarni et al. (2017) developed a carotene-rich ice cream fortified with pumpkin (*Cucurbita maxima*) powder. They reported that increasing the amount of pumpkin powder by 1.0%, 1.5% and 2.0% weight per volume in ice cream resulted in increased values for hardness, melting resistance and viscosity, but decreased overrun. The addition of 1.5% pumpkin powder was the most accepted by sensory panelists and provided a carotene content of 103 mg/100 g in the ice cream. Khongjeamsiri et al. (2011) used pumpkin paste (steamed pumpkin flesh to water ratio of 1:1) to raise the antioxidants in Job's tears ice cream. They reported that the higher addition of pumpkin paste (20-65% weight per weight, w/w) affected the color, hardness and product desirability, especially at levels > 50%. Complementing these studies, the current study investigated the physicochemical properties, nutritional attributes and sensory quality of ice cream products made with mashed pumpkin, including their microbiological safety, as a prelude for stimulating consumer demand and serving as an alternative choice for healthy frozen desserts.

Materials and Methods

Raw materials

Fresh pumpkin (*Cucurbita maxima*) of the Thong-Ampai variety was procured from a market in Nakhon Pathom province, Central Thailand. Whole fresh pumpkins were cleaned and the hard shell and seeds removed. The cut pumpkin was steamed for 10-15 min or until cooked, then ground to obtain a pumpkin mash. To produce the ice cream, coconut milk (Aroy-D®), full fat milk (Foremost®), fresh whipping cream (Foremost®), unsweetened soy milk (Ohayo®) and sugar (Mitr-Phol®) were purchased from a supermarket in Thailand. Isolated soy protein and guar gum were obtained from Solution Ingredients Co., Ltd.).

Ice cream making process

All liquid ingredients were stirred and heated to 50–55°C, followed by the addition of the dried ingredients. The mixture was homogenized using a homogenizer (IKA Ultra-Turrax; USA) at 6,000 revolutions per minute (rpm) for 5 min. The ice cream mix was pasteurized at 85°C for 2 min and then rapidly cooled in an ice water bath. The pasteurized mix was ripened at 4°C for 6–12 hr. The cold mixture was beaten and frozen in a shaved surface exchanger using an ice cream maker (Taylor 103-34; USA). The finished ice cream was packed in plastic cups, each covered with a plastic lid and kept at -18°C before being subjected to analysis.

Experimental study plan

Dairy, coconut, and soy milk were studied as the main ingredients based on 25% pumpkin ice cream samples. Proximate analysis evaluated the fat, protein and total solids contents. Sensory analysis was carried out based on a 9-point hedonic scale with 30 panelists. The best formula was chosen for further development of pumpkin ice cream product. Pumpkin mash at levels of 0, 25, 30, 35 or 40 w/w were studied to formulate the pumpkin ice cream. The oxygen radical absorbance capacity (ORAC), β-carotene, and dietary fiber were examined. Other analysis considered the physical properties of melting rate, viscosity, overrun, pH and color as well as some proximate and microbiological characteristics. In addition, the developed product was subjected to sensory analysis using the same approach mentioned above.

Physicochemical analysis

The apparent viscosity of the ice cream mixture (600 mL) after aging at 4°C was measured using a rotational viscometer (Brookfield, DV; USA) with a spindle RV-3 at 100 rpm. The value was read after 30 s and reported in millipascal seconds. A known volume of ice cream mix and frozen ice cream were weighed and overrun was calculated according to Goff and Hartel (2013).

The melting rate was determined by measuring the weight of melted ice cream at 25°C. A sample (100 g) of ice cream was placed on a wire screen (6 holes/cm) on top of a funnel that was attached to a graduated cylinder. The weight of the melted ice cream was recorded every 5 min for up to 60 min. The slope obtained by plotting the time in minutes against the dripped volume in milliliters was taken as the melting rate.

The crude protein, fat, dietary fiber and total solid contents of the ice cream were analyzed according to official methods (Association of Official Analytical Chemists, 2012). The pH of the mixture was measured using a pH meter (Mettler Toledo Delta 340; USA). The colors of the ice cream products were measured using a spectrophotometer (ColorFlex EZ, Hunter Associates Laboratory Inc.; USA.). The CIE color values were expressed as L^* "lightness", a^* "redness" and b^* "yellowness", respectively.

The antioxidant ability to scavenge peroxyl radicals was measured based on oxygen radical absorbance capacity (ORAC) following the method of Huang et al. (2002). In brief, 500 µL of sample, 3.0 mL of fluorescein solution (8.2×10^2 µM), and 500 µL of AAPH (153 mM) (2,2-azobis [2-amidinopropane] dihydrochloride; Wako Pure Chemical; Japan) were mixed in a tube. Then, 75 mM potassium phosphate buffer solution at pH 7.2 was used for sample dilutions. The solution was measured using a spectrofluorometer (PerkinElmer LS 55; USA) with an excitation wavelength at 493 nm and an emission wavelength at 515 nm. The ORAC value (micro moles Trolox equivalents per 100 g) was calculated from a linear regression equation of a standard curve of Trolox (6-hydroxy2,5,7,8-tetramethychroman-2-carboxylic acid, Sigma-Aldrich; United States).

The amount of β-carotene was determined using a modified method of Speek et al. (1986). The sample was saponified using 10% ascorbic acid and 2 M potassium hydroxide (KOH) in methanol. This solution was extracted twice with hexane (C_6H_{14}) and washed with 10% sodium chloride (NaCl) until alkali free. The aliquot was evaporated in a rotary evaporator at 35°C. The residue was dissolved in the mobile phase and filtered through a 0.4 mm syringe filter. Analysis was based on HPLC using a C18 column with a protective guard column, equipped with a diode array detector.

Sensory analysis

Semi-trained panelists (n = 30) were recruited to evaluate the ice cream samples. The attributes of each sample were assessed in terms of overall acceptance, texture, taste, odor and color using a 9-point hedonic scale (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely). Approximately 25 g of each ice cream sample was placed in a separate disposable container which was coded with a 3-digit number. The samples were kept at 0°C before being served.

Microbiological analysis

Pathogenic microorganisms and microbial sanitary indices were determined according to the Bacteriological Analytical Manual (Food and Drug Administration, 2009).

Statistical analysis

The study involved three independent experiments. All data were analyzed using analysis of variance facilitated by the SPSS statistical software (version 19; IBM. Inc.; USA). Duncan's multiple range test was used to determine significance among the various samples at a significant difference level of 0.05.

Results and Discussion

Basic formula of 25% pumpkin ice cream

Medium bases and proximate analysis

A selected level of 25% pumpkin mash was chosen based on preliminary experiments (Ngamtin, 2016). Three medium bases of dairy milk, coconut milk and soy milk were used to modify the 25% pumpkin ice cream products in the first trial. The medium base contained 63% of the ice cream's main ingredients, 25% mashed pumpkin and 12% sugar and other food additives (for example, 0.1% stabilizer and 0.05% emulsifiers), as shown in Table 1. The dairy milk base used 42% full fat milk and 21% whipping cream, the coconut base contained 63% full fat coconut milk and the soy milk base contained 55% full fat soy milk and 8% soy protein. These ingredients impacted on the proximate values of the finished ice cream products. The highest fat content was in the coconut base formula (11.2%), followed by the dairy milk base (10.5%) and the soy milk base (2.0%). The protein content was highest in the soy milk base formula (6.1%), followed by the dairy milk base (2.2%) and then the coconut milk base (1.4%). The dairy milk and coconut base ice creams had higher total solids (27.0–27.5%) the soy milk base (24.2%), as shown in Table 1. There were significant differences in the proximate values of the 25% pumpkin ice creams made from the various bases

Table 1 Ingredient bases and proximate analysis of 25% pumpkin ice cream treatments

Ice cream base	Main Ingredients					Proximate analysis (g/100g)		
	Whole milk	Whipping cream	Coconut milk	Soy milk	Soy protein	Fat	Protein	Total solids
Dairy milk	42	21	0	0	0	10.50 ± 0.14^b	2.20 ± 0.09^b	27.00 ± 0.25^a
Coconut	0	0	63	0	0	11.20 ± 0.08^a	1.40 ± 0.11^c	27.50 ± 0.41^a
Soy milk	0	0	0	55	8	2.00 ± 0.11^c	6.10 ± 0.20^a	24.20 ± 0.36^b

Means (±SD) within the same column followed by different lowercase superscripts are significantly ($p < 0.05$) different.

related to components, especially for the medium base since the other ingredients were the same. However, the fat level content can be used to classify quality grades of ice cream products based on regular (10%), premium (12%) and super-premium (16%) as the functional fat in ice cream provides it with a firm body, a creamy texture and a velvety mouth feel, which increase product acceptability (Goff and Hartel, 2013).

Sensory evaluation

The milk base had the highest score for all attributes with values greater than 7 (like moderately to like very much) for overall acceptance (7.4), texture (7.2), taste (7.18), color (7.2) and odor (7.1), as shown in Table 2. The attribute scores of the coconut base were slightly lower than for the milk base samples but not significantly so. The lowest scores for all sensory attributes were recorded for the soy milk base in the range 6.0–6.5 (like slightly to like moderately), which may have been due to the grassy and beany flavors as well as the astringent and bitter taste of the volatile and nonvolatile components in soy beans (Li, 2006). The sweet flavors and aromas in the diary milk and coconut milk products increased consumer likeness and acceptance. In addition, the opaque white color of dairy milk and coconut milk may have enhanced the bright creamy yellow color of the 25% pumpkin ice cream, whereas the whitish yellow color of soy milk resulted in the ice cream appearing dull and yellowish.

Due to the high fat content in the milk and coconut bases (Table 1) and because fat plays a key role in building internal structures, the ice cream products had a creamy, smooth texture. The milk fat boosted the volatile flavors and enhanced the whipping property to incorporate air bubbles into the ice cream structures (Goff and Hartel, 2013). Traditional low fat ice cream may have textural and flavor defects, such as coarseness, icing and crumbly body (Akalm et al., 2008). The total solids is related to the solid to water ratio; less total solids may have proportionality more water to freeze, thus contributing to greater formation of ice crystals, resulting in a rough texture (Flores and Goff, 1999). Thus, the soy milk base may have produced ice cream with a coarser texture compared to the other bases that had high total solids. Preference for these medium base ice creams rests on their health benefits, such as dairy milk as a calcium source, coconut milk containing medium chain fatty acid and soy milk containing phytoestrogen. However, for the successful development of pumpkin ice cream, consumers generally preferred the physical quality attributes and the taste sensation characteristics of each base. Consequently, the milk-based formula was selected for further development of healthy pumpkin ice cream.

Influence of pumpkin mash on quality of ice cream products

The accepted basic formula for the original 25% pumpkin ice cream consisted of a milk base comprising 42% whole milk and 21% whipping cream as the main ingredients (Table 1). This product had a yellowish color, sweet pumpkin flavors and odors and a smooth fine texture.

Proximate and nutritive attributes

Pumpkin is a very good source of β-carotene, antioxidants and other health benefits, such as vitamin A and fiber (Koh and Loh, 2018). Hence, the aim to increase nutritive values to produce a healthier finished product also affected ingredient formulation. Changes in the amounts of full fat milk and whipping cream were investigated, but the same respective ratio (2:1) was retained (Table 3). With regard to the sweetness of the pumpkin ice cream treatments, sugar was slightly reduced when increasing the percentage pumpkin mash, because of the sweet taste of native pumpkin flesh. The amounts of minor ingredients were similar for all formulations. Since pumpkin mash is of vegetable origin, it is a good carbohydrate source, in particular of dietary fiber, rather than being a source of protein or fat. Increasing the amount of pumpkin mash from 0% up to 40% reduced the fat content in the pumpkin ice cream products from 12.1% to 7.9% and the protein content from 2.5% to 1.5%, whereas a significant rise in total solids was observed (Table 3). Since each ingredient has a specific functional property in ice cream, any changes may affect quality and consumer acceptance.

Table 2 Sensory scores of 25% pumpkin ice creams using different medium bases

Ice cream base	Overall acceptance	Texture	Taste	Color	Odor
Milk	7.40 ± 0.61^a	7.20 ± 0.72^a	7.18 ± 0.66^a	7.20 ± 0.60^a	7.10 ± 0.65^a
Coconut milk	7.23 ± 0.68^a	6.97 ± 0.71^a	7.07 ± 0.74^a	7.17 ± 0.70^a	6.83 ± 0.64^a
Soy milk	6.17 ± 0.79^b	6.53 ± 0.62^b	6.40 ± 0.67^b	6.37 ± 0.76^b	6.03 ± 0.80^b

Sensory score range (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely)

Means (±SD) within the same column followed by different lowercase superscripts are significantly ($p < 0.05$) different.

Table 3 Ingredient formulations, proximate analysis, β-carotene and dietary fiber of pumpkin ice cream products

Pumpkin mashed (%)	Ingredient formulation*			Proximate analysis (g/ 100 g)			ORAC µmoles (TE/ 100 g)	β-carotene (µg/ 100 g)	Dietary fiber (g/ 100 g)
	Whole milk	Whipping cream	Sugar	Fat	Protein	Total solids			
0	59	29.0	12.0	12.1 ± 0.61^a	2.5 ± 0.06^a	22.6 ± 0.15^e	643.5 ± 21.8^e	80.20 ± 3.00^e	0.20 ± 0.05^d
25	42	21.0	12.0	10.5 ± 0.14^b	2.2 ± 0.09^b	27.0 ± 0.25^d	1,107.6 ± 13.1^d	604.00 ± 19.10^d	1.40 ± 0.11^c
30	39	19.5	11.5	9.0 ± 0.31^c	1.8 ± 0.06^c	28.1 ± 0.37^c	1,728.4 ± 18.3^c	822.73 ± 21.30^c	1.90 ± 0.09^b
35	36	18.0	11.0	8.3 ± 0.35^{cd}	1.6 ± 0.06^{cd}	28.7 ± 0.21^b	2,192.1 ± 17.9^b	996.70 ± 31.50^b	2.00 ± 0.06^b
40	33	16.5	10.5	7.9 ± 0.15^d	1.5 ± 0.12^d	29.6 ± 0.36^a	2,865.7 ± 22.0^a	1,207.30 ± 23.10^a	2.40 ± 0.14^a

ORAC = oxygen radical absorbance capacity; TE = Trolox equivalent

* 0.5% stabilizer and 0.05% emulsifier were added.

Means (±SD) within the same column followed by different lowercase superscripts are significantly ($p < 0.05$) different.

The results of this study showed significant increases in ORAC, β-carotene and dietary fiber as the percentage of pumpkin mash increased from 25% to 40% (Table 3). The value of ORAC in pumpkin (25–40%) ice cream products was in the range 1,108–2,866 µmoles TE/100 g, β-carotene was in the range 604–1,207 µg/100 g and dietary fiber was in the range 1.4–2.4 g/ 100 g. The control results (without adding pumpkin mash) were approximately 644 µmoles TE/100 g ORAC, 80 µg/ 100 g β-carotene and 0.2 g/100 g dietary fiber. For good health and wellness, individuals should have a recommended daily intake of 800 µg retinol equivalent (RE) vitamin A and 25 g dietary fiber. In the current study, the developed pumpkin (25–40%) ice cream products provided a vitamin A equivalent (6 µg β-carotene = 1 retinol equivalent) of 101–201 µg RE or about 13–25 % of recommended intake. The dietary fiber intake was 6–10%. This increased health benefit was due to the pumpkin mash and may differ depending on the pumpkin variety and seasonal factors. Numerous research studies show that consuming foods that provide antioxidants and essential vitamins, including non-nutritive nutrients like fiber, can reduce the risk of non-communicable diseases and cancer while strengthening the immune system (O'Keefe, 2019). To increase the health benefits of ice cream products, fresh or preserved fruits, as well as some vegetables and herbs, are generally added as extra ingredients.

Physical, microbiological and sensory analysis

The quality of the finished pumpkin ice cream products relied on the ingredient formulations, which served specific functions during processing. The current study changed the amount of pumpkin mash in the ice cream formulas. As the percentage of pumpkin mash increased (0–40%), the apparent viscosity (2.26×10^4-3.03×10^4 mPa.s) steadily increased in the ice cream because of the macro molecules contained in the pumpkin flesh. Soluble fiber and hydrocolloids display stronger intermolecular forces attracting them to one another and show a greater strength in hindering molecular flow. This finding was supported by the increase in total solids when more pumpkin mash was added (Table 3). Adding the macro molecules of the soluble fiber increased the viscosity of yogurt-ice cream (El-Nagar et al., 2002; Fagan et al., 2006).

Normally, increasing the viscosity of mixed ice creams might lead to a rise in overrun. Contrary to the current study, a lower overrun in the pumpkin ice cream treatments resulted when the viscosity increased, due to the increase in pumpkin mash (Table 4). The overrun of the control sample was 84%, for 25% pumpkin ice cream it was 73% and this reduced to 62% for the sample containing 40% pumpkin mash. In fact, the high viscosity in an ice cream mixture will promote the stability of the air bubbles because it increases their ability to develop and form entanglements which entrap and stabilize air cells (Soukoulis et al., 2008). This result may have been caused by cellulose fiber that can weaken the fat structure network through the destabilization and the partial coalescence of fat globules (Kokubo et al., 1996; Sakurai et al., 1996). This coalescence can also be enhanced when air cells move close together, resulting in a coarsening of the foam structure. Thus, when coalescence occurs, the air cell size distribution shifted to larger sizes and decreased overrun (Sofjan and Hartel, 2004).

Furthermore, under acidic conditions and the thermal process, casein tends to aggregate by reducing steric and electrostatic repulsions (Arbuckle, 1986; Gastaldi et al., 1996). This could lead to foaming instability and to a decrease in the whipping rate. The pH of the developed pumpkin ice cream products tended to reduce slightly ($p < 0.05$) when increased pumpkin mash was added, because the nature of pumpkin is that it is a low acidity. A low (acid) pH (6.8–6.9) of the ice cream resulted from adding pumpkin mash (30–40%), whereas the 25% pumpkin ice cream and the control had a nearly neutral pH of 7.0 (Table 4).

The vivid yellow color of pumpkin ice cream products was clearly due to the intense yellow color of the fruit, while its taste, odor and texture were also unique. The rich yellow color of pumpkin ice cream samples increased with the addition of increasing levels of pumpkin mash. Though the reduced of the L* value declined from 91 to 81, increases were noted for both *a** from -9 to -6 and *b** from 67 to 103 (Table 4). The sample not containing pumpkin mash was a creamy white color and had color values of *L**, *a** and *b** of 99, 1.1 and 6.8, respectively.

Ice cream meltdown occurs when the solid ice crystals melt and turn into a liquid state at room temperature. During ice cream meltdown, the produced water is diffused into the frozen concentrated serum phase, then the diluted solution flows through the complex foamy structure of ice cream and finally drips. Adding pumpkin mash may affect the proportion of solid (ice and fat), liquid and gas in the ice cream structure. A delay in the melting rate was recorded in the pumpkin ice cream products, except for the sample with 40% added pumpkin mash (Table 5). The increased viscosity of this sample created a gel-like network of soluble fiber, like pectin, where the water molecules became immobilized and were unable to move freely among other molecules of the mix, thus leading to delayed product melting (El-Nagar et al., 2002).

Table 4 Physical properties of pumpkin ice cream products

Pumpkin mashed (%)	Viscosity (mPa.s)	Overrun (%)	pH	Color values L*	a*	b*
0	$2.04 \times 10^4 \pm 306^e$	84.3 ± 4.0^a	6.95 ± 0.03^a	98.5 ± 0.8^a	1.1 ± 0.6^a	6.8 ± 0.7^e
25	$2.26 \times 10^4 \pm 493^d$	73.0 ± 5.0^b	7.00 ± 0.02^a	91.1 ± 5.9^b	-8.9 ± 0.6^c	66.9 ± 3.9^d
30	$2.56 \times 10^4 \pm 351^c$	69.0 ± 2.6^b	6.89 ± 0.04^b	87.7 ± 3.8^{bc}	-6.9 ± 0.5^b	83.6 ± 3.4^c
35	$2.94 \times 10^4 \pm 551^b$	67.0 ± 3.0^{bc}	6.82 ± 0.02^c	82.0 ± 3.8^{cd}	-6.2 ± 0.2^b	95.6 ± 2.0^b
40	$3.03 \times 10^4 \pm 764^a$	61.7 ± 4.1^c	6.80 ± 0.02^c	80.6 ± 1.9^d	-6.1 ± 0.2^b	102.7 ± 3.0^a

Means (±SD) within the same column followed by different lowercase superscripts are significantly ($p < 0.05$) different.

Table 5 Melting property of pumpkin ice cream and control

Ice cream formulation	Weight of ice cream (g)												
	0 min	5 min	10 min	15 min	20 min	25 min	30 min	35 min	40 min	45 min	50 min	55 min	60 min
Control	0	6.5±1.2^{a}	10.7±0.8^{a}	21.2±1.1^{a}	29.3±1.1^{a}	36.8±0.9^{a}	42.5±1.4^{a}	52.5±1.5^{a}	57.9±1.1^{b}	66±1.6^{b}	74.7±1.8^{a}	83.1±4.2^{a}	87.3±4.5^{a}
25% Pumpkin	0	4.8±0.8^{a}	10.5±1.1^{a}	22.8±1.1^{a}	27.3±1.1^{a}	34.7±1.9^{a}	43.9±1.1^{a}	46.2±1.3^{b}	51.2±1.2^{c}	57.7±3.7^{c}	65.5±2.3^{b}	76.9±5.7^{b}	84.6±5.4^{a}
30% Pumpkin	0	4.3±1.3^{a}	7.8±1.8^{a}	15.5±1.5^{b}	20.6±1.2^{b}	26.2±3.0^{b}	38.3±3.8^{b}	42.6±3.5^{c}	47.7±1.7^{c}	56.7±0.2^{c}	62.3±2.7^{b}	73.1±3.9^{c}	82.7±1.8^{a}
35% Pumpkin	0	3.70±2.3^{a}	6.60±1.6^{a}	12.90±0.9^{b}	18.70±0.9^{b}	21.60±1.6^{c}	28.20±3.1^{c}	34.30±3.5^{d}	40.30±1.8^{d}	47.70±3.1^{d}	54.00±3.4^{c}	65.80±1.6^{d}	74.20±2.3^{b}
40% Pumpkin	0	5.20±1.1^{a}	11.40±1.8^{a}	22.90±1.6^{a}	31.40±1.6^{a}	39.80±1.5^{a}	46.50±2.0^{a}	54.60±1.2^{a}	63.60±2.9^{a}	72.20±2.0^{a}	76.10±2.4^{a}	81.90±2.3^{a}	85.40±0.9^{a}

Means (±SD) within the same column followed by different lowercase superscripts are significantly ($p < 0.05$) different.

Microbial and pathogenic bacterial contents must be determined to certify product safety. The total viable count of each ice cream product was between 1.6×10^2 colony forming units (cfu)/g, with no detection of *Escherichia coli*, *Salmonella* spp., *Listeria monocytogenes* or *Staphylococcus aureus* (Table 6). This result was due to the application of good sanitation practices and hygiene in the production process, as well as the proper pasteurized condition used with the mixed ice cream products. Hence, the developed pumpkin ice creams were safe for human consumption.

Varying the level of pumpkin mash (0–40%) changed the physicochemical properties, proximate values and visual appearance of the pumpkin ice cream products as mentioned above. Since these changes might affect consumers' perceptions of the ice cream, consumer liking was evaluated. An increasing trend in overall liking was found when more pumpkin mash was added, except for the sample containing 40% pumpkin mash. This increasing preference was most likely due to the unique color, odor and taste of the pumpkin ice cream products as well as perceived health benefits. The acceptance scores of overall liking, texture, taste, odor and color of all pumpkin ice cream products exceeded 7 (like moderately to like very much), as shown in Table 7. The 40% pumpkin ice cream appeared more like frozen pumpkin than an ice cream product and thus had a score less than the other samples, except for its color. A control sample without adding pumpkin mash produced the lowest scores for almost all sensory attributes, though each attribute had a score of nearly 7.

The original milk-based formula to produce pumpkin ice cream was preferred over that using coconut milk or soy milk. The developed pumpkin ice cream products (25–40%) had a vivid yellow color, a real taste and flavor of pumpkin and a creamy texture that consumers preferred. Gains in the health benefits (ORAC, β-carotene, vitamin A, dietary fiber) increased with each incremental addition of pumpkin mash in the ice cream products, excluding the control which had no pumpkin. There was a trend of increasing viscosity as well as a reduction in overrun, pH and the melting rate with increasing additions of pumpkin mash. All pumpkin ice cream products were free of pathogenic bacteria and safe for consumption and were acceptable to consumers based on the sensory analysis. These results may encourage the use of other fruits or vegetables with proven health benefits to make value-added ice cream products as well as promoting increased use of local raw materials.

Table 6 Microbial quality of pumpkin ice cream products

Pumpkin mashed (%)	Total viable count (cfu/ g)	*E. coli* (0.01 g)	*S.* spp. (25 g)	*L. monocytogenes* (25 g)	*S. aureus* (0.01 g)
0	1.8×10^2	nd	nd	nd	nd
25	1.8×10^2	nd	nd	nd	nd
30	2.0×10^2	nd	nd	nd	nd
35	1.6×10^2	nd	nd	nd	nd
40	1.7×10^2	nd	nd	nd	nd

S. spp. = *Salmonella* spp.; nd = not detected

Means (±SD) within the same column followed by different lowercase superscripts are significantly ($p < 0.05$) different.

Table 7 Sensory score of pumpkin ice cream products

Pumpkin mash (%)	Overall acceptance	Texture	Taste	Odor	Color
0	7.07 ± 0.58^{a}	7.10 ± 0.55^{ab}	7.13 ± 0.68^{a}	7.03 ± 0.61^{a}	6.90 ± 0.55^{b}
25	7.17 ± 0.59^{a}	7.13 ± 0.63^{ab}	7.03 ± 0.72^{a}	7.17 ± 0.53^{a}	7.07 ± 0.64^{ab}
30	7.17 ± 0.59^{a}	7.20 ± 0.71^{ab}	7.17 ± 0.65^{a}	7.20 ± 0.55^{a}	7.13 ± 0.63^{ab}
35	7.40 ± 0.72^{a}	7.40 ± 0.62^{a}	7.23 ± 0.77^{a}	7.20 ± 0.76^{a}	7.17 ± 0.46^{ab}
40	7.18 ± 0.67^{a}	7.00 ± 0.90^{b}	7.03 ± 0.72^{a}	6.97 ± 0.85^{a}	7.23 ± 0.73^{a}

Sensory score range (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely).

Means (±SD) within the same column followed by different lowercase superscripts are significantly ($p < 0.05$) different.

Conflict of Interest

The authors confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Acknowledgements

The authors are grateful to Mr. George A. Attig and Dr Christine Stanly for editing earlier versions of the manuscript as well as to the panelists for participating in the sensory evaluation.

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