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Investigation of Physicochemical, Textural, and Sensory Properties of Ice Cream Formulated with Kiwifruit Puree

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Abstract

In the present study, the kiwifruit puree was incorporated into the ice cream mix at different concentration levels of 3, 6, 9, and 12%. The formulated ice cream samples were investigated for physicochemical properties (fat, protein, total solids, pH, and ash), textural properties (meltdown, viscosity, overrun, firmness), and free radicle scavenging activity (DPPH), and overall acceptability. An increase in the kiwifruit puree resulted in a decrease in the fat content, protein content, pH, and total solids content while the ash % was increased. Better textural properties were observed for the ice cream formulations with the addition of kiwifruit puree thus a significant effect was observed in meltdown, viscosity, overrun, and firmness with increasing the puree concentration. Ice cream samples with a maximum level of kiwifruit puree also showed higher free radical scavenging activity and overall acceptability. The results showed that the most preferred formulation was the ice cream containing 12% kiwifruit puree (T_4).

Keywords: *Dairy products, kiwifruit, ice cream, physicochemical properties, textural properties*

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Introduction

In recent decades, consumers have increased awareness about health and quality of life thus they adopt healthy eating habits, which encourages the food processors to meet consumers' demands (Guiné et al., 2020). Ice cream is a dairy product that is recognized worldwide for its pleasant flavor, nourishing effect, distinctive texture, and unique sensory characteristics. It is the most consumed frozen dairy product around the globe having a wide range of flavors, and having a high business probability (Goff and Hartel, 2013). The production of ice cream using health-promoting ingredients is an area with great potential for development in this industry. Different functional ingredients having biological activities are being added to formulate flavored ice-creams. Low storage temperature and stabilizing properties made ice cream a suitable medium for the delivery of bioactive components and functional ingredients (Goraya and Bajwa, 2015). New formulations of ice cream are produced by the addition of various functional ingredients to target consumers having health concerns (Shaviklo et al., 2011).

Fruits could be a very good option, and for this purpose, fresh, frozen, canned, or preserved fruits and fruit pastes/ pulps are usually used in ice cream mixes. Fruits deliver functional properties to ice cream due to their high quantity of bioactive compounds. Exotic fruits such as mango, kiwifruit, persimmon, and avocado are excellent sources of nutrients due to their composition (Gorinstein et al., 2011). Kiwifruit, an edible berry of the woody wine of the genus Actinidia (Stonehouse et al., 2013), has a reputation for being nutrient-dense fruit (C Hunter et al., 2011). Kiwifruit contains higher amounts of vitamins (C, K, E), and dietary fiber along with minerals like potassium and folate (Reddy et al., 2014). A wide range of biologically active compounds like antioxidants, polyphenols, flavonoids, carotenoids, phytonutrients, and enzymes are also present in kiwifruit providing numerous metabolic and functional health benefits (Richardson et al., 2018). Numerous databases have evidenced the positive impacts of kiwifruit on different metabolic conditions like the balance of insulin and glucose levels, energy homeostasis, management of body weight, and potential cardiovascular protective properties (Aune et al., 2017). Human intervention studies have revealed the positive influence of kiwifruit on the health of the digestive system (Richardson et al., 2018).

Commercially produced ice cream is relatively low in natural bioactive compounds and antioxidants such as vitamin C, polyphenols, and natural colors. There is a great potential to explore the possibility of developing such products with improved nutritional attributes using additives like natural colorants, antioxidants, and vitamins, along with manipulation of ingredients

like the reduction of fat to satisfy consumer needs (Sun-Waterhouse et al., 2013). The objective of this study was to investigate the effects of the addition of different concentration levels of kiwifruit puree (0%, 3%, 6%, 9%, and 12%) on the physicochemical and textural properties of ice cream at different storage times.

Materials and Methods

Procurement of raw material

All the raw materials including milk, cream, sugar, skim milk powder, and kiwifruit was procured from the local market of Faisalabad, Pakistan. The prepared food-grade mix of emulsifier and stabilizer named Cremadon was purchased from a chemical store "Skhawat Essence", Lahore, Pakistan. Kiwifruit fruits were thoroughly washed, cleaned, dried, and peeled, then puree was prepared with a blender and stored at -18°C. The kiwifruit puree was used in different concentrations (3%, 6%, 9%, and 12%) for preparing the different formulations of ice cream.

Table 1. Kiwifruit puree-based ice cream formulations

Treatments	Kiwifruit puree %	Ice cream %
T_0	0	100
T_1	3	97
T_2	6	96
T_3	9	91
T_4	12	88

Preparation of ice cream

The fruit ice cream was manufactured in the milk processing plant of the National Institute of food science and Technology (NIFSAT) University of Agriculture, Faisalabad, Pakistan. Ice cream mixes contained fat 10%, SNF 11%, sugar 15%, stabilizer-emulsifier 0.5%, and water 63.5%. All dry and liquid ingredients were mixed at 50°C to attain a uniform mixture. Pasteurization of the ice cream mix was done at 70°C for 30 minutes. Following the pasteurization, the ice cream premix was homogenized and then subjected to cooling at 4°C for 24 hours. In the next step, kiwifruit puree was added to the ice cream mix samples at different concentrations of 3, 6, 9, and 12%. Ice cream samples were subjected to freezing and overrun was also achieved. The fruit ice cream formulations were packed and immediately transferred to freezing at a temperature of -20°C for 45 days of storage study at an interval of 15 days.

Physicochemical and textural analysis

Physicochemical parameters such as protein content, ash content, and pH were performed according to the AOAC (2019), while total solids were assessed through the gravimetric method (AOAC, 2019). Regarding textural properties, the meltdown time of ice cream samples was evaluated by the method of Clarke (2015). The overrun was determined according to the method adopted by Goff and Hartel (2013). Viscosity was measured by using a viscometer Brookfield LVDVE (MA, USA) with spindle number 4 (Akesowan, 2008). The texture analyzer (TA-XT2i, Stable Microsystems Ltd., UK) was used to determine the firmness of the ice cream.

Free radicle scavenging activity (DPPH)

Free radicle scavenging activity through 2,2-Diphenyl-1-picrylhydrazyl (DPPH) was conducted according to the method adopted by Lapsongphon and Changso (2019). The ice cream sample (1 mL) was mixed with 1 mL of 0.1 mM DPPH in the ethanol solution. The reaction tubes were wrapped in aluminum foil and incubated for 10 min in darkness. The absorbance was monitored at 517 nm. DPPH assay was expressed as µmol Trolox eq/100 g sample.

Overall acceptability

Overall acceptability was conducted using the 9-point hedonic scale technique defined by Meilgaard *et al.* (2007).

Statistical analysis

All analyses were carried out in duplicate and mean values were presented. The results obtained were statistically analyzed at a 5% level of significance by using the Tuckey HSD comparison test through statistical software "Statistics" version 8.1. The results were presented as mean ± standard deviation.

Results and Discussion

Physicochemical Properties

Some physicochemical properties of ice cream samples enriched with kiwifruit puree at different concentration levels are shown in tables 2-6. It is clear from the table that the addition of kiwifruit puree caused a significant change in the physicochemical properties of ice cream formulations while the effect of storage days was non-significant. According to the results, a decreasing trend was observed for most physicochemical parameters in ice cream samples, in which the addition of kiwifruit puree decreased their ratios. The quantity of most constituents in ice cream was diluted with the addition of the puree because it contained 80 % water.

Fat content: The mean values of the fat content of fruit ice cream are depicted in Table 2. Results showed a highly significant ($P<0.01$) relationship between set treatments and the percentage of fat. In kiwifruit ice cream, fat content varied from 10% to 7.01% reflects with an increased amount of fruit puree, the level of fat content decreased. The lowest fat percentage 7.17% was observed in treatment (T_4) with 12% fruit puree. Storage study period (45 days) results for fat percentage showed non-significant results for all formulated ice cream treatments. These results are in line with the findings of Murtaza *et al.* (2004), who reported that fig paste incorporation into ice cream samples did not significantly affect the fat percentage during storage. A 100 gram of kiwifruit has low levels of fat (0.52 gram) and more water (83.1 gram) therefore as a substitution, formulation with the inclusion of kiwifruit puree has decreased total fat content in ice cream (USDA, 2016).

Table 2. Effect of kiwi fruit on the fat content (%) of ice cream

Treatments	Days			
	0	15	30	45
T_0	10.00 ± 0.23^{a}	9.95 ± 0.16^{a}	$9.93\pm.20^{a}$	9.90 ± 0.14^{a}
T_1	9.25 ± 0.19^{ab}	$9.20\pm o.12^{ab}$	9.18 ± 0.26^{ab}	9.15 ± 0.19^{ab}
T_2	8.50 ± 0.24^{bc}	8.45 ± 0.17^{bc}	8.43 ± 0.30^{bc}	8.40 ± 0.20^{bc}
T_3	7.80 ± 0.27^{cd}	7.75 ± 0.23^{cd}	7.70 ± 0.17^{cd}	7.63 ± 0.13^{cd}
T_4	7.17 ± 0.04^{d}	7.10 ± 0.06^{d}	7.08 ± 0.05^{d}	7.01 ± 0.03^{d}

Protein content: Table 3 depicted the mean values for the protein content of the ice cream and showed that the inclusion of different levels of kiwifruit puree had a highly significant effect ($P<0.01$) on the protein content. While the effect of storage on different fruit puree levels was non-significant. The protein content of ice cream was observed in decreasing order from 8.00% to 5.97% with an increased concentration of fruit puree. Ice cream prepared without the addition of fruit puree exhibited the highest amount of protein content (8%) as compared to 12% inclusion treatment T4 (6.10%). The findings of the current study are in line with the findings of Hassan and Barakat (2018) who incorporated the different proportions of carrot and pumpkin pulp into the ice cream mix and observed a decreased protein content from 4.28% to 3.60% in ice cream.

Table 3. Effect of kiwi fruit on the protein content (%) of ice cream

Treatments	Days			
	0	15	30	45
T_0	8.00 ± 0.16^{a}	7.95 ± 0.11^{a}	7.93 ± 0.13^{a}	7.90 ± 0.08^{a}
T_1	7.45 ± 0.13^{ab}	7.35 ± 0.08^{abc}	7.34 ± 0.15^{abc}	7.29 ± 0.13^{abcd}
T_2	7.00 ± 0.16^{bcde}	6.86 ± 0.12^{bcdef}	6.81 ± 0.19^{bcdefg}	6.79 ± 0.14^{bcdefg}
T_3	6.53 ± 0.19^{cdefg}	6.44 ± 0.13^{defg}	6.40 ± 0.09^{efg}	6.36 ± 0.11^{efg}
T_4	6.10 ± 0.07^{fg}	6.05 ± 0.35^{fg}	6.00 ± 0.32^{e}	5.97 ± 0.12^{e}

Total solids: The mean values of the total solids content of kiwifruit ice cream are presented in Table 4. Varying concentrations of fruit puree had a significant effect ($P<0.05$) on the total solids of the formulated ice cream. On the other hand, the interactive impact of storage period and treatment was observed as non-significant. The total solids in the ice cream decreased from 36.50% to 34.30% as we increased the level of kiwifruit puree in the ice cream mix. The highest amount of total solids was shown by control treatment T0 with 36.50% and the lowest 34.30% was exhibited by T4 treatment supporting the fact that kiwifruit increased proportion in formulated ice cream led to a significant reduction in total solids. The outcomes of the present study demonstrated a similar trend for total solids as described in a study by (Karaman et al., 2014), in which ice cream was enriched with persimmon puree and total solids reduction was reported from 32.50% to 28.01% due to the presence of lower total solids in the persimmon fruit.

Table 4. Effect of kiwi fruit on the total solids content (%) of ice cream

Treatments	Days			
	0	15	30	45
T_0	36.50 ± 0.73^{a}	36.48 ± 0.33^{a}	36.46 ± 0.20^{a}	36.44 ± 0.43^{a}
T_1	35.90 ± 0.64^{a}	35.88 ± 0.43^{a}	35.86 ± 0.85^{a}	35.85 ± 0.64^{a}
T_2	35.30 ± 0.84^{a}	35.28 ± 0.63^{a}	35.26 ± 1.09^{a}	35.25 ± 0.63^{a}
T_3	34.80 ± 1.03^{a}	34.78 ± 0.70^{a}	34.66 ± 0.47^{a}	34.61 ± 0.13^{a}
T_4	34.30 ± 0.20^{a}	34.16 ± 0.69^{a}	34.01 ± 0.79^{a}	33.94 ± 0.66^{a}

pH value: The mean values of pH for various treatments are presented in Table 5 showing that different concentrations of kiwifruit puree resulted highly significant (P<0.01) impact on the pH of ice cream. The impact of storage duration on the kiwifruit ice cream was non-significant, showing that the pH of the ice cream was reduced with the progression of storage. The pH values shift from 6.74 to 6.18. The treatment T0 showed the highest value for the pH of 6.74 followed by the T1 (6.53), T2 (6.41), and T3 (6.36), while the lowest value for pH was shown by the T4 (6.33). Hence, it was clear that the pH of kiwifruit ice cream exhibited a decreasing trend from T0 to T4. Presented results revealed the fact that the pH of all formulated treatments was lowered with an increase in the concentration of fruit paste and these findings were similar to those reported by Topdaş et al. (2017) who added the cornelian cherry paste to ice cream.

Table 5. Effect of kiwi fruit on the pH value of ice cream

Treatments	Days			
	0	15	30	45
T_0	6.74±0.13^{a}	6.72±0.08^{a}	6.70±0.12^{a}	6.69±0.07^{a}
T_1	6.53±0.12^{a}	6.51±0.08^{a}	6.49±0.15^{a}	6.48±0.11^{a}
T_2	6.41±0.15^{a}	6.37±0.13^{a}	6.33±0.08^{a}	6.31±0.16^{a}
T_3	6.36±0.20^{a}	6.35±0.22^{a}	6.34±0.08^{a}	6.33±0.11^{a}
T_4	6.33±0.12^{a}	6.27±0.05^{a}	6.21±0.04^{a}	6.18±0.08^{a}

Ash content: The addition of different concentrations of kiwifruit resulted highly significant (P<0.01) effect on the ash content of the formulated samples while its effect during storage duration was observed as non-significant. The mean values of different treatments for the ash content of ice cream are given in Table 6. It is evident from the table that ash content was increased from T0 to T4 after increasing the concentration of kiwifruit puree. Ash content of control treatment T0 was observed lowest (1.68%) and trend observed as T1 (1.81%) < T2 (1.95%) < T3 (2.08%) < T4 (2.17%). This increasing trend reflects that an increased percentage of kiwifruit puree ash content was increased. Study results coincide with research conducted by Topdaş et al. (2017) and showed a similar increase in the ash content of ice cream through the addition of cornelian cherry paste in the ice cream premix.

Table 6. Effect of kiwi fruit on the ash content (%) of ice cream

Treatments	Days			
	0	15	30	45
T_0	1.68±0.03^{f}	1.67±0.03^{f}	1.67±0.03^{f}	1.66±0.04^{f}
T_1	1.81±0.03^{ef}	1.80±0.04^{ef}	1.81±0.04^{ef}	1.82±0.03^{ef}
T_2	1.95±0.03^{bcde}	1.94±0.03^{cde}	1.93±0.03^{de}	1.92±0.04^{de}
T_3	2.08±0.04^{abcd}	2.07±0.04^{abcd}	2.07±0.05^{abcd}	2.06±0.04^{abcd}
T_4	2.17±0.03^{a}	2.16±0.05^{a}	2.15±0.04^{ab}	2.14±0.04^{abc}

Free radicle scavenging activity (DPPH)

The mean values for the free radicle scavenging activity of ice cream samples are depicted in Table 7. Results showed that the scavenging potential of ice cream increased significantly with increasing the level of kiwifruit puree. Treatment T4 with 12% fruit puree, showed the highest scavenging activity (61.41 µmol Trolox 100 g-1) as compared to the control treatment that showed relatively lowest potential (4.51 µmol Trolox 100 g-1) even at 0 days of storage. There was a positive correlation between radical scavenging activity and the concentration of fruit puree added. This significant increase in antioxidant activity of all the ice cream samples is due to the higher ascorbic acid content of kiwifruit. During storage, the antioxidant activity of all the samples remained quite stable as low-temperature storage conditions preserve the phenolic and vitamin content of the products. The outcomes of the current research were observed similar to the results obtained by Chamchan et al. (2017) and Topdaş et al. (2017), who added ginger, lemongrass extract, and cornelian cherry paste respectively in the development of ice cream.

Table 7. Effect of kiwi fruit on the free radicle scavenging activity (µmol Trolox 100 g^{-1}) of ice cream

Treatments	Days			
	0	15	30	45
T_0	4.51±0.07^{e}	4.47±0.06^{e}	4.39±0.06^{e}	4.28±0.06^{e}
T_1	27.46±0.06^{d}	27.31±0.06^{d}	27.20±0.05^{d}	27.05±0.05^{d}
T_2	39.19±0.08^{c}	39.08±0.07^{c}	38.96±0.07^{c}	38.83±0.07^{c}
T_3	48.39±0.09^{b}	48.25±0.09^{b}	48.13±0.09^{b}	48.09±0.09^{b}
T_4	61.41±0.06^{a}	61.29±0.06^{a}	61.19±0.06^{a}	61.11±0.06^{a}

Textural Properties

Figures 1-4 represented the values of textural factors. Results showed that the addition of kiwifruit puree caused a significant change in the textural properties of ice cream formulations.

Meltdown: The mean values for the meltdown of kiwifruit ice cream are depicted in Figure 1. It displayed that the addition of fruit puree had a highly significant (P<0.01) effect on the melting rate of ice cream while the storage study showed a non-significant effect. The melting rate of the ice cream changed from 55.00 g/10 min to 28.93 g/10 min. The highest value for the meltdown was depicted by T1 (59.00 g/10 min) having 3% kiwifruit puree followed by T0 (55.00 g/10 min), T2 (47.00 g/10 min), T3 (37.40 g/10 min), and the lowest value for T4 (28.93 g/10 min) having 12% kiwifruit puree. There is a significant decrease in the meltdown of the kiwifruit ice cream after the addition of fruit puree from 3% to 12%. This decreasing trend may be because the fat content of ice cream decreased as we increased the concentration of fruit puree, and the level of fat is the key factor that affects the meltdown of ice cream. Treatment T4 showed a different behavior and started the melting process late as compared to other samples, this behavior was probably due to the low air incorporation and a higher level of pulp, inducing more firmness to the product. According to Correia et al. (2008), low overrun and higher total solids levels may be linked with a low rate of melting. An ideal melting behavior is characterized by a sequence of events, with the product becoming a smooth and homogeneous fluid (Goff and Hartel, 2013). Derived results supported the reported evidence that the higher the fat content, the lower will be the meltdown (Syed et al., 2018). The outcomes of the current research are relatable to the research conducted by (Temiz and YeşilSu, 2010) in which mulberry pekmez and grape pekmez were added into the ice cream mix, which decreased the melting resistance of the ice cream samples.

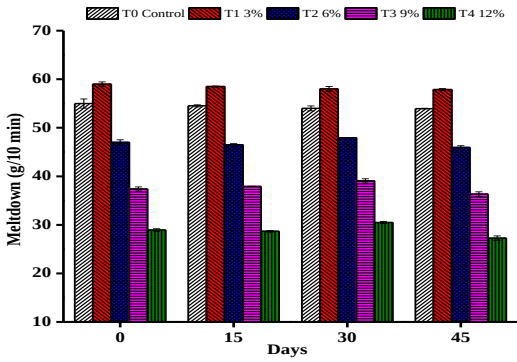

Figure 1. The meltdown of ice cream enriched with kiwi fruit puree

Viscosity: Viscosity is considered the thickness of a liquid. The inclusion of the kiwifruit and storage days had a highly significant impact (P<0.01) on the viscosity of the ice cream mix. Figure 2 depicted the mean values for the various treatment of kiwifruit ice cream. It represented that the viscosity of the fruit ice cream decreased from T1 to T4 after increasing the concentration of fruit puree from 3% to 12%. The treatment T0 without fruit puree showed the highest value for viscosity at 480.00 mPa.s and treatment T4 which contains 12% fruit puree exhibited the lowest value of 226.30 mPa.s for viscosity. Other treatments like T1, T2, and T3 showed the viscosity values decreased to 404.00 mPa.s, 339.07 mPa.s, and 279.00 mPa.s, respectively. The decreasing trend in the viscosity may be due to a decrease in the total solids of the ice cream after kiwifruit puree addition because it contains a high amount of moisture and low total solids. The viscosity of the ice cream mix substantially decreased with the addition of cornelian cherry paste into the ice cream and exhibited the same decreasing trend as depicted by the present study (Topdaş et al., 2017).

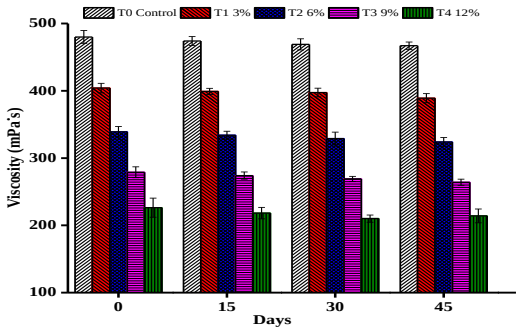

Figure 2. The viscosity of ice cream enriched with kiwi fruit puree

Overrun: Figure 3 depicted that the overrun value of the ice cream significantly decreased from T1 to T4 after the inclusion of kiwifruit puree from 3% to 12%. The overrun value of the product varied between 49.93% and 28.99%. The highest value for the overrun was exhibited by the control treatment T0 with 49.93% overrun followed by T1 (41.86%), T2 (38.81%), T3 (29.84%), and the lowest overrun value obtained for T4 (28.99%). This decreasing trend of overrun value for fruit ice cream might be owing to the lowering of fat content after the addition of kiwifruit. In other studies by (Goraya and Bajwa, 2015) ice cream prepared with different forms of processed amla depicted the same decreasing trend for the overrun values. It is an important parameter that affects the physical characteristics of the product as a reduction in fat content in the recipe causes to decrease in the overrun (Aziz et al., 2018).

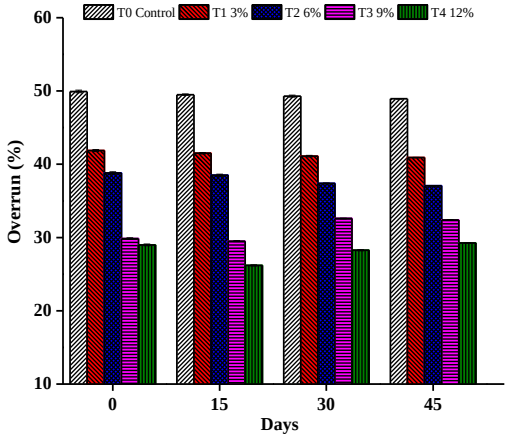

Figure 3. Overrun of ice cream enriched with kiwi fruit puree

Firmness: Figure 4 shows the mean values of firmness for the various formulations of kiwifruit ice cream. The value for the firmness of the product varied non-significantly from 3.61 N to 3.39 N. The highest value for the firmness was shown by control treatment T0 with 3.61 N and after that, it decreased gradually from T1 to T4 with the addition of fruit puree. Treatment T4 which contains the highest amount of 12% of fruit puree showed the lowest value for the firmness of kiwifruit ice cream. The results from the table showed that the firmness of the ice cream significantly decreased after increasing the amount of fruit puree. The impact of the storage period on the firmness of the ice cream was also non-significant. In other studies, the decreasing trend for firmness was exhibited by incorporating date syrup into ice cream (Hashim and Shamsi, 2016).

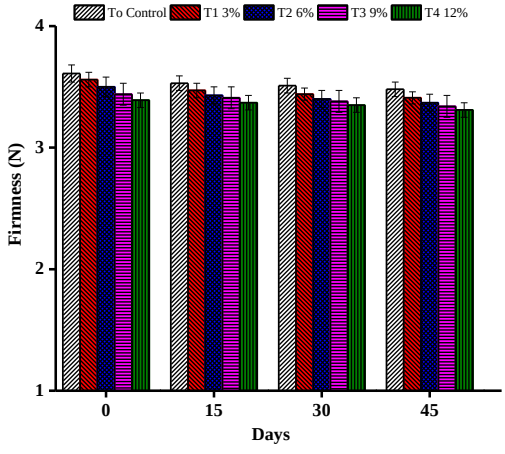

Figure 4. The firmness of ice cream enriched with kiwi fruit puree

Overall acceptability

The score for the overall acceptance of the kiwifruit ice cream was documented with the help of a 9-point hedonic scale. Figure 5 shows the mean values for the different treatments of kiwifruit ice cream, varying concentrations of kiwifruit puree had a highly significant impact on the overall acceptability of the ice cream. During the total storage duration (45 days), a significant impact on the overall acceptability of the ice cream was noticed. At the 0 days of storage, the overall acceptability of all samples T1, T2, T3, and T4 increased as depicted by the graph with obtained scores of 5.90, 6.70, 7.25, and 7.95, respectively. The highest score (7.95) for the overall acceptance of ice cream was obtained by treatment T4 which had 12% kiwifruit puree while control treatment T0 scored the lowest (5) for the overall acceptance of the ice cream. The outcomes of the current research comply with the results of Mann et al., (2013) and, Hassan and Barakat (2018) who added the kinnow peel and pumpkin, carrot pulp respectively into ice cream formulation and reported an increase in the overall acceptability score.

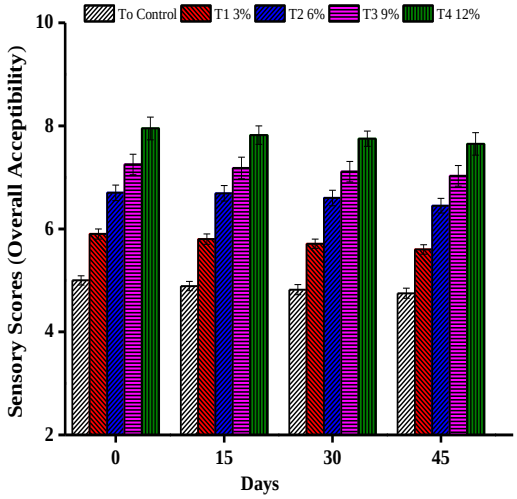

Figure 5. Overall acceptability of ice cream enriched with kiwi fruit puree

Conclusion

The plain ice cream and ice cream formulations produced by adding kiwifruit puree were compared in terms of quality parameters. Based on the results, it is concluded that kiwifruit puree addition to ice cream formulation significantly affected the physicochemical and textural properties of the ice cream. It was observed that level of fat, protein, total solids, and pH values decreased with increased kiwifruit puree concentration while ash % was increased. Similarly, the values for a meltdown, viscosity, overrun, and firmness decreased significantly with increasing the level of fruit puree. The addition of fruit puree in ice cream improved the free radical scavenging activity of all formulated treatments. The overall acceptability of all the treatments was also increased as the level of fruit puree was increased from 3% to 12% as compared with the control treatment.

Declarations

Competing interests

The authors report no conflicts of interest.

Author's contribution

Asad Iqbal conceptualized the idea and perform the study. Abdul Wahab and Muhammad Adil Farooq provided technical assistance and guided the data collection. Sadia Hassan and Huma Ambreen helped with drafting the manuscript.

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