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Processing and characterization of a functional ice cream supplemented with kiwi and pineapple juices

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During the last years, ice cream industry has undergone an outstanding development, which by the way allowed discovering and understanding the correlated stability interactions between structure, texture, and storage. In this study, novel functional ice cream treatments were prepared by using kiwi juice and pineapple juice, severally (10, 15, and 20%). The physicochemical characteristics, rheological properties, oxidative stability, and organoleptic attributes of ice cream samples were evaluated. The results revealed that kiwi juice-ice cream and pineapple juice-ice cream exhibited higher antioxidant activity as compared to the control ice cream. Furthermore, the addition of pineapple juice exhibited high melting temperatures than kiwi juice formulas, particularly at the levels of 15 and 20%. The supplementation of ice cream with kiwi juice and pineapple juice at sequential concentrations was related to a statistically substantial influence on the organoleptic parameters of ice cream samples including the color, flavor, texture, melting and the overall acceptability.

Keywords: Ice cream, Kiwi, Pineapple, Physicochemical characteristics, Antioxidant activity, Organoleptic properties

INTRODUCTION

Among the several innovative novel dairy products, ice cream is a foremost sweetened frozen product in the worldwide market, since consumers progressively associate the segment as being more of an everyday, year-round domestic grocery (Soukoulis et al. 2009). Ice cream is a dairy product of high caloric and nutritional density with lower contents of natural antioxidants and dietary fibers. Currently, consumer awareness and attention have been directed to foods rich in dietary fibers, natural antioxidants, minerals, vitamins, natural colorants, low cholesterol, low calories, and free of artificial ingredients, etc. Ice cream is considered a

complicated colloidal food system which in its frozen form composed of air cells, ice crystals, and moderately combined fat globules distributed in a continuous freeze-concentrated aqueous phase comprising proteins, polysaccharides, and minerals particularly calcium, but also potassium and sodium (Goff 2008). The development and stabilization of ice cream structure is a dynamic procedure where the major constituents specifically, water, fat, and biopolymers (polysaccharides and proteins) go through substantial physical and colloidal variations, for instance hydration of biopolymer, protein-polysaccharide phase separation, crystallization of fat droplet, fat droplet partial coalescence, ice

nucleation and crystallization, freeze-concentration, and formation of biopolymer entanglement (Bolliger et al. 2000; Chang and Hartel, 2002; Cook and Hartel, 2011; Goff, 1997; Soukoulis et al. 2009).

During the last 20 years, ice cream industry has undergone an outstanding development, which by the way allowed discovering and understanding the correlated stability interactions between structure, texture, and storage. This has promoted food manufacturers to fairly understand the combination of functional novel components in ice cream industry to not only deliver modified techno-functionality, for example water-binding, emulsification, viscosity improvement, and cryoprotection, but to improve the nutritional health aspects of the obtained product as well. The health-promoting ingredients, for instance dietary fibers (Soukoulis et al. 2009), natural antioxidants (Sun-Waterhouse et al. 2013), probiotics (Cruz et al. 2009), prebiotics (Akalın et al. 2008), fat sources rich in polyunsaturated fatty acids (omega 3/6 fatty acids) (Song et al. 2011), low glycemic index sweeteners (Whelan et al. 2008), and minerals (Erkaya et al. 2012), have been incorporated in ice cream processing.

Dietary fibers include various food entities, such as pectin, cellulose, hemicelluloses, lignin, seaweed etc. They extensively exist in several sources, for instance vegetables, fruits, oats, and wheat. The incorporation of dietary fibers demonstrated a satisfactory enhancement in the physical characteristics of ice cream, and showed a slight impact on the overrun, texture, and viscosity (Tiwari et al. 2015). The dietary fibers of wheat and oat improved the development in viscosity because of the water holding capacity (Soukoulis et al. 2009). In terms of health, fruits possess several benefits and can be utilized as natural antioxidants (Durmaz, 2012). Antioxidants are defined as the substances that have the ability to inhibit or delay the oxidation of other compounds through hindering the initiation or propagation of oxidizing chain interactions (Velioglu et al. 1998). Recently, several studies have revealed the potential health risks associated with synthetic antioxidants consumption (Panicker et al., 2014; Vandghanooni et al. 2013), and strict rules regulate their addition in foods currently. Consequently, consideration has been focused on the utilization of safe natural antioxidants (Konczak et al. 2010).

Pineapple is a common worldwide tropical fruit with a global production of 26.9 million tons in

2016. Approximately 70% of the flesh is consumed fresh and the rest 30% is frequently used to prepare juices, jams and cans (Huang et al. 2014). Several studies have stated that pineapple pomace mainly contains dietary fiber, pectins, flavonoids, sugars, vitamins, polyphenols and minerals, with substantial biological activities, for instance antimicrobial, antioxidant activities, and gastrointestinal-protective properties (Alotman et al. 2009; Nakthong et al. 2017). On the other hand, the composition of kiwi fruits in proteins, polyphenols, vitamins, elementals, and lipophilic components has been well reported. These attributes offer high antioxidant activity and reflect beneficial health benefits (Lim et al., 2016). Kiwi possesses higher amounts of polysaccharides (Sutherland et al., 1999). Kiwi fruits have been used in eastern medicine for the treatment of several dissimilar types of cancers, such as lung, stomach, and liver cancer (Liu et al. 2015). In this consent, the main objective of this study was to investigate the possibility of using kiwi and pineapple juices in the production of a novel nutritional functional ice cream, and to evaluate the physicochemical and sensory characteristics of the product obtained.

MATERIALS AND METHODS

Materials

Fresh cow milk (3% fat), fresh cream (33% fat), and whole milk powder (68% non-fat solids & 28% fat) were obtained from El-Marai Co., Al-Qassim, KSA. Sugar, gelatin, fresh kiwi (*Actinidia chinensis*) and pineapple fruits (*Ananas comosus*) were purchased from the local market (Buraydah city, Al-Qassim, KSA). All chemicals and reagents used for analysis were of high purity and analytical grade.

Kiwi and pineapple pulps preparation

Fresh kiwi and pineapple were manually peeled, washed, and cut into cubes. Then, the cubes were blanched under a live steam for 10 min, and mixed to obtain homogeneous puree using (Santos, VITA-MAX CORP-Light Industrial Food Preparing Machine Model, VM0122E, USA). Kiwi and pineapple juices were filled in glass jars, pasteurized at 85-90°C for 10 min, cooled in an ice-water bath for 20 min, and stored at 4°C for further use in ice cream preparation.

Preparation of ice cream

The processing of ice cream treatments was carried out in the Department of Food Science

and Human Nutrition, Faculty of Agriculture and Veterinary Medicine, Qassim University according to the procedure reported by Arbuckle (2013) using the formulas shown in Table 1. Briefly, whole milk powder and sugar were mixed together in order to make a "dry mixture". Then, the fresh cow milk was mixed with the cream to prepare the "liquid mixture". After that, the liquid mixture was heated in a water bath to 30-40°C, and the dry mixture was slowly added to the liquid mixture with a gentle stirring. Gelatin was dissolved in an appropriate volume of water by gentle mixing using a boiling-water bath, and then added to the whole mixture. The attained mixture was blended by using a mixer (Santos, VITA-MAX CORP-Light Industrial Food Preparing Machine Model, VM0122E, USA) for 1 min at speed 1, pasteurized in a double boiler at 80°C for 15 min, cooled to 4°C, and juices were added by substituting ~10, 15, and 20%, respectively. As shown in Table 1, the formulated ice cream batches were basically calculated as 10% fat, 11% non-fat solids, and 14% sugar taking in mind that kiwi and pineapple as sweetening components after determining the percentage of sugar in Brix. The degree of sweetness in ice cream treatments was established by subtracting the added kiwi and pineapple sugars from the theoretical amount of sucrose. The obtained pasteurized mixtures were aged in the refrigerator at 4°C for 20 hrs., whipped under a frozen condition in the ice cream machine (Promag, ice cream batch machines, Italy) for 20 min at the middle speed. Finally, ice cream treatments were collected at an exit temperature of -5°C, placed in a one L plastic container, sealed, hardened under -18±1°C for 24 hrs before analysis.

Proximate physicochemical and rheological analysis of ice cream

The different treatments of ice cream were analyzed for moisture, total solids, non-fat solids, crude protein, fat, ash, crude fiber, available carbohydrates, energy value (kcal 100/g fresh weight), and ascorbic acid (vitamin C) contents according to the standard methods of AOAC (2016). The viscosities of the ice creams were taken at 5°C using a digital Brookfield Viscometer, (Physical, Anton Paar GmbH, and Graz, Austria). Before measuring the viscosity, the samples was stirred gently to remove the air from the mixes. The colour parameters of ice cream samples were obtained by measuring L^* (brightness, 0: black, 100: white), a^* (+: red, -: green), and b^* (+: yellow,

-: blue) values using the method of described in (Anonymous, 1979) by used Hunter Lab, Reston, VA, USA.

Determination of overrun, melting temperature, and melting resistance

The overrun and melting resistance for three batches of both types of kiwi juice-ice cream and pineapple juice-ice cream, as well as the typical control ice cream were determined (Arbuckle, 2013; Schmidt, 2004). The overrun of ice cream samples was calculated by using the equation of [% overrun = (volume of ice cream – volume of mixture used) / volume of mixture used × 100]. In addition, the melting temperature and melting resistance were determined by allowing 25 g of ice cream samples to melt at the room temperature. Ice cream samples were put on a narrow wire screen placed over a glass funnel, and the drops were collected in a beaker. The time of the first drop was taken as the melting temperature. The weight of drainage was determined after 45 and 90 min. The percentage of the relative melted quantity during each period to determine the melting resistance was calculated (Muse and Hartel, 2004).

Phytochemicals and antioxidant activity

Total phenolic content (TPC) determination

The TPC of ice cream samples was determined using the Folin-Ciocalteu reagent following the adapted procedure reported by Bettaieb (Bettaieb et al. 2010). The absorbance was measured at 760 nm, and the recorded readings were compared to a standard curve of Gallic acid (GA). The TPC of ice cream treatments was expressed as mg of Gallic acid equivalents (GAE) per gram based on the dry weight (DW).

Total flavonoids (TF) and total flavonols (TFL) determination

The TF content in ice cream samples was determined according to procedure described by Mohdaly (Mohdaly et al. 2013). TF content was presented as mg quercetin equivalent (QE) per 100/g DW. While, the TFL content was estimated according to the method of Kumaran and Karunakaran (2007). The absorbance was measured at 440 nm, and TFL content was expressed as mg quercetin equivalent (QE) per 100/g DW.

Table 1: Different formulas of ice cream supplemented with kiwi and pineapple (amount per 100 g mixture).

Formulas	Milk	Cream	Milk powder	Sugar	Gelatin	Fruit juice
Control	59.84	20.30	5.36	14	0.5	0.0
10% Kiwi	49.73	18.52	8.65	12.6	0.5	10
15% Kiwi	44.58	17.39	10.42	11.9	0.5	15
20% Kiwi	39.72	16.23	12.35	11.2	0.5	20
10% Pineapple	50.21	18.48	8.85	11.96	0.5	10
15% Pineapple	45.60	17.19	10.55	11.16	0.5	15
20% Pineapple	40.5	15.9	12.45	10.65	0.5	20

DPPH radical scavenging assay

The radical scavenging activity in ice cream samples was spectrophotometrically determined by using DPPH radicals following the method of Lu (Lu et al. 2007). The antiradical activity was presented as micromoles of Trolox equivalents (TE) per 100 g of the dry weight.

Sensory evaluation

After one day of frozen storage, the organoleptic properties of the different treatments of ice cream were evaluated. Twelve panelists from the staff members of Food Science and Human Nutrition Department, Faculty of Agriculture and Veterinary Medicine, Qassim University were asked to evaluate the manufactured ice cream for the following parameters; 40 for flavor, 30 for texture, 10 for melting, 10 for color, 10 for appearance, and 100 for the overall acceptability. The results were statistically analyzed and the average of mean values of above-mentioned parameters and their standard errors were calculated (Arbuckle, 2013).

Statistical Analysis

The statistical analysis was performed by using SPSS program (version, 19). The obtained data were analyzed using the one-way ANOVA test regarding to the experimental design and comparisons by applying Tukey' LSD at a significance level of 0.05 according to Steel and Torrie (1980)..

RESULTS AND DISCUSSION

Approximate chemical composition of ice cream formulas

The chemical composition and caloric value of ice cream formulas supplemented with kiwi and pineapple juices is shown in Table 2. The different prepared formulas were characterized by their significantly ($P < 0.05$) higher contents of the dry

matter particularly the solids not-fat as compared to the control ice cream which possessed the highest moisture content (64.49%). Also, there was a substantial increase in the contents of ash and carbohydrates in the different formulas as compared to the control ice cream sample which contains 0.75% and 20.44%, respectively. On the other hand, compared to the control sample, the different formulas of ice cream have shown a significant decrease in their crude protein content which mainly attributed to the replacement of fresh milk. Nevertheless, small quantities of fiber (0.02% - 0.09% on fresh weight) have been identified as a function of the addition of kiwi juice and pineapple juice. Similar results have been reported by Amal (Amal et al. 2016). It was shown that the caloric value of ice cream formulas significantly varied among the different formulas, particularly at the substitution levels of 15% and 20%.

Rheological parameters of ice cream

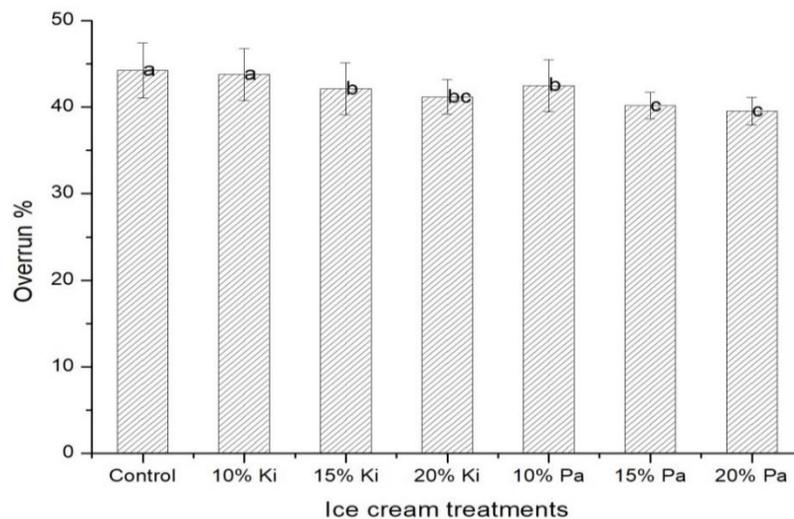
The overrun of the different formulas of both kiwi juice-ice cream and pineapple juice-ice cream formulas ranged between 41.16-43.76% and 39.54-42.49%, respectively (Figure 1). The control ice cream sample possessed the highest overrun value (44.23%). The overrun of pineapple juice-ice cream significantly ($P < 0.05$) decreased by increasing the substitution level over 15%, a result was not observed in kiwi juice-ice cream. These results revealed that increasing the addition of pineapple juice over 20% may considerably affect the overrun. It is well-know that the overrun mainly depends on fat, milk solids not-fat, and the solid contents of the ice cream mixture (Sun-Waterhouse et al. 2013). The ice cream formulas produced in the present study have a moderate content of fat (10%). It is recognized that a higher overrun can be attained through raising the fat content, since a larger volume of air bubbles is trapped by the more coalesced fat droplets exist (El-Rahman et al. 1997).

Table 2: Chemical composition and relative energy value of ice cream supplemented with kiwi and pineapple juice.

Component %	Ice cream formulas						
	C	10% Ki	15% Ki	20% Ki	10% Pa	15% Pa	20% Pa
Moisture	64.49 ^a ±0.06	62.29 ^b ±0.17	61.44 ^c ±0.14	60.47 ^c ±0.12	62.08 ^b ±0.13	61.2 ^c ±0.11	60.12 ^c ±0.11
SNF	25.47 ^d ±0.02	27.62 ^c ±0.08	28.36 ^b ±0.05	29.43 ^a ±0.07	27.87 ^b ±0.09	28.62 ^{ab} ±0.1	29.75 ^a ±0.1
Protein	4.28 ^a ±0.02	3.82 ^b ±0.01	3.66 ^c ±0.01	3.61 ^c ±0.01	3.80 ^b ±0.02	3.62 ^c ±0.02	3.59 ^c ±0.01
Fat	10.03 ^a ±0.22	10.04 ^a ±0.22	10.08 ^a ±0.22	10.11 ^a ±0.22	10.09 ^a ±0.22	10.07 ^a ±0.22	10.10 ^a ±0.22
Ash	0.75 ^c ±0.03	0.90 ^{ab} ±0.03	0.96 ^a ±0.03	0.99 ^a ±0.03	0.80 ^{bc} ±0.03	0.85 ^b ±0.03	0.93 ^a ±0.03
Fibers	00 ±00	0.02 ^d ±0.01	0.04 ^c ±0.01	0.07 ^b ±0.01	0.04 ^c ±0.01	0.07 ^b ±0.01	0.09 ^a ±0.01
Carbohydrates	20.44 ^d ±0.21	21.23 ^c ±0.1	23.45 ^b ±0.09	24.94 ^a ±0.08	19.28 ^d ±0.1	21.45 ^c ±0.09	23.14 ^b ±0.08
Energy (kcal 100g)	186.23 ^{cd} ±2.9	190.47 ^c ±2.2	199.16 ^b ±1.33	205.19 ^a ±2.31	183.13 ^d ±2.15	190.91 ^c ±2.54	197.82 ^b ±3.2

(Mean ± SE), n=3

C, typical ice cream; Ki, kiwi juice; Pa, Pineapple juice; SNF, solids not-fat

**Figure 1: Overrun of ice cream formulas supplemented with kiwi juice and pineapple juice**

Furthermore, the modification in milk proteins emulsification ability such as the amphiphilic characteristics can modify their interactions with some other constituents on the interfaces of air-cells, causing diverse values of overrun in ice cream (Schmidt, 2004).

The variations in the protein, soluble non-starch polysaccharide, and sugar contents of kiwi juice and pineapple juice are responsible for the observed values of overrun. For instance, there were substantial amounts of polysaccharides in kiwi and pineapple (Nakthong et al. 2017; Sutherland et al. 1999). These polysaccharides would influence the coagulation of milk, the rheological attributes of ice cream emulsion, and subsequently the microstructure of ice cream (Fagan et al. 2006; Schmidt, 2004; Sun-Waterhouse et al. 2013). The results revealed that

15% of both kiwi juice and pineapple juice substitution resulted in appropriate flavor and color, and the increasing the substitution level over 20% may influence the overrun. Lack of smoothness and creaminess is attributed to the extremely low overrun which indicates that little air has been involved, resulted in an excessively cold feeling in the mouth.

The melting temperature of the kiwi juice-ice cream and pineapple-ice cream formulas is shown in Table 3. Increasing the substitution levels of kiwi juice and pineapple juice more than 10% significantly increased the melting temperature as compared to the control sample (1.3°C). The addition of pineapple juice exhibited high melting temperatures than kiwi juice formulas, particularly at the levels of 15 and 20%. This may be attributed to the higher polysaccharide substances of pineapple juice, which by the way help in the

formulation of a good matrix with water in the acidic nature of ice cream mixture. Nevertheless, it was reported that the hardness of ice cream could be influenced by several factors, among them overrun, ice crystal content, ice crystal size, degree of fat destabilization, and the rheological attributes (da Silva Dias, 2014; Kwon et al. 2007; Muse and Hartel, 2004).

The melting resistance of kiwi juice-ice cream and pineapple-ice cream samples is shown in Table 3. The weight loss in the control ice cream sample was significantly ($P < 0.05$) higher than the other ice cream formulas. Kiwi juice-ice cream was more resistance to melting as compared to pineapple juice-ice cream. The low overrun with high amount of pineapple juice formulas reveals a compact structure with high melting resistance which may be attributed to the prevention of ambient air incorporation in ice cream matrix (Table 3). Moreover, kiwi juice-ice cream exhibited higher resistance to melting than pineapple juice-ice cream at both 45 and 90 min. These results are correlated to the overrun since the low overrun was associated with high melting resistance as previously reported (Moeenfarid and Mazaheri, 2008; Muse and Hartel, 2004; Sun-Waterhouse et al. 2013).

Kiwi and pineapple-ice cream had higher rheological properties expressed as apparent viscosity, plastic viscosity, yield stress, flow behavior index and consistency coefficient index than control ice-cream. Addition of fruit juice increased significantly for the rheological parameters of control samples, except for the flow behavior index, and these increases were related to added fruit juice ratio (Table 4). These changes may due to the thickening effect of the soluble fiber and pectin contents of fruit juice. Moreover, the high rheological parameters of kiwi and pineapple juice-ice cream can be partially attributed to their low pH. values. In similar studies, Erkaya (Erkaya et al. 2012) was found that ice cream mix containing different ratios of Cape gooseberry fruit and Jambul fruit pulp. As shown in table (4), a lowest viscosity value was obtained in the control sample (229 mPs) and the highest in pineapple 20% (348 mPs). These findings are in agreement with the results of Hwang, Shyu, and Hsu (2009) for ice cream samples with grape wine lees, Dervişoğlu and Yazici (2006) for ice cream samples with citrus fibre and Cakmakci, Topdas, Kalın, Han, Şekerçi, & Köse, (2015) for ice creams with oleaster (*Elaeagnus angustifolia* L.) flour.

The lightness (L^*) values of ice cream samples were close to each other, but they were significantly higher for the Ki 10 and 15P% than for others (Table 4). All of the samples taken into consideration were found to have negative greenness rates, whereas Ki 10% and Pa 10% samples seemed to be similar to and sometimes higher than the others. The colour rates of the samples were affected favourably by an increase in the concentration of fruit juices. Samples had negative a^* (greenness) values, and the Ki 20% (4.24) sample was significantly higher than the other samples. The b^* values were increased by the addition of kiwi and pineapple juices. Ice cream without juice gave the lowest b^* rate (9.63), whereas the highest rate was received from the kiwi juice-ice cream 20% (11.07) samples. Vital (2018) reported that the addition of grape juice increased the colour properties; these results are in agreement with the results of the present study.

Phytochemicals and antioxidant capacities of ice cream formulas

Table 5 shows the contents of TPC, TFL, carotenoids, vitamin C, as well as the antioxidant capacity of ice cream formulas prepared by using 10, 15, and 20% of kiwi or pineapple juices. The highest TPC content (207 mg GAE/g DW) was found in 20% kiwi juice-ice cream, and the lowest TPC content (11.2 mg GAE/g DW) was found in control ice cream sample. It was shown that the TPC content gradually increased with the increase in kiwi and pineapple juices supplementation ratios. Kiwi juice-ice cream showed higher TPC as compared to pineapple juice-ice cream. The content of carotenoids ranged between 1.8 and 2.9 2.32 mg/100 g DW in kiwi juice-ice cream and from 1.40 to 2.20 mg 100/g DW in pineapple juice-ice cream, while carotenoids were not identified in the control sample. The content of TF ranged between 2.7 and 4.90 mg QE 100/g DW in kiwi juice-ice cream and from 2.40 to 3.70 mg QE 100/g DW in pineapple juice-ice cream. Compared to the control ice cream, the incorporation of kiwi and pineapple juices into ice cream resulted in valuable TPC, carotenoids, TF and contents as similarly indicated by the dietary fibers-supplemented of dairy products (Fayed, 2015; Nguyen and Hwang, 2016; Yu et al. 2014). These phytochemicals enhance the functional characteristics of ice cream, and could be further scaled up; even the polyphenols can form complexes with the different components of ice cream such, as polysaccharides and proteins

during the processes of mixing and/or aging (Arts et al. 2002).

Table 3: Melting resistance of ice cream formulas incorporated with kiwi and pineapple juices after 45 and 90 min, respectively.

Formulas	Melting resistance	Weight loss% at (45 min)	Weight loss% at (90 min)
C	1.30 ^a ±0.2	9.64 ^d ±0.3	18.93 ^d ±0.5
10% Ki	4.13 ^b ±0.3	4.64 ^b ±0.2	8.57 ^b ±0.4
15% Ki	7.37 ^c ±0.3	3.21 ^a ±0.2	6.43 ^a ±0.3
20% Ki	13.48 ^d ±0.26	1.75 ^a ±0.1	5.71 ^a ±0.4
10% Pa	5.33 ^b ±0.2	7.14 ^c ±0.2	15.86 ^{cd} ±0.4
15% Pa	6.30 ^{bc} ±0.2	6.61 ^c ±0.4	13.93 ^c ±0.7
20% Pa	8.48 ^c ±0.3	2.77 ^a ±0.2	13.39 ^c ±0.5

(Mean ± SE), n = 3. a, b, c... superscripted letters refer that there is no significant difference ($P > 0.05$) between any two means have the same superscripted letter.

Table 4: Effect of using different percentage of kiwi and pineapple juice on physical and rheological properties of kiwi and pineapple juice-ice cream.

Properties	Ice-cream formula						
	Control	Ki 10%	Ki 15%	Ki 20%	Pa10%	Pa 15%	Pa 20%
Apparent viscosity (mPas)	229.2 ^{bc} ±0.4	199 ^c ±0.2	259.2 ^b ±0.24	328.7 ^a ±0.2	208.9 ^c ±0.25	279.3 ^b ±0.3	348.3 ^a ±0.2
Plastic viscosity (mPas)	166.1 ^c ±0.8	156.4 ^c ±1.4	200.4 ^b ±1.1	234.9 ^a ±1.2	166.2 ^c ±1.1	204.8 ^b ±1.2	243.9 ^a ±1.2
Yield stress (N/m ²)	4.53 ^c ±0.6	4.4 ^c ±0.5	7.1 ^b ±0.7	9.9 ^a ±0.9	4.5 ^c ±0.5	7.6 ^b ±0.7	10.5 ^a ±1
Flow behavior index	0.55 ^a ±0.03	0.57 ^a ±0.03	0.51 ^b ±0.04	0.45 ^c ±0.05	0.55 ^a ±0.03	0.51 ^b ±0.04	0.44 ^c ±0.04
Consistency coefficient index (mPas)	149.4 ^c ±0.4	129.5 ^c ±0.3	219.47 ^b ±0.6	279.2 ^{ab} ±0.7	139.15 ^c ±0.3	229.3 ^b ±0.3	309.13 ^a ±0.2
pH value	6.43 ^a ±0.03	6.21 ^b ±0.06	6.18 ^b ±0.02	6.14 ^b ±0.04	6.37 ^a ±0.06	6.22 ^b ±0.03	6.14 ^b ±0.02
<i>L</i> [*]	87.7 ^a ±0.3	83.11 ^b ±0.6	80.81 ^c ±0.2	78.4 ^{cd} ±0.4	76.4 ^{cd} ±0.6	73.3 ^d ±0.3	71.4 ^e ±0.2
<i>a</i> [*]	3.23 ^e ±0.13	3.81 ^c ±0.2	4.08 ^b ±0.2	4.24 ^a ±0.2	3.77 ^d ±0.16	3.92 ^{bc} ±0.13	4.14 ^b ±0.12
<i>b</i> [*]	9.63 ^d ±0.03	10.2 ^c ±0.16	10.58 ^b ±0.12	11.14 ^a ±0.2	9.87 ^{cd} ±0.06	10.02 ^c ±0.1	10.14 ^c ±0.2

Table 5: Phytochemicals composition of ice cream fortified with different concentration of pineapple and kiwi juice.

Parameters	Ice-cream formula						
	Control	10 % Ki	15% Ki	20% Ki	10% Pa	15% Pa	20% Pa
TPC (mg GAE/100g)	11.2 ^c ±0.4	1.90 ^{ab} ±0.25	1.97 ^a ±0.24	20.7 ^b ±0.23	17.9 ^{ab} ±0.25	1.87 ^b ±0.24	19.8 ^b ±0.2
TFL (mg QE/100g)	0.0±0.0	2.7 ^b ±0.4	3.4 ^b ±0.6	4.9 ^a ±0.4	2.4 ^c ±0.2	2.8 ^c ±0.2	3.7 ^b ±0.2
Carotenoids (mg/100g)	0.0±0.0	1.8 ^{bc} ±0.2	2.2 ^b ±0.3	2.9 ^a ±0.5	1.4 ^c ±0.1	1.8 ^{bc} ±0.2	2.2 ^b ±0.3
TF (mg QE/100g)	0.0±0.0	2.7±1.7 ^d	3.4±1.2	4.9±1.4	2.4 ^c ±1.2	2.8±1.2	3.7±1.2
Vit. C (mg/100g)	0.0±0.0	3.17 ^c ±0.3	4.42 ^b ±0.3	5.51 ^a ±0.4	2.77 ^d ±0.1	3.4 ^c ±0.3	4.52 ^b ±0.3
DPPH (µmol TE/100g)	0.0±0.0	45.9 ^c ±3	67.9 ^b ±2	83.7 ^a ±4	40.9 ^c ±1	57.8 ^{bc} ±2	63.8 ^b ±2

Control: ice cream without supplement; Ki: Kiwi; Pa: pineapple; TPC: total phenolic compounds; TFL: total flavonoids

Table 6: Organoleptic properties of ice cream fortified with different concentrations of pineapple and kiwi juices.

Organoleptic parameters	Ice-cream formulas						
	Control	Ki 10%	Ki 15%	Ki 20%	Pa10%	Pa 15%	Pa 20%
Color	9.2 ^a ±0.4	9.0 ^b ±0.2	9.2 ^a ±0.24	8.7 ^c ±0.23	8.9 ^b ±0.25	9.3 ^c ±0.24	8.3 ^d ±0.2
Flavor	35.1 ^{ab} ±0.8	32.4 ^c ±1.4	35.4 ^a ±1.1	34.9 ^{ab} ±1.2	31.2 ^d ±1.1	34.8 ^{ab} ±1.2	33.9 ^b ±1.2
Body& Texture	28.3 ^a ±0.6	27.4 ^b ±1.1	28.1 ^a ±0.7	27.9 ^{ab} ±1	26.4 ^c ±1	27.2 ^b ±0.7	26.5 ^c ±1.1
Melting	9.25 ^a ±0.3	9.15 ^a ±0.3	8.42 ^c ±0.4	8.15 ^c ±0.5	8.77 ^b ±0.3	8.25 ^c ±0.4	8.11 ^c ±0.4
Appearance	9.4 ^a ±0.3	9.25 ^{ab} ±0.3	9.47 ^a ±0.2	9.17 ^c ±0.1	9.15 ^c ±0.3	9.27 ^{ab} ±0.3	9.13 ^c ±0.2
Overall acceptability	91.25 ^a ±1.3	87.2 ^c ±1.6	90.6 ^a ±1.2	88.8 ^b ±2.4	84.72 ^d ±2.6	88.22 ^c ±2.2	85.94 ^d ±2.4

Furthermore, vitamin C shows a comparable trend to that of TPC and TF, specifying that increasing kiwi and pineapple juices supplementation levels increased the content of vitamin C. As shown as an adequate quantity of vitamin C through dietary consumption is essential for persons who do not have the ability to synthesize this compound, but need it to neutralize the reactive oxygen species (Rababah et al. 2005). In addition, the antioxidant activities of kiwi and pineapple juices ice cream sample are presented. Kiwi juice-ice cream and pineapple juice-ice cream exhibited higher antioxidant activity as compared to the control ice cream. The DPPH radical scavenging activity of 10% kiwi juice-ice cream was 45.9µmol TE/100 g DW, which significantly ($P < 0.05$) increased by increasing the supplementation level. A similar trend was also observed for pineapple juice-ice cream samples. The obtained results are in agreement with the findings previously reported (Barakat and Hassan, 2017; Nguyen and Hwang, 2016).

Sensory evaluation of ice cream formulas

Table 6 shows the sensory evaluation scores of kiwi juice- and pineapple juice-ice cream samples as compared to the control ice cream. The supplementation of ice cream with kiwi juice and pineapple juice at sequential concentrations was related to a statistically substantial influence on the organoleptic parameters of ice cream samples including the color, flavor, texture, melting and the overall acceptability. Regarding the color scores, the highest scores were recorded for the control sample and 15% Kiwi juice-ice cream, while the lowest scores were detected for the ice cream sample supplemented with 20% of pineapple juice. It was reported that the color and flavor of ice cream supplemented

with vegetables or fruits were improved (Hassan and Barakat, 2018; Singh et al. 2006). The flavor of the ice cream samples containing 15% of kiwi juice showed the highest score (35.4) while lowest scores were detected in 10% pineapple juice-ice cream (31.4) and 10% kiwi juice-ice cream (32.4). The flavor of pineapple juice-ice cream increased with the increase in the supplementation ratio. There were significant variations in the texture and melting characteristics among the different treatments of ice cream formulations. The recorded scores for the appearance were not significantly ($P > 0.05$) influenced. Consequently, the rheological properties of the different ice cream formulas need further evaluation. The overall acceptability of the control sample, 15% and 20% kiwi juice-ice cream showed the highest scores (90.8, 90.4, and 89.8, respectively) as compared to the other formulations of ice cream. It is clearly shown that panelists favored the prepared ice cream formulas with kiwi and pineapple juices and gave the samples high scores. Thus, scaling up these economics formulas as designated in this investigation could be concerned as also suggested for commercial production (Denzil, 2014). In a similar study, Ishimoto (2008) performed sensory analysis of ice lollies and sorbets made with dry bagasse from grape juice production. The authors reported mean colour scores of 7.81 and 7.49 for ice lollies and sorbet, respectively, while aroma received corresponding scores of 6.81 and 7.02, values that were close to those obtained in this study.

CONCLUSION

This study shows the potential value of kiwi and pineapple juices as a good natural source of energy and nutritive components. Based on its medium sweetness, nutritive value and attractive stable colors, kiwi and pineapple may be used as a good suitable source of natural additives or substituted materials for the production of several

products like ice cream. Ice-cream formulated with kiwi and pineapple juices showed higher antioxidant activity than the control and. In addition, it had the flavor, odor and color of kiwi and pineapple. Thus, the products do not require the addition of synthetic flavorings or colorants. Although, addition of kiwi and pineapple juices to ice cream mix resulted a very desirable product especially at 15% substitution, therefore we extremely believe in the possibility of producing highly delicate and nutritive kiwi and pineapple juices ice cream on the industrial scale. Therefore, the intake of functional foods along with their composition can be more beneficial to increased nutritional properties of foods such as ice cream. Therefore, our study may provide a base of knowledge for future research.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

KME suggested the point of this manuscript. MSA developed the idea. AHA and ABMM conceived and designed the experiments. KME and MSA follow up the results of the different experiments. AHA prepared and wrote the introduction and methodology sections and performed the practical part. ABMM prepared the study tools and collected data, executed the program and reviewed data analysis. All authors read and approved the final version.

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