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Utilization of camel's milk for preparation of banana, guava, persimmon, and mango ice milk

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Abstract: The present work was focused on application of camel's milk with banana, guava, persimmon, and zebda-mango fruits for preparation ice milk. Four ice milk treatments [T_B (banana), T_G (guava), T_P (persimmon), and T_Z (zebda-mango)] besides the first control [C* (contains cow's milk)] and second control [C** (contains camel's milk)] were prepared. The chemical analysis between different fruits showed noticeable differences in the total solids (TS), fat, protein, ash, crude fiber, carbohydrate, total soluble solids (TSS), pH value, radical scavenging activity (RSA), and total phenolic compounds (TPC). The physicochemical properties (especially freezing point, pH value and acidity) besides the rheological parameters of ice milk mixtures showed significant ($p < 0.05$) changes between controls and fruits treatments, in addition the rheological parameters (except flow behaviour index) of $T_G > T_Z > T_P > T_B > C^* \approx C^{**}$. During aging times from fresh up to 4 hrs, the rheological parameters (apparent and plastic viscosities, and consistency coefficient) were increased significantly, but the yield stress and flow behaviour index were decreased significantly. The physicochemical properties of fruits ice milk treatments whether at 1 or 30 days showed significant differences between controls and fruits ice milk treatments. With regard to the RSA and TPC of ice milk treatments, the treatments were recorded significant increases in the previous parameters than controls. Through the storage periods, the significant decreases in each RSA and TPC values were reported. The melting rates of $C^{**} \approx C^{*} > T_B > T_P > T_Z > T_G$ were noticed throughout the storage periods of 1 and 30 days. Zebda-mango ice milk was ranked the best treatment according to the panelist's judgment, followed by banana, persimmon, and then guava ice milk treatments. The total production costs showed that the $T_P > C^{**} \approx T_G \approx T_Z > T_B > C^*$, in addition the profits of $C^* > T_B > C^{**} \approx T_G \approx T_Z > T_P$, when the present treatments compared with the selling price in supermarket.

Keywords: Banana, camel's milk, guava, ice milk, and zebda-mango.

1. Introduction

Camels (*Camelus bactrianus* and *Camelus dromedarius*) are domesticated in the areas of arid and semi-arid owing of it's well adapted to live in the cruel climate. Camel's milk is consumed in the different areas because of it’s the nutritional and medicinal characteristics [1]; also camel's milk is considered a substantial source of the major and minor components for people in many areas. Approximately 2.9 million tones of camel's milk are obtained worldwide. Moreover, camel's milk distinguished a great attention by both scientists and dairy market producers lately, additionally it contains low αs_1-casein, high β-casein, and high unsaturated fatty acids, besides that the β-lactoglobulin not found. Camel's milk is low in the cholesterol level, whereas it high in vitamins C and B, minerals, and α-hydroxyl acids, furthermore it contains the protective proteins such as immunoglobulins, lactoferrin, and lysozyme, which in turn have the antimicrobial properties besides that the therapeutic possibilities (anemia, diabetes, arthritis, jaundice, and cancer or tumor). Camel's milk can be utilized in many dairy products likes soft cheese, fermented milk, beverages.....etc. [2,3].

As known, ice cream is common and widely consumed especially in the countries which have hot climate like the Middle East [4]. Ice cream is a sweetened frozen dairy product mostly consumed as a dessert or snack. Ice cream contained milk, cream, sugar or sugar alternatives, stabilizer, emulsifier, fruits and colourants. Preparation of ice cream was done through blended the previous contents, followed by agitated to incorporate the air spaces and then cooled down below the water freezing point to prepare the final ice cream product [5].

Ice cream manufacturing from camel’s milk besides the other formulation created dairy product has lower dry matter, viscosity, and melting point compared to cow’s milk ice cream [6], therefore the early studies created ice cream containing camel’s milk with bovine milk, consequently the resultant parameters of sensory evaluation were accepted [7]. Additives and flavouring ingredients were reported in the preparation of camel’s milk ice cream to improve the sensory evaluation, nutritional value and health benefits [8].

Banana fruit is one of an important tropical fruits in the world market, furthermore it has many minerals such as phosphorus, calcium, potassium and nitrogen which in turn help to keep healthy tissues, moreover it's a good source of carbohydrates, vitamins, and other minerals, which is considered essential part of the human diet [9]. Banana fruit is famous in many fields such as the nutritional, traditional, and medicinal applications. It has 22.84 g carbohydrates / 100 g, and 358 mg potassium /100 g that represented 8% of daily recommended value [10].

Guava (*Psidium guajava* L.) is grown in the tropical and subtropical regions, it has a high nutritive value, and gives fruit one or two times in a year, but the best quality type fruit which results in winter season. Guava fruit is called as "apple of the poor" owing of it's a high nutritive value, low cost, and easy availability. Also, it acts an important role in reducing the nutritive disorders because of vitamin C deficiency in human health [11,12]. Guava is rich in phenol compounds, flavonoids, lectins, tannins, triterpenes, essential oils, saponins, carotenoids, vitamins A, B3 (niacin), B5 (pantothenic acid), and C, dietary fiber, minerals (calcium, phosphorus, and iron), and fatty acids [13-15].

Mango (*Mangifera indica* L.) is a source of reducing and nonreducing sugars, fats, minerals, vitamins, dietary fibers, antioxidants, polyphenols, tannins, flavour compounds and pigments with the high energy value of 60 kcal / 100 g of mango [16]. Also, mango fruit is a source of bioactive compounds (i.e. provitamin a carotenoids, ascorbic acid (vitamin C) and phenolic compounds) and fibers [17]. Mango pulp is a source of amino acids, reducing sugars, aromatic compounds, and functional compounds, such as vitamins, pectin, anthocyanins and polyphenols [18]. Mango fruit has industrial application whether it's immature or fully ripe [19].Persimmon (*Diospyros kaki* L.) was characterized a precise nature, poor handling applications, sensitive texture and inadequate storage conditions, therefore both the novel automatic systems and developing fast were created for solving the foregoing problems [20]. Persimmon cultivars have astringent falvour because of high soluble tannin content. In addition, an astringent falvour was created when the soluble tannins linked with salivary proteins, followed by aggregation or precipitation, which leads to a dry sensation or a rough "sandpapery" in the mouth. Moreover, the persimmons can be divided into two groups: 1) astringent and 2) non-astringent (sweet persimmons) [21]. The purpose of the present work was focused on application of camel's milk for preparation of ice milk supplemented with banana, guava, persimmon, and zebda-mango fruits.

2. Materials and Methods

2.1. Materials

Cow's milk (12.57% TS, 3.80% fat, 3.45% protein, 8.77% milk solid not fat (MSNF), and 0.67% ash) was obtained from Dairy Department, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt. Camel's milk (.1076% TS, 2.80% fat, 2.75% protein, 7.96% MSNF, and 0.66% ash) was purchased from Bir Al-Abed, North Sinai Governorate, Egypt. Banana, guava, persimmon, and zebda-mango fruits, and sugar were purchased from local market in Ismailia, Egypt. Whole milk powder (WMP) (97.50% TS, 28% fat, 34.20% protein, 69.50% MSNF, and 6.80% ash) and skim milk powder (SMP) (97% TS, 1.30% fat, 35.77% protein, 95.7% MSNF, and 7.93% ash) were imported from United States, and purchased from local market in Ismailia, Egypt. Sodium carboxymethyl cellulose (CMC) was obtained from Al Gomhoria Co., Cairo, Egypt. Folin-Ciocalteu reagent and 1, 1-diphenyl-2-picrylhydrazyl (DPPH) were imported from Sigma Chemical Co., (St. Louis, MO, USA), and obtained from El-Nasr pharmaceutical and chemical Co., Cairo, Egypt. Other chemicals were in a good analytical grade.

2.2. Methods

2.2.1. Preparation of banana pulp

Banana fruit was cleaned for 5 minutes (min) by tap water. Banana peel was removed manually, banana pulp was cut into small pieces by knife and well mixed by a masher. Banana pieces placed in the screw capped plastic containers and stored at 4 °C in the refrigerator before adding to the initial freezing step in ice milk equipment.

2.2.2. Preparation of guava pulp

Guava fruit was cleaned for 5 min by tap water. Guava fruit was cut into two parts by knife, the inside seeds were removed from guava fruit, the obtained was cut into small pieces, followed by milling using electric mixer and the mashed guava pulp was placed in the sterilized plastic bags, and then stored at 4 °C in the refrigerator until use.

2.2.3. Preparation of persimmon pulp

Mature persimmon fruit was cleaned for 5 min by tap water. Persimmon fruit was mixed well using the electric mixer, filtration of persimmon mixture was done using strainer, and the pulp was placed in the screw capped plastic containers at 4 °C in the refrigerator before adding to the initial freezing step in ice cream equipment.

2.2.4. Preparation of zebda-mango pulp

Zebda-mango fruit were washed with tap water for 5 min by tap water. Mango peel was removed, mango pulp cut into small pieces by knife, homogenized using blender, placed in sealed bags and kept at 4 °C in the refrigerator before until use.

2.2.5. Preparation of ice milk supported by different fruits

Ice milk mix and flavoured ice milk mixes were made as described by Marshall and Arbuckle [22]. The formulations of different types of ice milk mixes are tabulated in Table 1. Whole milk powder and skim milk powder were mixed with sugar and CMC to create a dry mixes. Dry mixes were added slowly to cow's milk or camel's milk and distilled water when the temperature was reached to 65 °C. The mixture was heated to 80 °C / 15 min, followed by cooling to 5 °C. The resultant mixes were mixed well with banana, guava, persimmon and zebda-mango pulps (1.5% TS) by electric mixer followed by aging for 4 hrs, and the freezing and whipping were done together in an ice cream maker (Taylormate TM Model 152, Taylor Company, Blackhawk Blvd, USA). Samples of flavoured ice milk were collected, placed in 80 ml plastic cups and stored at –20 °C until analyzed.

Table 1. Formulations of flavoured-ice milk

Ingredients	Kg /100 kg mix▼					
	C*	C**	T_B	T_G	T_P	T_Z
Water	45.42	36.58	32.05	31.05	30.61	30.38
Whole milk powder	10.71	10.71	10.71	10.71	10.71	10.71
Skim milk powder	2.35	1.80	0.23	0.23	0.23	0.23
Cow's milk	26.32	–	–	–	–	–
Camel's milk	–	35.71	35.71	35.71	35.71	35.71
CMC	0.20	0.20	0.20	0.20	0.20	0.20
White sugar	15	15	15	15	15	15
Banana pulp	–	–	6.10	–	–	–
Guava pulp	–	–	–	7.10	–	–
Persimmon pulp	–	–	–	–	7.54	–
Zebda-mango pulp	–	–	–	–	–	7.77
Total solids	31.57	31.55	31.48	31.48	31.48	31.48

C*: 4% fat (3% from WMP + 1% from cow's milk), 12.50% MSNF; C**: 4% fat (3% from WMP + 1% from camel's milk), 12.50% MSNF; T_B: 4% fat (3% from WMP + 1% from camel's milk), 11% MSNF and 1.5% banana pulp solids; T_G: 4% fat (3% from WMP + 1% from camel's milk), 11% MSNF and 1.5% guava solids; T_P: 4% fat (3% from WMP + 1% from camel's milk), 11% MSNF and 1.5% persimmon pulp solids and T_Z: 4% fat (3% from WMP + 1% from camel's milk), 11% MSNF and 1.5% zebda-mango pulp solids.

2.3. Analysis of fruits, ice milk mixes and ice milk products

2.3.1. The TS, fat, protein contents, and acidity of samples were determined according to methods of AOAC [23]. The pH values of ice milk treatments were determined using the pH meter with a glass electrode (HANNA - Instrument - Portugal). The TSS of different samples were determined with an ATAGO type refractometer (Schmidt Haenach, Germay) and the values were expressed as degree °Brix (%).

2.3.2. Radical scavenging activity

The RSA was determination by the DPPH according to Hwang and Do Thi [24]. The hydrogen atom or electron donation abilities of the samples and some pure compounds were measured from a lightpurple colored DPPH methanol solution. One milliliter of various concentrations (100 ~ 1.000 µg / mL) of each extract in 10% ethanol was added to a 1 mL DPPH radical solution in methanol (final DPPH concentration, 0.2 mM). The mixture was shaken vigorously, allowed to stand for 25 min and the absorbance of the resulting solution was measured at 515 nm. The percent inhibition of the DPPH free radical was calculated by the following equation:

$$\text{Inhibition of DPPH (\%)} = \frac{A_{(\text{control})} - A_{(\text{sample})}}{A_{(\text{control})}} \times 100$$

Where, $A_{\text{control:}}$ is the absorbance of the control reaction (containing all reagents except test compound). $A_{\text{sample:}}$ is the absorbance with the test compound.

2.3.3. Total phenolic compounds

The TPC were determined in the methanolic extracts using Folin-Ciocalteu as determined by Barros et al. [25]. Aliquot of 0.1 ml extract was mixed with 5 ml of Folin-Ciocalteu phenol reagent [diluted with distilled water 1:10 (v/v)] and 4 ml of anhydrous sodium carbonate [7.5 % (w/v)]. The tubes were whirled for 30 s and allowed to stand for 60 min at room temperature (25 ± 1 °C) for colour development. The absorbance was measured at 765 nm by spectrophotometer (model 6505 UV/Vis, Jenway, UK). A calibration curve of gallic acid (0 – 0.10 mg / ml) was prepared and the TPC was determined from the linear regression equation (R^2 = 0.9986) of the calibration curve. The results were expressed as mg of gallic acid equivalent per 100 g of sample.

2.3.4. Specific gravity

The specific gravity of ice milk mix was measured by using of a bottle pyconometer as described by Winton [26] at 20 °C. Specific gravity of resultant ice milk samples was carried out by means of filling a cool cup (with known weight and volume) with ice milk mix, then weighted and the weight of contents calculated. Finally, specific gravity was obtained by dividing the weight of the frozen ice milk by the cup volume. Specific gravity = weight of ice cream / cup volume.

2.3.5. Calculation of weight per gallon

Weight per gallon of both of ice milk mix and ice milk in kilogram was determined according to Burke [27] by multiplying the specific gravity of the mix and ice milk by the factor 4.5461.

2.3.6. Calculation of the overrun

The overrun percent of the resultant ice milk was calculated as mentioned by Marshall and Arbuckle [22] by the following equation: % Overrun = [(volume of ice milk – volume of mix) / (volume of mix)] ×100

2.3.7. Freezing point for ice milk mix

Freezing point mixes was determined according to the method of Arbuckle [28] as follows: Amount of 75 ml of ice milk mix sample was placed to test tube (100 –120 ml) and placed in the frozen brine (100 g NaCl /1000 g distilled water). About 2 kg small ice flakes was added to the brine solution. Thermometer which has different units was placed in the mix. Manually agitation all the time was used with following the change on the thermometer. At first a steady decrease in the temperature, then a sudden rise and the temperature will be constant for some time. This constant for some time is the freezing point of the mix.

2.3.8. Melting rate

Melting rate of the ice milk treatments was determined as reported by Segall and Goff [29]. Samples of ice milk were left to melt at room temperature (25 ± 1 °C) and the melted portion was weighed every 10 min. The percent mass loss / min in the linear region (slope) were used to compare the meltdown rate of different samples.

2.3.9. Rheological measurements of ice milk mixtures

The rheological parameters (apparent viscosity, plastic viscosity, yield stress, consistency coefficient, and flow behavior index) of flavoured ice milk mixtures were carried out at 10 °C by using a Brookfield viscometer (Brookfield-Engineering Laboratories, USA) equipped with SC4-21 spindle running at 50 rpm. The rheological measurements were done in triplicate.

2.3.10. Sensory evaluation

Samples of ice milk (80 ml) were stored at –20 °C. Flavoured ice milk was brought from freezer. The staff members of sensory panel were composed from 12 panelists working in Dairy Department, Faculty of Agriculture, Suez Canal University, Egypt. The treatments were analyzed using the scale of 9-point hedonic according to Stone and Sidel [30] for colour and appearance, flavour, body and texture, melting quality and overall acceptability.

2.3.11. Cost of production and the profit of ice milk

Production costs and the profit of all treatments were calculated according to prices of materials used in ice milk manufacture in the Egyptian market.

2.3.12. Statistical analysis

Results of treatments were analyzed statistically by the two way analyses of variance using computer program software SAS (version 8 for Windows, USA). A Duncan analysis ($p < 0.05$) was used to determine the differences between mean values of treatments.

3. Results and discussion

3.1. Chemical analysis of banana, guava, persimmon, and zebda-mango pulps

The chemical analysis of banana, guava, persimmon, and zebda-mango pulps are shown in Table 2. The TS of banana, guava, persimmon, and zebda-mango pulps were 24.60, 21.19, 19.90, and 19.30%, respectively. Fat, ash, and carbohydrate contents of banana pulp were slightly higher than other fruits, while the crude fibers (4.97%) were higher in guava pulp. The highest of TSS and pH values were related to (zebda-mango pulp and persimmon pulp) and persimmon pulp, respectively. Both the RSA and TPC values were higher in the persimmon pulp compared to other fruit pulps. Therefore, the variations among four types of fruits in their parameters will affect the resultant flavoured ice milk treatments.

The present data are in agreement with that observed by Dar et al. [16], they found that the protein, fat, carbohydrate, fiber, and ash contents of mango fruit (*Mangifera indica* L.) cultivars were 0.51, 0.27, 17, 1.8, and 0.50%, respectively. According to Guiamba [17], the chemical parameters of mango fruit was 83.5% moisture, 0.8% protein, 0.4% fat, 15% carbohydrate, and 1.5% fiber contents. Othman and Mbogo [31] reported that the TSS, fat, fiber, and ash contents of mango fruit were (14.5 – 30%), 0.20, 0.85, and 0.55%, respectively. Moreover, the fiber content of Dodo mangoes (Morogoro, Tanzania) reached to 3.7% [32]. The findings of Yousaf et al. [33] were close to our results in many parameters, they showed that the guava fruits varieties recorded 83% moisture, 2.58% protein, 0.6% fat, 0.7% ash, 2.8 – 5.5% fiber, 15% carbohydrate, 3.76 – 4.47 pH values, and 5.3 – 8.10 TSS. On the other hand, the TPC of guava fruit was 148 mg gallic acid/100 g [34]. From the point of view Ozen et al. [35], the persimmon fruit contains 80.3% moisture, 0.58% protein, 0.19% lipids, 18.6% carbohydrate, vitamins, minerals (magnesium, potassium, zinc, copper, iron, and manganese) and organic acids. Gautam et al. [36] showed that the kaki fruit without peel included 79.34% moisture, 15.95% TSS, 0.12% acidity, 5.86 pH value, 0.66% fiber, 0.38% ash, 3.75 TPC mg gallic acid/100 g, and 75.82% RSA. Also, the parameters of 18.59% carbohydrate, 0.19% fat, and 0.58% protein were determined by Yaqub et al. [37], and are in line with our data. Furthermore, the pH values, TSS, and colour (lightness, redness, and yellowness) of the ripe persimmon fruit were 6.16, 19.54, and (64.63, 35.45, and 45.65), respectively [38]. It could be noted that, the variations among the parameters of same fruits can be related to fruits properties, climate, soil type, fertilization, harvest time, processing, and storing conditions.

Table 2. Chemical analysis of banana, guava, persimmon, and zebda-mango pulps

Parameters	Banana pulp	Guava pulp	Persimmon pulp	Zebda-mango pulp
TS %	24.60±0.43	21.19±0.35	19.90±0.25	19.30±0.15
Fat %	0.91±0.05	0.55±0.04	0.73±0.06	0.74±0.05
Protein %	0.80±0.06	0.85±0.08	0.46±0.03	0.55±0.05
Ash %	0.83±0.06	0.78±0.08	0.66±0.06	0.61±0.03
Crude fiber %	2.13±0.10	4.97±0.14	3.25±0.10	3.90±0.80
Carbohydrate %	22.07±0.32	19.01±0.20	18.05±0.16	17.40±0.42
TSS (°Brix) %	17.60±0.18	13.20±0.30	20.10±0.43	20.15±0.33
pH value	5.10±0.15	4.82±0.12	5.56±0.16	4.68±0.11
RSA %	20.80±0.46	56.57±0.67	61.45±1.14	50.37±0.75
TPC (mg gallic acid /100 g)	76.50±0.93	122.86±3.25	125.70±3.65	115.50±2.58

TS: total solids; RSA: radical scavenging activity (DPPH); TPC: total phenolic compounds; TSS: Total soluble solids

3.2. Physicochemical properties of flavoured ice milk mixtures

Table 3 shows the physicochemical characteristics of ice milk mixtures supported with banana, guava, persimmon, and zebda-mango pulps. Obviously, the differences between the C* and C** were insignificant ($p > 0.05$) with regard to their specific gravity, weight per gallon, and freezing point, but the pH value and acidity of the C* were lower and higher significantly ($p < 0.05$), respectively than the C**, due to the TS of cow's milk was higher than camel's milk, moreover the TS have positively relation with the acidity. Also, the specific gravity and weight per gallon of T_B, T_G, T_P, and T_Z compared to the C** were showed insignificant ($p > 0.05$) differences, owing of the TS of all ice milk mixtures were almost identical. Hasan et al. [39] observed that the specific weight ice cream increased with the increase of fruit powders owing of the increment in TS of ice cream treatments. In contrast the same previous treatments (T_B – T_Z) were recorded significant ($p < 0.05$) differences in parameters of freezing point, pH value, and acidity.

The freezing points of C^*, C^{**}, T_P, and T_Z were resemble ($p > 0.05$) together (–2.40 °C) and lower than T_B and T_G (–2.37 °C), this can be explained by the effect of different components which come from dairy ingredient and fruit in the formulation on the freezing point, such as sugar, salts, fiber, and TSS. The early study of Arbuckle [28] mentioned that the freezing point of ice cream mixtures reflected many of molecules in the solution, especially sugar content which represented the predominant component. On the other hand, Hassan and Hussein [40] showed that the minimum freezing points in ice cream mixtures probably as a result of high ash and fiber content which come from the persimmon fruit compared to control treatment. The pH values and acidities of T_B up to T_Z recorded significant ($p < 0.05$) decreases and increases, respectively compared to the C** due to the fruits supplementation (banana, guava, persimmon, and zebda-mango pulps), which of course varied among together in their pH values and acidities. The present data are in harmony with that observed by Hassan and Hussein [40], they showed that the pH values slightly declined with persimmon addition in ice cream preparation, owing of the low persimmon pH value (pH 5.53). Güven and Karaca [41] reported that the acidity of fruit frozen yoghurt increased with the increase of fruit content, besides the probiotic cultures. Pratap et al. [42] reported that the acidity of frozen yoghurt blended with banana / plantain species significantly changed compared to control treatment. Sulejmani and Demiri [43] reported that the use milk powder, sugar, and emulsifier in the production of ice cream significantly affected the pH values of ice cream treatments.

3.3. Rheological measurements of flavoured ice milk mixtures

Table 3 represents the rheological measurements of flavoured ice milk mixes during aging step. According to the present rheological measurements (apparent and plastic viscosities, yield stress, consistency coefficient, and flow behaviour index), no significant ($P > 0.05$) differences were observed between the two controls, due to the TS of each C* and C** formulations were close together. In addition, the differences between all the flavoured ice cream mixes and the two controls were significant ($P < 0.05$), besides that the rheological characteristics (except the flow behaviour index) were ordered as the follows: $T_G > T_Z > T_P > T_B > C^* \approx C^{**}$. This can be attributed to the fiber contents of different fruits (see Table 1) which have high WBC, besides its role to increase the viscosities of ice milk mixtures. Taking into account that the carbohydrate exhibited viscous behaviour sometimes has good WBC than protein [44]. Klopfenstein [45] reported that the viscosity of ice cream mixture was increased owing of Ragi fiber content (22%), moreover the fiber content increased viscosity parameter through networks formation of hydrated cellulose besides hemicelluloses [46].

The early studies of Sreenath et al. [47] are in agreement with our data, such as the insoluble fiber of mango pulp is responsible for the viscous behaviour. Also, Patel et al. [48] stated that the viscosity increment in mango ice cream mixtures related to pectin of mango pulp addition. Vani and Zayas [49] revealed that the high persimmon fiber has substantial role for forming viscous, due to it high WBC. Furthermore, the yield stress and consistency coefficient of persimmon milk drink increased in parallel the increment of persimmon level due to its sugar, and hydrocolloid such as pectin [50]. Marshall et al. [51] noticed that the persimmon supplementation in ice cream mixture had been improved the viscosity. Furthermore, the WBC and viscosity of yoghurt supported by apple and banana fruits compared control treatments were higher due to the fiber content of mango fruit [52].

During aging from fresh up to 4 hrs, the apparent and plastic viscosities, and consistency coefficient of all ice milk mixtures were increased significantly ($p < 0.05$), but both yield stress and flow behaviour index were decreased significantly ($P < 0.05$). This can be related to the hardening of fat, and the increase of water imbibed by protein and CMC.

It is could be noted that, the relation between the parameters of each viscosity, overrun, and melting rate was positively. According to Marshall et al. [51], the higher ice cream viscosity has been resulted greater melting resistant. In contrast Alizadeh et al. [53] showed that the relation between the parameters of each viscosity and overrun was inversely in ice cream supplementation with stevia levels.

Table 3. Physicochemical and rheological properties of flavoured ice milk mixtures

Parameters		Treatments$^{▼}$ C*	C**	T_B	T_G	T_P	T_Z
SG		1.1090±0.0007^{A}	1.1088±0.0006^{A}	1.1087±0.0007^{A}	1.1085±0.0008^{A}	1.1089±0.0007^{A}	1.1086±0.0009^{A}
WG (kg)		5.0416±0.0029^{A}	5.0407±0.0027^{A}	5.0403±0.0023^{A}	5.0393±0.0030^{A}	5.0412±0.0025^{A}	5.0398±0.0028^{A}
FP (°C)		–2.40±0.02^{B}	–2.40±0.01^{B}	–2.37±0.01^{A}	–2.37±0.01^{A}	–2.40±0.02^{B}	–2.40±0.01^{B}
pH value		6.40±0.02^{B}	6.45±0.03^{A}	6.36±0.03^{BC}	6.35±0.02^{C}	6.38±0.02^{BC}	6.30±0.03^{D}
Acidity (%)		0.25±0.01^{D}	0.23±0.01^{E}	0.29±0.01^{BC}	0.31±0.03^{AB}	0.27±0.01^{CD}	0.34±0.03^{A}
Plastic viscosity (mPa.s)	Fresh	68.10±0.45^{Dc}	67.57±0.47^{Dc}	69.12±0.40^{Cc}	75.53±0.55^{Ac}	71.87±0.52^{Bc}	72.15±0.48^{Bc}
	2 hrs	81.13±0.48^{Db}	80.76±0.46^{Db}	82.56±0.62^{Cb}	90.21±0.44^{Ab}	85.11±0.43^{Bb}	85.75±0.47^{Bb}
	4 hrs	97.22±0.44^{Da}	96.35±0.45^{Da}	98.36±0.50^{Ca}	106.88±0.58^{Aa}	101.95±0.44^{Ba}	101.66±0.54^{Ba}
Yield stress (mPa.s)	Fresh	6.05±0.09^{Da}	5.95±0.08^{Da}	6.55±0.10^{Ca}	8.72±0.18^{Aa}	6.87±0.05^{Ba}	6.90±0.17^{Ba}
	2 hrs	5.85±0.08^{Db}	5.80±0.07^{Db}	6.32±0.08^{Cb}	8.10±0.11^{Ab}	6.68±0.08^{Bb}	6.76±0.14^{Bb}
	4 hrs	5.57±0.07^{Dc}	5.48±0.06^{Dc}	6.10±0.07^{Cc}	7.36±0.13^{Ac}	6.48±0.06^{Bc}	6.54±0.11^{Bc}
Consistency coefficient (mPa.s)	Fresh	95.15±1.85^{Dc}	94.22±1.75^{Dc}	98.45±1.93^{Cc}	111.27±1.70^{Ac}	102.22±0.98^{Bc}	102.90±1.72^{Bc}
	2 hrs	109.43±2.17^{Db}	108.70±2.22^{Db}	113.12±1.55^{Cb}	124.16±1.66^{Ab}	117.78±1.34^{Bb}	118.30±1.80^{Bb}
	4 hrs	121.6±2.32^{Ca}	120.11±1.84^{Ca}	125.66±1.78^{Ba}	136.67±1.89^{Aa}	127.84±1.74^{Ba}	128.91±1.91^{Ba}
Flow behaviour index	Fresh	0.79±0.03^{Aa}	0.77±0.03^{Aa}	0.70±0.01^{Ba}	0.50±0.02^{Da}	0.63±0.03^{Ca}	0.62±0.03^{Ca}
	2 hrs	0.68±0.03^{Ab}	0.66±0.02^{Ab}	0.61±0.02^{Bb}	0.45±0.02^{Db}	0.56±0.02^{Cb}	0.54±0.02^{Cb}
	4 hrs	0.59±0.02^{Ac}	0.58±0.03^{Ac}	0.53±0.03^{Bc}	0.39±0.01^{Dc}	0.48±0.01^{Cc}	0.47±0.03^{Cc}
Apparent viscosity (mPa.s)	Fresh	327.80±4.20^{CDc}	324.80±4.30^{Dc}	337.10±6.40^{BCc}	360.90±5.40^{Ac}	344.45±6.22^{Bc}	346.30±5.38^{Bc}
	2 hrs	353.90±3.95^{Db}	350.65±4.33^{Db}	360.85±6.78^{CDb}	385.93±5.71^{Ab}	370.56±5.92^{BCb}	373.91±7.15^{Bb}
	4 hrs	387.70±5.33^{Ca}	385.70±3.40^{Ca}	395.25±8.30^{Ca}	423.10±4.90^{Aa}	408.20±6.65^{Ba}	410.50±8.32^{Ba}

C*: 4% fat (3% from WMP + 1% from cow's milk), 12.50% MSNF; C**: 4% fat (3% from WMP + 1% from camel's milk), 12.50% MSNF; T_B: 4% fat (3% from WMP + 1% from camel's milk), 11% MSNF and 1.5% banana pulp solids; T_G: 4% fat (3% from WMP + 1% from camel's milk), 11% MSNF and 1.5% guava solids; T_P: 4% fat (3% from WMP + 1% from camel's milk), 11% MSNF and 1.5% persimmon pulp solids and T_Z: 4% fat (3% from WMP + 1% from camel's milk), 11% MSNF and 1.5% mango pulp solids; SG: Specific gravity; WG: Weight per gallon; FP: Freezing point.
Capital letters: mean values are significant ($p < 0.05$) with different letters for rows; small letters: mean values are significant ($p < 0.05$) with different letters for columns of each parameter; *, control; $^{▼}$: mean values

3.4. Physicochemical properties of flavoured ice milk products

Table 4 shows the physicochemical properties of flavoured ice milk products. The specific gravity, weight per gallon, overrun, and freezing time of C* and C** were without significant ($p > 0.05$) changes whether at 1 day or 30 days, because of the TS of two controls formulations were close together. On the other hand, the pH value of the C** was higher significantly ($p < 0.05$) than the C* owing of contribution of cow's milk (pH 6.67) in preparation of the C* compared to the C** which contains camel's milk (pH 6.73). It is clear that the specific gravity, weight per gallon, and pH values of the treatments (T_B – T_Z) were exhibited significant ($p < 0.05$) decreases than the control treatments, while the overrun and freezing time of the same treatments were showed significant ($p < 0.05$) increases than the controls at 1 day through the storage period. This can be attributed to the fruits addition, especially fiber content to ice milk preparations caused increases the overrun values which in turn affected the specific gravity and then weight per gallon. Moreover, the early work of Abdrabou and EI-Hofi [54] are in harmony with the present study, they reported that the reduction pH value of ice cream related to guava puree addition, due to guava fruit contains several acidic ingredients such as citric acid. Güven and Karaca [41] found that the increase of sugar and fruit levels caused the increase of each overrun and viscosity. On the other hand, Singh et al. [55] showed that the decrease in the specific gravity and weight per gallon of ice milk was in parallel the lack of air and moisture of ice cream. Moreover, Rawendra and Dwi [56] illustrated that the overrun of ice cream treatments increased with the increase of durian, melon, guava, and jackfruit fruits.

During the storage period at 30 days, the specific gravity, weight per gallon, overrun, and pH value of all treatments were recorded the same variations trends which at 1 day. Meanwhile, the specific gravity and weight per gallon values of treatments were increased statistically ($p < 0.05$), whereas the overrun and pH values were declined significantly ($p < 0.05$) than that at 1 day. Our results are in agreement with that mentioned by Singh et al. [55], they found the acidities of ice cream treatments increased significantly through the storage days, whereas the pH values decreased. In addition, the decline in overrun led to shrinkage of ice milk created heavy and dense; therefore the increase in the specific gravity was occurred. Also, Potter and Hotchkiss [57] stated that the ice cream shrinkage during storage period was resulted by the air loss owing of collapse of weakened films which leading to the volume loss. As well as, Güzeler et al. [58] found that the overrun decreased significantly in spite of the ice cream contained different stabilizers and emulsifiers. Noteworthy, the increase of specific gravity based on the formulation components, also mixture ability towards air pulps retention, and then the overrun in the treatments [51]. Many factors influence on the overrun such as fat, emulsifier, stabilizer, viscosity, and treating conditions [59,60]. The relation between the specific gravity and weight per gallon from one hand and the overrun from other hand was inversely. The relationship between the viscosity, overrun, and melting resistance was positively, therefore ice cream treatment which has low overrun will be melt-down quickly, in contrast a better melting resistance was obtained with high overrun, because of a more air volume in ice cream created slowly heat transfer [59]. Also, we can say the effects of ice milk ingredients on the specific gravity or overrun can be attributed to their impact on the apparent viscosity of ice milk mixture [54].

Table 4. Physicochemical properties of flavoured ice milk products

Treatments	Physicochemical properties of flavoured ice milk products▼				
	1 day				
	Specific gravity	Weight per gallon (kg)	Overrun (%)	Freezing time (min)	pH value
C*	0.7467±0.0008^{Ba}	3.3946±0.0028^{Ba}	48.02±0.45^{Ad}	13.83±0.10^{d}	6.43±0.03^{Ab}
C**	0.7471±0.0004^{Ba}	3.3965±0.0030^{Ba}	47.91±0.36^{Ad}	13.82±0.12^{d}	6.48±0.01^{Aa}
T_B	0.7427±0.0006^{Bb}	3.3760±0.0027^{Bb}	49.27±0.48^{Ac}	14.05±0.11^{c}	6.39±0.01^{Ac}
T_G	0.7268±0.0007^{Bd}	3.3043±0.0029^{Bd}	52.51±0.52^{Aa}	15.10±0.12^{a}	6.37±0.02^{Ac}
T_P	0.7339±0.0005^{Bc}	3.3363±0.0027^{Bc}	51.10±0.60^{Ab}	14.60±0.15^{b}	6.40±0.03^{Abc}
T_Z	0.7332±0.0008^{Bc}	3.3334±0.0031^{Bc}	51.19±0.49^{Ab}	14.66±0.11^{b}	6.33±0.02^{Ad}
Treatments	30 days				
C*	0.7549±0.0021^{Aa}	3.4320±0.0062^{Aa}	46.90±0.21^{Bd}	–	6.37±0.02^{Bb}
C**	0.7562±0.0018^{Aa}	3.4377±0.0075^{Aa}	46.63±0.33^{Bd}	–	6.41±0.03^{Ba}
T_B	0.7513±0.0012^{Ab}	3.4155±0.0056^{Ab}	47.57±0.28^{Bc}	–	6.30±0.01^{Bc}
T_G	0.7368±0.0019^{Ad}	3.3495±0.0068^{Ad}	50.45±0.52^{Ba}	–	6.29±0.02^{Bc}
T_P	0.7432±0.0011^{Ac}	3.3788±0.0048^{Ac}	49.20±0.38^{Bb}	–	6.34±0.01^{Bb}
T_Z	0.7433±0.0016^{Ac}	3.3790±0.0040^{Ac}	49.15±0.48^{Bb}	–	6.23±0.02^{Bd}

Capital letters: mean values are significant ($p < 0.05$) with different letters for of each treatment at the same storage period (1 day or 30 days); small letters: mean values are significant ($p < 0.05$) with the different letters for columns of the same parameter; *, control; **, control; ▼: mean values.

3.5. Radical scavenging activity and total phenolic compounds of ice milk treatments

Fig. 1 shows the RSA and TPC of ice milk treatments. Obviously, the two controls treatments have RSA and TPC, due to their phenolic compounds come from milk [61], besides that their protein and peptides contents have antioxidant activity [62]. Also, both casein and whey proteins have prospective bioactive proteins / peptides with significant antioxidant activity [63]. According to Chatterton et al. [64], the natural bioactive compounds in milk are oligosaccharides, growth factors, hormones, gangliosides, mucins, endogenous peptides, milk lipids, minerals, vitamins, trace elements, and nucleotides. Moreover, the C** has high levels of each RSA and TPC than the C*, which can be explained by the bioactive components (alkaloids, steroids, and glycosides) of camel's milk was higher than cow's milk [65]. Moreover, the bioactive peptides of camel's milk had higher functionality properties likes antioxidant activity, antimicrobial activity, and antihypertension effect compared to it's from bovine milk [66]. Furthermore, the bioactive peptides were created after the enzymatic activity of camel's colostrum, camel's milk, and whey proteins could be considered responsible for the increase antioxidant activity [67]. Camel's and yak's milk are abounding in many bioactive components, which has functional characteristics beyond its nutritive value [68]. The T_B, T_G, T_P, and T_Z recorded the higher RSA and TPC values than the controls treatments. This can be attributed to contribution the fruits supplementation (banana, guava, persimmon, and zebda-mango) which have high levels from each RSA and TPC (see Table 1). The clear confirmation from the early studies such as, Palafox-Carlos et al. [69] and Peng et al. [70] showed that the most phenolic compounds in mango were gallic acid, quercetin, chlorogenic acid, catechin, and syringic acids, in addition both gallic acid and chlorogenic acid represented the highest ingredients in mango fruit. Yousaf et al. [33] observed that the TPC of guava cultivars ranged from 94.06 – 190.64 mg gallic acid/100 g. Likewise, Alothman et al. [71] found that the TPC varied from 109 – 191 mg gallic acid /100 g. Also, the RSA of the same guava types ranged from 36.8 – 71%. Gil et al. [72] and Ribeiro et al. [73] reported that the TPC in mango fruit ranged from 9 – 208 mg gallic acid /100 g. It is clear that, both the persimmon and C* treatments were exhibited the highest and lowest of RSA and TPC values, respectively for along the storage periods. Results of Karaman et al. [74] are in line with our finding, they noticed rising the TPC of treatments in case of incorporation the persimmon in ice cream preparation. Also, the persimmon bioactivity was attributed to the water soluble fiber, trace elements, minerals, and phenolic which contributed in the RSA of fruit [75].

The storage periods from 1 day up to 30 days were showed significant ($P < 0.05$) decreases in the RSA and TPC of all treatments, which can be explained by the degradation of bioactive components through storage periods [55]. Moreover, Patthamakanokporn et al. [34] found that the TPC of guava fruit declined statistically owing of its degradation as the storage periods proceeding from fresh up to 90 days at –20 °C.

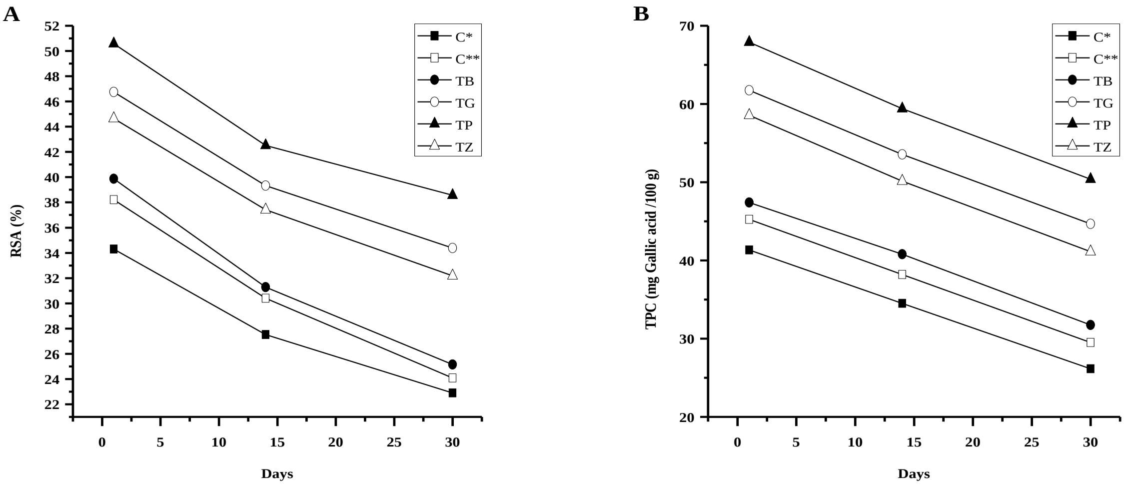


Fig. 1. Radical scavenging activity and total phenolic compounds of ice milk treatments

3.6. Melting rate of flavoured ice milk treatments

Fig. 2 shows that no significant ($p > 0.05$) changes in the melting rates of two controls were observed along times of 15, 30, 45, and 60 min whether at 1 day or 30 days. In addition, the melting rates of the two controls were acquired higher melting rates than banana, guava, persimmon, and zebda mango ice milk treatments, due to the fruit solid addition (1.5%) instead of SMP in ice milk formulations led to the increase of each WBC and the melting resistance owing of their fiber contents compared to controls. The previously studies of Rawendra and Dwi [56] and Walstra [76] are consistent with our data, they showed that the high fiber content in ice cream preparation increases the melting time. Also, Yangılar [77] revealed that the first dripping time was prolonged in parallel the increase of banana pulp in ice cream treatments. Moreover, adding mango pulp has been decreased the melting rates of ice cream treatments [48].

Fruits ice milk treatments were ordered according to the melting rates as the follows: $C^{**} \approx C^{*} > T_B > T_P > T_Z > T_G$ throughout the storage periods of 1 and 30 days. Noteworthy, the melting rates of all treatments at 30 days were decreased than that at 1 day, which explained by the overrun reduction during the end storage periods. Also, the relationship between melting rate from one hand and overrun besides viscosity values was inversely. In other words, the increase of melting resistance and smoothness were directly related with the viscosity increases [51]. Sofjan and Hartel [59] reported that the melting rate declined with the increment in air cells or air cells amount. However, Muse and Hartel [78] observed that the ice milk with low overrun will be melted slowly; additionally an inferior melting resistance with high overrun is mainly specialized to a diminish rate of heat transfer through air bubbles. According to the sensory evaluation scores, the best treatment was mango ice milk (T_Z) in spite of highest melting resistance was guava ice milk (T_G), therefore no relation between the sensory evaluation and the melting rates was observed [79]. As noted by Gorinstein et al. [80], the persimmon addition with ice cream preparation retarded the melting rate due to a high amount of persimmon fiber.

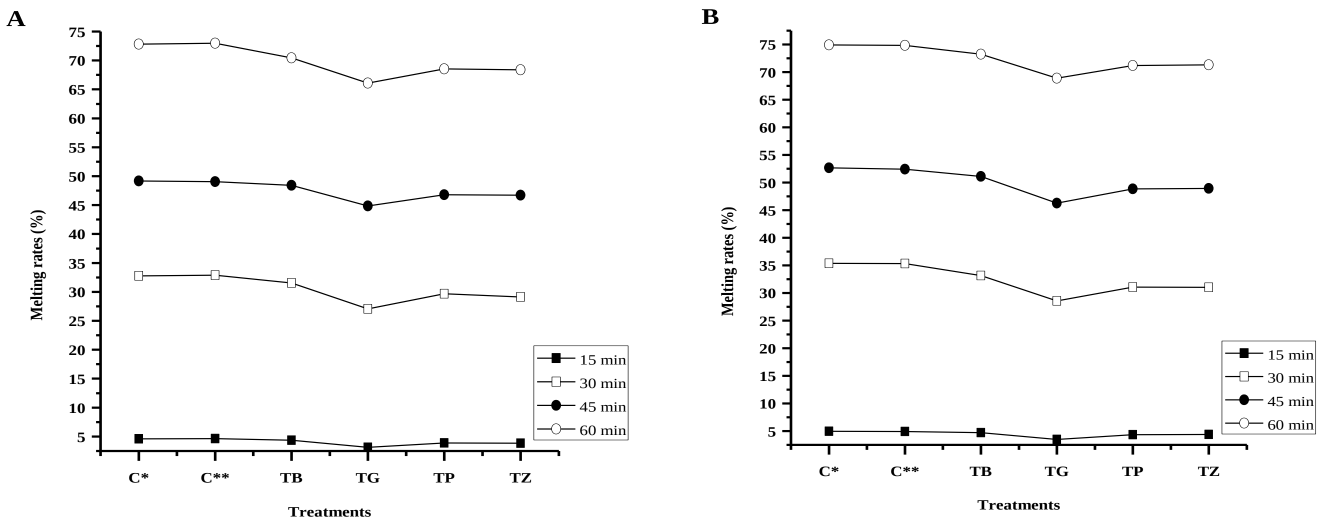
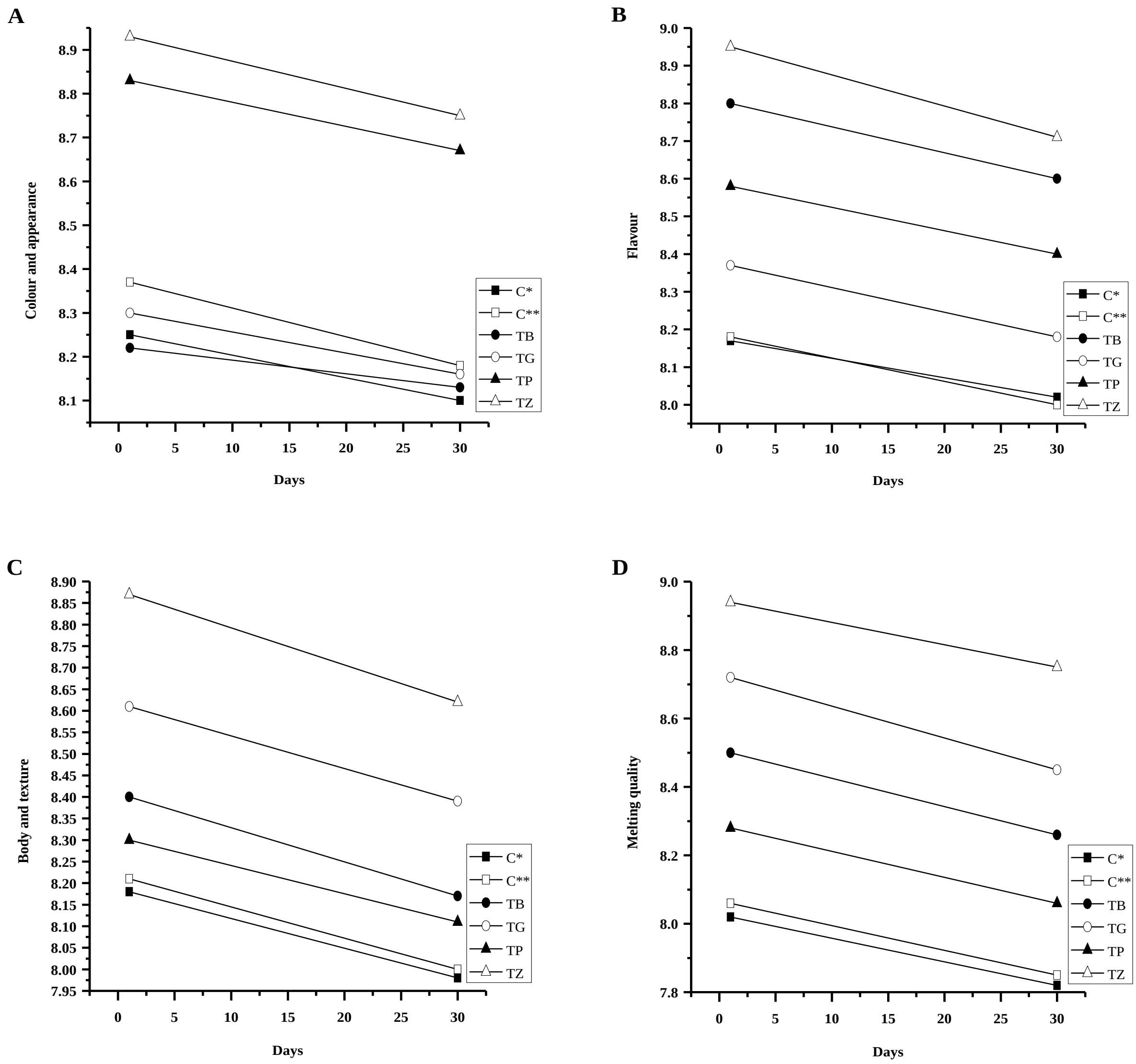


Fig. 2. Melting rates of flavoured ice milk treatments at 1 day (A) and 30 days (B)

3.7. Sensory evaluation of fruits ice milk treatments

The sensory evaluation scores of the fruits ice milk treatments are listed in Fig. 3 The parameters of colour and appearance, flavour, body and texture, and overall-acceptability were revealed insignificant ($p > 0.05$) changes between the two controls, whilst the same parameters were showed significant ($p < 0.05$) differences between controls treatments and the fruits based ice milk treatments. With regard to the parameter of colour and appearance, mango ice milk treatment and then persimmon ice milk ranked as the best treatments according to the sensory evaluation scores. Replacing of SMP by banana, guava, persimmon, and zebda-mango fruits as solids enhanced the flavour of ice milk treatments than the control (C**), in addition mango ice milk treatments ranked as best treatment followed by banana, persimmon, and then guava ice milk treatments. Jokar and Azizi [50] reported that the persimmon addition (10%) in milk drink led to rising of taste and consistency scores; however the taste, colour, and consistency scores increased in parallel persimmon addition from 5 up to 10%. Nonetheless, the sensory evaluation scores of the persimmon ice cream compared to unsupported ice cream were higher [74]. It is clear that, mango ice milk ranked as highest scores in parameters of body and texture, and melting quality, but the persimmon ice milk organoleptically appeared a lowest score. No coarse texture or weak body was noticed in all ice milk treatments, moreover no sandiness defect was observed in all ice milk treatments which related to the large ice crystals. Remarkable, the overall acceptability parameter was related with the flavour parameter; therefore the mango ice milk was ranked as the best one according to the panelist's scores. This can be attributed to desirable colour, and a pleasant flavour comes from mango supplementation. As the storage periods proceeding, all parameters of the sensory evaluation significantly ($P < 0.05$) decreased. The previous study of Singh et al. [55] illustrated that when the storage period proceeding, the moisture decreased from an ice cream; consequently the denser will be occurred, and then it will affect the mouthfeel. According to the obtained resulted, the storage periods should not be more than one month, due to the longer storage period will be caused undesired changes in ice milk characteristics [55].



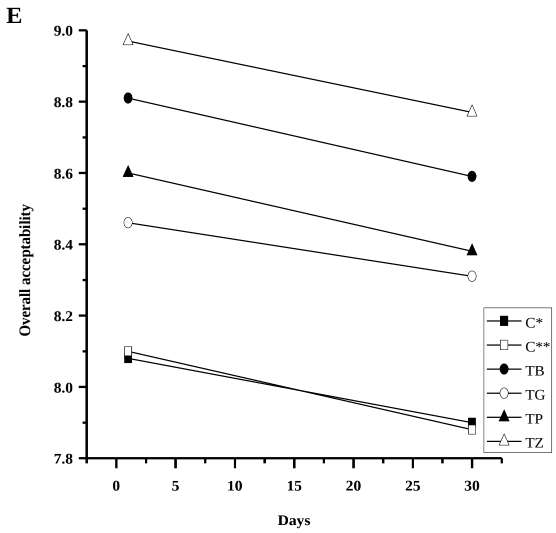


Fig. 3. Sensory evaluation of fruits ice milk treatments

A) Colour and appearance
B) Flavour
C) Body and texture
D) Melting quality
E) Overall acceptability

3.8. The production cost and profits of flavoured ice milk

The production cost and profits of ice milk treatments are presented in Tables 5 and 6, respectively. The differences in the production costs between the two controls were clear, which in turn attributed to the high price of camel's milk. In addition, the production costs of T_B, T_G, T_P, and T_Z were higher than the C*, on the other hand, the production costs of fruits ice milk treatments were close to the C**, which explained by the contribution of camel's milk besides the fruits types in ice milk treatments. Total costs of production of 100 g flavoured ice milk were ordered as the follows: T_P > C** ≈ T_G ≈ T_Z > T_B > C*. In respect of the profits of flavoured ice milk treatments, the comparison of selling price in supermarket (L.E. / 100 g ice milk) with that prepared (100 g ice milk) in the laboratory of Dairy Department, we can calculate and arrange the profit / 100 g ice milk as the follows: C* > T_B > C** ≈ T_G ≈ T_Z > T_P. In spite of the production costs of flavoured ice milk treatments were higher than C* or close to C**, but still lower than the selling price of supermarket, moreover the supplementation of ice milk with different fruits (banana, guava, persimmon, and mango) will increase the purchase chances as a result of the increase consumers awareness towards the healthy dairy products compared to the traditional ice milk products.

Table 5. The production costs of flavoured ice milk treatments

Items	**Price / 100 kg ingredients**					
	C*	C**	T_B	T_G	T_P	T_Z
Total cost of production (L.E)	3170.88	4464.84	4365.68	4486.68	4575.06	4468.59
Cost of 100 g flavoured ice milk (L.E)	3.17	4.46	4.37	4.49	4.58	4.47

Table 6. Profits of flavoured ice milk treatments

Items	C*	C**	T_B	T_G	T_P	T_Z
Price of selling in supermarket (L.E / 100 g ice milk)	7	7	7	7	7	7
Cost of 100 g ice milk (L.E)	3.17	4.46	4.37	4.49	4.58	4.47
Profit /100 g ice milk (L.E)	3.83	2.54	2.63	2.51	2.42	2.53
Profit %	55	36	38	36	35	36

Profit % = (profit /100 g ice milk/ price of selling in supermarket) × 100

4. Conclusion

According to the obtained resulted, it could be concluded that the replacement of 1.5% SMP by the fruit solids (banana, guava, persimmon, and zebda-mango pulps) in ice milk preparations showed the following significant differences: 1) Physicochemical properties of ice milk mixtures, especially freezing point, pH value, and acidity. 2) The rheological properties (apparent and plastic viscosities, yield stress, consistency coefficient and flow behaviour index) of mixtures. 3) Physicochemical properties of ice milk products, especially specific gravity, weight per gallon, overrun, freezing time, and pH value. 4) The RSA and TPC of ice milk treatments. 5) Melting rates of flavoured ice milk treatments. 6) Sensory evaluation (colour and appearance, flavour, body and texture, and overall-acceptability) of fruits ice milk treatments, in addition the best treatment was mango ice milk. According to the obtained resulted, the storage periods shouldn’t be more than one month. Ultimately, the profits of fruits ice milk treatments were higher compared to that selling in supermarket.

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