Egypt. J. Food. Sci. **Vol. 52,** No.2, pp. 155-172 (2024)

Egyptian Journal of Food Science
http://ejfs.journals.ekb.eg/

Effect of Dried Mucilage Extracted from Basil, Chia, Cress, and Flax Seeds on Zebda-Mango Ice Milk Prepared Using Camel's Milk

Ahmed M. Abdeldaiem[1*], Fawzi M. Abbas[1], Aida S. Salem[2] and Hanan F. Dokdok[2]

[1]*Department of Dairy Science, Faculty of Agriculture, Suez Canal University, Ismailia 41522, Egypt*

[2]*Dairy Technology Department, Animal Production Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.*

APPLICATION of dried basil seed mucilage (BaSM), dried chia seed mucilage (ChSM), dried cress seed mucilage (CrSM) and dried flax seed mucilage (FlSM) as the alternative stabilizers in preparations of Zebda-mango ice milk using camel's milk (ZICM) was studied. Two controls beside four ZICM treatments were carried out as follows: the first control (C*) and the second control (C**) were close together in the formulations except the C* contains cow's milk, while the C** contains camel's milk. The four ZICM treatments were supported with 1.65% BaSM (T1), 0.88% ChSM (T2), 0.70% CrSM (T3) and 1.39% FlSM (T4). The chemical analysis of different dried seedsmucilage showed clear differences between their parameters. Generally, the physicochemical and rheological properties of ZICM mixtures showed significant ($p<0.05$) differences between the two controls and ZICM treatments. Moreover, the physicochemical properties of resultant ZICM exhibited significant ($p<0.05$) changes between the controls andother treatments whether at 1 or 30 days separately. The treatments of ZICM were higher significantly ($p < 0.05$) in the radical scavenging activity (RSA) and total phenolic compounds (TPC) values than the two controls. The melting rates of ZICM treatments showed that the T3> T2 > T4> T1 > C* ≈ C**. According to the sensory evaluation scores, basil ice milk ranked as the best treatment than other treatments.

Keywords: Camel's milk, Mucilage, Radical scavenging activity, Total phenolic compounds, Zebda-mango ice milk.

Introduction

Camel's milk can be utilized in many dairy products likes soft cheese, fermented milk, beverages, etc (Abd El-Aziz et al., 2022; Patel et al., 2022). Camel's milk production was ranged from 875 and 1616 liters along lactation period, while the average of milk production was recorded 1207 liters (Musaad,2013).Also, camel's milk-based ice cream besides the other components produced commercially in the United Arab Emirates, Morocco, and Kazakhstan (Konuspayeva and Faye, 2021). Camel's milk has 2.5 – 4.5% protein, 2.9 – 5.5 % fat, 2.9 – 5.8% lactose, 0.35 – 0.90% ash, and 86.3 – 88.5% water. The MSNF can be influenced by feed and water availability (Hashim et al., 2009).

Ice cream and other frozen desserts are considered complex colloidal systems consisting of fat, proteins, sugars, air, stabilizers, emulsifiers, minerals, flavor agents (natural or artificial), etc. besides countless interfaces between the different ingredients (Goff, 2002; Frøst et al., 2005). Also, ice cream was defined previously as the product which made by freezing the pasteurized ice cream mix with whipping process to incorporate air and to guarantee uniformity of consistency (Arbuckle, 1987) besides the development of the desired texture, structure, and palatability (Bahramparvar&Mazaheri Tehrani, 2011). Ice cream consists of fat globules, ice crystals, liquid phase, and air cells. Quality of ice cream depends

*Correspondence e-mail: ahmed_elyan@agr.suez.edu.eg
Received :11/9/2024; Accepted :2/11/2024
DOI: 10.21608/EJFS.2024.320004.1194

on storage time, ice crystal size, temperature and temperature fluctuation during storage. Ice crystals were consisted at the beginning of the freezing step. The freezing process comprises rapid removal of heat in parallel agitating vigorously to merge air, therefore imparting the softness and desirable smoothness of the frozen product (Marshall et al., 2003). Ice cream manufacturing from camel milk besides the other formulation created dairy product has lower dry matter, viscosity, and melting point compared to cow's milk ice cream (Jafarpour, 2017), therefore the early studies created ice cream containing camel's milk with bovine milk, consequently the resultant parameters of sensory evaluation were accepted (Soni and Goyal, 2013). 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 (Ho et al., 2022).

The mucilage of seed coat classified into three groups, i.e. endosperm non-starch polysaccharide (galactomannans), mucilaginous of seed coat (chia seed, flaxseed, and yellow mustard), and endosperm of cell wall material (soybean hemicelluloses and xyloglucans) (Ferreira et al., 2020; Cuomo et al., 2020). Mucilage sophisticates a jelly-like texture around fruit, and then prevents seeds from drying out, therefore presents a hydrating factor besides it acts as the energy reservoir (Zhang et al., 2020;Yang et al., 2012). Mucilage are a subgroup of hydrocolloids comprising monosaccharides attached with organic acids, close to each other owing of the hydrocolloid and hydrophilic components which resulted gel or sticky solution in presence of water (Singh and Barreca, 2020). BahramParvar et al. (2012) used concentrations of BaSM, guar gum, and CMC in ice cream formulations as stabilizers. The increase of BaSM ratio in ice cream mixture was increased the apparent viscosity and decreased the melting resistance. Levels of 0.35% BaSM and 0.15% CMC were increased fat destabilization in ice cream treatments. The effect ofChSM on thephysicochemical and sensory characteristics of chocolate flavoured prebiotic ice creamwas reported by Maestrello et al. (2018). The lowest content of ChSM treatment (0.6 g/100 g) showed that higher melting resistance, however that same value was showed less overrun. At 1.2 or 1.8 g ChSM /100 g ice cream, the resultant treatments were ranked the highest overrun. All ice cream treatments had sensory evaluation scores between 6 and 7, which indicating that the consumers liked slightly up to moderately. The fatty acid profiles of ChSM were possessed polyunsaturated fatty acids.

The effect of CrSM and FlSM on ice cream preparations as compared with guar gum was mentioned by Abd El-Aziz et al. (2015). The overrun of ice cream containing 0.025% FlSM or CrSM was ranked a high value, while the ice cream of 0.05% guar gum was recorded less value. Level of 0.025% FlSM, CrSM or guar gum was the best level to improve of ice cream properties. Azarpazhooh et al. (2021) found the optimum levels for preparing FlSMbased cocoa milk were recorded as 2.5% FlSM, 1% Stevia, and 10.9 min ultrasound time. The optimized conditions were 6.34 pH, 10.4 mPas viscosity, 0.71% sedimentation, 48.4 lightness (L* value) values, and 4.98 overall acceptability. The TPC and RSA of the optimized FlSM cocoa milk were higher than control sample, and the peroxide values were less.The purpose of the present research was to use the dried mucilages of basil, chia, cress, and flax seeds in preparations novel ZICM treatments asfunctional food properties.

Materials and Methods

Materials

Cow's milk (12.57% total solids (TS), 3.8% fat, 3.45% protein, 4.65% lactose, 8.77% MSNF, and 6.67 pH value) was obtained from Dairy Department, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt. Camel's milk (10.76% TS, 2.8% fat, 2.75% protein, 4.47% lactose, 7.96% MSNF, and 6.73 pH value) was purchased from Bir Al-Abed, North Sinai Governorate, Egypt. Zebda-mango fruits, basil, chia, cress and flax seedsand sugar were purchased from local market in Ismailia, Egypt. Whole milk powder (WMP)(97.5% TS, 28% fat, 34.2% protein, 28.5% lactose, and 69.5% MSNF) and skim milk powder (SMP) (97% TS, 1.3% fat, 35.77% protein, 52% lactose, and 95.7% MSNF) were imported from United States, and purchased from local market in Ismailia, Egypt. 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.

Methods

Preparation of zebda-mango pulp

Zebda-mango fruit were washed 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 until use.

Preparation of basil, chia, cress, and flaxseeds mucilage

Seeds of basil, chia, cress, and flax were soaked in the distilled water at level 1:10 (w/w) of all for 24 hr at room temperature. Filtration by gauze was done to obtain seeds mucilage. The liquid mucilage of seeds were poured in stainless steel boxes (35 × 35 × 5 cm3) and placed in the oven (model: JSON-100, South Korea) at 65 °C for 15 hr. Dried mucilage of seeds were collected separately and placed in sealed plastic containersuntil use.

Preparation of ZICM with dried seeds mucilage

The BaSM, ChSM, CrSM and FlSMwere prepared previously, and then itsviscosities had been equated with the viscosity of CMC through the preliminary experiments (data not shown). ZICM was prepared by the method of Marshall and Arbuckle (1996). Formulations of different treatments are presented in Table 1. WMP and SMP were mixed with sugar, CMC, BaSM, ChSM, CrSM and FlSM to prepare the dry mixes. The dry mixes were added slowly to cow's milk or camel's milk and filtered 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 separatelywell with Zebda-mango pulps by electric mixer followed by aging for 4 hr, and the freezing and whipping processes were done together in an ice milk maker (Taylormate TM Model 152, Taylor Company, Blackhawk Blvd, USA). Treatments of ZICMwere collected, placed in 100 ml plastic cups and stored at –20 °C until analyzed.

Analysis of mango pulp, dried seeds' mucilage, ice milk mixes and ice milk resultants

Chemical composition

The total solids, fat, protein, and fiber contents and acidity of treatments were determined according to methods of AOAC (2016).The pH values of ice milk treatments were determined using the pH meter with glass electrode (HANNA-Instrument. Portugal).

TABLE 1. Formulations of ZICM with the dried mucilage

Ingredients	Kg /100 kg mix					
	*C	C**	T1	T2	T3	T4
Filtered water	40.13	31.40	31.47	31.41	31.43	31.45
WMP	10.71	10.71	10.71	10.71	10.71	10.71
SMP	2.46	1.80	0.28	1.11	1.27	0.56
Cow's milk	26.32	–	–	–	–	–
Camel's milk	–	35.71	35.71	35.71	35.71	35.71
CMC	0.20	0.20	–	–	–	–
White sugar	15	15	15	15	15	15
BaSM	–	–	1.65	–	–	–
ChSM	–	–	–	0.88	–	–
CrSM	–	–	–	–	0.70	–
FlSM	–	–		–	–	1.39
Zebda-mango	5.18	5.18	5.18	5.18	5.18	5.18
TS	32.68	32.55	32.48	32.54	32.52	32.50
Total	100	100	100	100	100	100

C*: (4%fat, 12% MSNF, 15% sugar, 1% mango solids and 0.2% CMC) (control contain cow's milk); C**: (4%fat, 12% MSNF, 15% sugar, 1% mango solids and 0.2% CMC) (control contain camel's milk); T1: (4%fat, 10.55% MSNF, 15% sugar, 1% mango solids and 1.65% BaSM); T2: (4%fat, 11.32% MSNF, 15% sugar, 1% mango solids and 0.88% ChSM); T3: (4%fat, 11.3% MSNF, 15% sugar, 1% mango solids and 0.7% CrSM) and T4: (4%fat, 10.81% MSNF, 15% sugar, 1% mango solids and 1.39% FlSM). BaSM: dried basil seed mucilage; ChSM: dried chia seed mucilage; CrSM: dried cress seed mucilage; FlSM: dried flaxseed mucilage

Total soluble solids

The total soluble solids (TSS) of different treatments were determined with a ATAGO type refractometer (Schmidt Haenach, Germay), and the values were expressed as degree °Brix (%).

Radical scavenging activity

The RSA was determination by the DPPH according toHwang and Do Thi (2014). One milliliter of various concentrations (100 - 1000 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;leave the mixture undisturbed 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,Acontrol: is the absorbance of the control reaction (containing all reagents except test compound).Asample: is the absorbance with the test compound.

Total phenolic compounds

The TPC were determined in the methanolic extracts using Folin-Ciocalteu as determined by Barros et al. (2011). 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 (R2 = 0.9986) of the calibration curve. The results were expressed as mg of gallic acid equivalent per 100 g of sample.

Specific gravity

The specific gravity of treatments was measured by using of a bottle pyconometer as described by Winton (1958) 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 or ice milk product, followed by samples weighting 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 milk / cup volume.

Calculation of weight per gallon

Weight per gallon of both of ice milk mix and ice milk in kg was determined according to Burke (1947) by multiplying the specific gravity of the ice milk mix or ice milk resultant by the factor 4.5461.

Calculation of the overrun

The overrun percent of the resultant ice milk was calculated as mentioned by Marshall and Arbuckle (1996) by the following equation:

% Overrun = [(volume of ice milk – volume of mix) / (volume of mix)] ×100

Freezing point of ice milk mix

Freezing point ice milk mixes was determined according to the method of Arbuckle (1987) as follows: Amount of 75 ml of ice milk mix sample was placed to test tube and placed in the frozen brine (100 g NaCl/1000 g distilled water, the freezing point = – 6.7 °C). About 2 kg small ice flakes was added to the brine solution. Thermometer was used to determine temperature of ice milk mixture. 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.

Melting rates of ZICM

Melting rates of ZIC Mtreatments were determined as reported by Segall and Goff (2002). 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 rates of different samples.

Instrumental colour measurement

The instrumental colour of different treatments was determined in three replicates as the CieLab coordinates [L* value = lightness-to-darkness, a* value = redness (+a) to greenness (–a), b* value = yellowness (+b) to blueness (–b)] using a hand-held Tristimulus reflectance colorimeter Minolta Chroma-meter CR-400 (Minolta Camera Co., Ltd., Osaka, Japan).

Rheological measurements of ice milk mixtures

The rheological parameters (apparent viscosity, plastic viscosity, yield stress, consistency coefficient, and flow behavior index) of 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 revolutions per minute. The rheological measurements were done in triplicate.

Sensory evaluation of ZICM treatments

Samples of ZICMwere stored at –20 °C, and 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 (2004) for colour and appearance, flavour, body and texture, melting quality and overall acceptability.

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.

Results and Discussion

Approximate chemical analysis of dried mucilage

The mucilage considered water soluble adhesive material included carbohydrates besides uranic acids units found in the plants parts, containing the mucous epidermis of an outer layer of leaves, seeds, bark, and buds (Mukherjee et al., 2019). As shown in Table 2, the chemical analysis of BaSM, ChSM, CrSM and FlSM were exhibited noticeable differences between them in the parameters of TS, fat, protein, ash, fibers, carbohydrate, yield, pH value, RSA, TPC, and instrumental colour (L*, a*, and b* values). In respect the highest parameter, BaSM was higher in fat, carbohydrate, TPC, and the lightness, while ChSM was higher in TS, and fibers, moreoverCrSM was higher in parameters of protein, ash, yield, pH value, RSA, redness, and yellowness. It was clear that the seeds mucilage which have protein and fiber contents represented good sources for the water holding; in addition it contribution in development ice milk properties will be noticeable. Yields of the resultant dried mucilage were differed between them due to it varied in their ingredients. Noteworthy, the resultant mucilage considered good sources for each TPC and RSA. It worth noting that the colour parameters of dried mucilage were impacted by heat treatment through mucilage drying step, therefore the lightness values of all seed mucilage were declined, besides the variations in each a* and b* values. Our results are in agreement with that reported by Stępień et al. (2021), they found the fiber content of FlSM ranged from 3 – 15%; in addition the FlSM contains 80% polysaccharides and 9% protein. Likewise, Nazir et al. (2017); Saeedi et al. (2015) reported that the yield of BaSM recorded 7.86 – 25%.

TABLE 2. Chemical analysis of dried mucilage.

Parameters		BaSM	ChSM	CrSM	FlSM
TS %		94.62±0.82	96.63±0.75	94.50±0.90	95.70±0.83
Fat %		2.70±0.03	1.90±0.04	1.88±0.03	1.23±0.03
Protein %		2.11±0.02	9.77±0.10	21.21±0.16	14.73±0.12
Ash %		4.87±0.05	7.62±0.08	8.65±0.10	7.30±0.10
Crude fibers %		22.46±0.11	24.08±0.20	18.74±0.13	14.58±0.14
Carbohydrate %		84.94±0.76	77.34±0.48	62.76±0.48	72.44±0.52
Yield %		10.28±0.13	13.80±0.21	14.67±0.25	10.72±0.16
pH value		6.43±0.02	6.54±0.03	6.65±0.04	6.47±0.03
RSA %		59.79±0.67	37.05±0.58	62.25±0.75	60.10±0.78
TPC (mg gallic acid /100 g)		25.65±0.22	18.87±0.11	28.40±0.37	26.80±0.24
Colour	L* value	50.16±0.37	45.35±0.25	41.45±0.38	48.20±0.40
	a* value	7.98±0.08	9.94±0.06	11.20±0.10	8.83±0.09
	b* value	6.87±0.05	8.72±0.08	9.46±0.04	7.66±0.05

L* value: denotes lightness-to-darkness from 100 to 0 units, respectively; a* value: represents redness (+a) to greenness (−a); b* value: represents yellowness (+b) to blueness (−b); TS: total solids; RSA: radical scavenging activity (DPPH); TPC: total phenolic compounds.

According to Fernandes et al. (2017);Wang et al. (2022), ChSM was included 5.1 – 12.1% protein and 0.9 – 2.8% fat, moreover the previous contents were depended on the extraction procedures. Also, ChSM was recorded 8.3% yield by non-thermal extraction according to method of Tavares et al. (2018). Chavan et al. (2017) recorded that the moisture (5.74%), protein (11.62%), lipids (3.20%), ash (5.09%), fiber (57.84%), and carbohydrates (12.49%) were attributed to ChSM. According to Nayak et al. (2013), yield of FlSM was 7.3%, which extracted by centrifugation.As expected, addition of dried mucilages in ice milk preparations will appear distinguished properties in terms of the physicochemical, rheological, and sensory properties, besides the antioxidant activities.

Physicochemical properties of ZICM mixes supported withdried mucilages

The physicochemical properties of ZICMmixes are presented in Table 3. No significant ($p > 0.05$) differences were observed between the first control (C*), and second control (C**) concerning specific gravity, weight per gallon, and freezing point. In contrast the pH value of C** significantly ($p < 0.05$) was higher than C*, while the acidity of C* significantly ($p < 0.05$) was higher than the C**, this can be explained by involving cow's milk in the C* formulation compared other control which contains camel's milk. Al-Saleh et al. (2014) reported that the protein content of cow's milk higher than that in camel's milk; consequently the acidity of cow's milk will be higher than camel's milk, due to the lower buffering capacity of camel's milk than cow's milk.Moreover, the differences between the C** from one hand, and other treatments (T1, T2, T3, and T4) from other hand were insignificant ($p > 0.05$), especially in parameters of specific gravity, and weight per gallon due to the TS of C**, T1, T2, T3 and T4 were close together. In addition, the variations between C**, T1, T2, T3, and T4 concerning the freezing point, pH value, and acidity were significant ($p < 0.05$). In general, the freezing point and pH values of T1 till T4 were significantly ($p < 0.05$) higher than the C**, whilst the acidities of same treatments compared the C** were decreased significantly ($p < 0.05$), this can be attributed to the mucilage types which have different ingredients. Furthermore, the differences between all treatments in the freezing points can be attributed to the influence of proportion, and fiber type which substantially will be affected the molecular weight, and freezing point (Hartel, 2001). Likewise, Hartel (2001) found that the fiber level didn't affect the percentage of amorphous water, where the gelling substantially dependent the freezing point, and the associated water proportion.

Effect of dried mucilage on the rheological measurements of ZICM mixes

The rheological properties of ZICM mixes with BaSM, ChSM, CrSM and FlSM are shown in Table 4. The parameters of apparent and plastic viscosities, yield stress, consistency coefficient and flow behaviour index declared no significant ($p >0.05$) changes were noticed between the first control and second control, on the other hand

TABLE 3. Physicochemical properties of ZICM mixeswith dried mucilage

Treatments	Physicochemical properties of zebda-mangoice milk mixes▾				
	Specific gravity	Weight per gallon (kg)	Freezing point (°C)	pH value	Acidity (%)
C*	1.1139±0.0011a	5.0640±0.0041^{a}	−2.41±0.02^{c}	6.24±0.02^{d}	0.33±0.03^{a}
C**	1.1133±0.0009^{a}	5.0613±0.0049^{a}	−2.42±0.02^{c}	6.29±0.02^{c}	0.29±0.02^{ab}
T1	1.1130±0.0010^{a}	5.0599±0.0055^{a}	−2.30±0.01^{a}	6.30±0.04^{c}	0.28±0.01^{bc}
T2	1.1133±0.0011^{a}	5.0611±0.0052^{a}	−2.36±0.0٣^{b}	6.35±0.03^{ab}	0.25±0.03^{bc}
T3	1.1132±0.0012^{a}	5.0607±0.0054^{a}	−2.36±0.02^{b}	6.39±0.02^{a}	0.24±0.02^{c}
T4	1.1131±0.0008^{a}	5.0603±0.0046^{a}	−2.32±0.02^{a}	6.32±0.03^{bc}	0.27±0.04^{bc}

C*: (4%fat, 12% MSNF, 15% sugar, 1% mango solids and 0.2% CMC) (control contain cow's milk); C**: (4%fat, 12% MSNF, 15% sugar, 1% mango solids and 0.2% CMC) (control contain camel's milk); T1: (4%fat, 10.55% MSNF, 15% sugar, 1% mango solids and 1.65% BaSM);T2: (4%fat, 11.32% MSNF, 15% sugar, 1% mango solids and 0.88% ChSM);T3: (4%fat, 11.3% MSNF, 15% sugar, 1% mango solids and 0.7% CrSM) andT4: (4%fat, 10.81% MSNF, 15% sugar, 1% mango solids and 1.39% FlSM).

Small letters: mean values are significant ($p < 0.05$) with the different letters for columns of the same parameter; *, control; **, control; ▾: mean values the rheological parameters of two controls were lower substantially ($p < 0.05$) than basil (T1), chia (T2), cress (T3) and flax (T4) mucilage basedice milk treatments due to the dried mucilage involved high amounts of each fiber and protein contents which have high ability toward water. The findings of Marand et al. (2020) are resemble with our data, they mentioned the increase of FlSM improved the viscosity due to its amount of fiber content, moreover the interaction of protein and fiber between the mucilage and milk resulted robust three dimensional networks, besides the increase of milk flow resistance. On the other hand, the protein and hydroxyl groups of mucilage are responsible for the high water binding capacity(WBC) of hydrocolloid (Tosif et al., 2021). Also, Ghumman et al. (2022) revealed that the mucilage can be interacted with other cationic polymers, owing of its anionic structure, moreover the polyelectrolyte complex was created owing of the cross-bridging between an anionic structures of seed mucilage besides the cationic structure of other polymers like chitosan. Cheng et al. (2015) reported that the interactions between protein and sugars types had been occurred in ice cream, consequently its improved ice cream formulations; moreover the product properties somewhat depend on these interactions between the molecules. The functional properties of ChSM and FlSM were foaming and stabilizing agents, fat replacer, thickening agent, WBC and emulsifying agent (Kaur et al., 2018;Pereira et al., 2019; Punia and Dhull, 2019; Cuomo et al., 2020; Lan et al., 2020).

The apparent and plastic viscosities, yield stress, and consistency coefficient of T3 > T2 > T4 > T1 > C* ≈ C**, whereas the flow behavior index of the foregoing treatments was in contrast with other rheological parameters, as the flow behavior index of C* ≈ C** > T1 > T4 > T2 > T3. This can be attributed to the WBC and viscosity of BaSM>ChSM>CrSM>FlSM due to their fiber and protein contents, besides their interactions with ice milk ingredients. Therefore, adding BaSM, ChSM, CrSM and FlSM showed noticeable improvement in the rheological properties of ice milk treatments. El-Aziz et al. (2015) mentioned that the viscosity of ice cream mixtures improved using FlSM and CrSM. Furthermore, BaSM acts as a stabilizer, an emulsifier, a thickener, and fat replacer (Farahmandfar et al., 2017); moreover its molecular weight was 2320 kDa (Naji-Tabasi and Razavi, 2017). Also, BahramParvar and Goff (2013) reported the BaSM in ice cream mix formulation significantly increased the viscosity value and reduced the melting rate compared to the ice cream of CMC and guar gum blends. Moreover, the CrSM or FlSMwith yoghurt increased the viscosity due to the WBC of CrSM (Hassan et al., 2015; Arabshahi et al., 2020).Sahan et al. (2008) reported that the WBC attributed to the hydrocolloid which imbibed free water in casein network, therefore the increase parameter of treatment was occurred.

TABLE 4. Rheological measurements of ZICM mixeswith dried mucilage

Rheological properties	Aging of mixes	Treatments▼					
		C*	C**	T1	T2	T3	T4
Plastic viscosity (mPa.s)	Fresh	73.28±0.76^{Ec}	72.85±0.91^{Ec}	75.35±0.67^{Dc}	96.30±1.15^{Bc}	99.14±1.18^{Ac}	79.87±0.78^{Cc}
	2 h	86.31±0.89^{Eb}	85.94±0.79^{Eb}	89.15±0.84^{Db}	108.86±0.93^{Bb}	111.56±0.88^{Ab}	93.25±1.07^{Cb}
	4 h	102.4±1.05^{Ea}	101.53±1.10^{Ea}	105.50±1.11^{Da}	128.40±1.25^{Ba}	134.62±1.29^{Aa}	108.70±0.92^{Ca}
Yield stress (mPa.s)	Fresh	7.18±0.07^{Da}	7.11±0.08^{Da}	7.66±0.06^{Ca}	8.18±0.06^{Aa}	8.29±0.05^{Aa}	7.87±0.08^{Ba}
	2 h	6.98±0.09^{Db}	6.93±0.06^{Db}	7.45±0.08^{Cb}	8.07±0.09^{Ab}	8.15±0.08^{Ab}	7.64±0.06^{Bb}
	4 h	6.70±0.08^{Ec}	6.61±0.09^{Ec}	7.21±0.05^{Dc}	7.81±0.06^{Bc}	8.04±0.06^{Ac}	7.39±0.07^{Cc}
Consistency coefficient (mPa.s)	Fresh	102.87±1.82^{Ec}	101.94±1.76^{Ec}	106.47±1.15^{Dc}	130.70±1.10^{Bc}	134.60±1.36^{Ac}	110.18±1.54^{Cc}
	2 h	117.15±1.90^{Eb}	116.42±1.64^{Eb}	121.91±1.23^{Db}	139.54±1.22^{Bb}	142.80±1.10^{Ab}	124.60±1.12^{Cb}
	4 h	129.32±1.78^{Ea}	127.83±1.76^{Ea}	134.85±1.36^{Da}	155.69±1.36^{Ba}	159.27±1.30^{Aa}	139.10±1.23^{Ca}
Flow behavior index	Fresh	0.90±0.03^{Aa}	0.88±0.04^{Aa}	0.80±0.05^{Ba}	0.61±0.02^{Da}	0.48±0.04^{Ea}	0.72±0.04^{Ca}
	2 h	0.79±0.04^{Ab}	0.77±0.05^{Ab}	0.70±0.02^{Bb}	0.52±0.04^{Db}	0.42±0.03^{Eb}	0.61±0.01^{Cb}
	4 h	0.70±0.03^{Ac}	0.68±0.02^{Ac}	0.60±0.03^{Bc}	0.45±0.03^{Dc}	0.36±0.02^{Ec}	0.53±0.03^{Cc}
Apparent viscosity (mPa.s)	Fresh	339.42±4.50^{Ec}	334.42±4.20^{Ec}	348.50±6.15^{Dc}	383.70±3.38^{Bc}	393.60±4.10^{Ac}	357.50±2.58^{Cc}
	2 h	365.52±5.60^{CDb}	362.27±3.60^{Db}	372.30±3.87^{Cb}	407.44±2.67^{Ab}	413.40±3.50^{Ab}	380.40±5.60^{Bb}
	4 h	399.32±4.80^{CDa}	396.32±6.10^{Da}	408.70±5.50^{BCa}	439.61±6.31^{Aa}	446.70±5.28^{Aa}	414.50±4.20^{Ba}

Capital letters: mean values are significant ($p < 0.05$) with different letters for the rows; Small letters: mean values are significant ($p < 0.05$) with different letters for the columns of each parameter; *, Control; ▯: mean values

As aging period preceding up to 4 hr, the apparent and plastic viscosities, and consistency coefficient of C*, C**, T1, T2, T3 and T4 mixtures were increased significantly ($p < 0.05$), while the yield stress and flow behaviour index were declined significantly ($P < 0.05$). This can be attributed to many reasons such as fat hardening, increase of WBC of fiber and protein contents. Moreover, the changes in gel structures probably occurred through the storage, thus it should be considered the aging and rheological differences when the gels applied in food applications (Ferraro et al., 2022). Bahramparvar and Mazaheri-Tehrani (2011) illustrated that the stabilizers (polysaccharides) can be interacted with water, lipid, and protein contents in ice cream mixture; therefore the increase in the viscosity will occurred.

Physicochemical properties of ZICM treatments

As reported in Table 5, the characteristics of specific gravity, weight per gallon, overrun, and freezing time showed that no significant ($p > 0.05$) changes were noticed between the C* and C** at 1 day and 30 days, owing of the TS of C* (32.68%) and C** (32.55%) were almost resemble in their formulations. In contrast the pH value of C* was significantly ($p < 0.05$) lower than C** because of the cow's milk within the formulation of C*, while the second control (C**) contains camel's milk. In addition, the specific gravity and weight per gallon of T1, T2, T3, and T4 showed significant ($p < 0.05$) decreases compared to the C** due to the dried mucilage addition resulted the increase of overrun values, in addition the inverse relation between the specific gravity and weight per gallon together from one hand,and the overrun from other hand was observed. In addition, the overrun and freezing time showed significant ($p < 0.05$) increasing compared to the C** whether at 1 or 30 days. The pH values of T1 till T4 showed significant ($p < 0.05$) differences compared to the controls owing of the dried mucilage supplementation in ZICMpreparations. In other words, the differences in pH values of mucilage based ice milk treatment were dependent on pH values of the dried mucilage, in addition the pH values of T3 > T2 > T4 > T1 > C** > C*. Kurt et al. (2016) declared that the gums tragacanth and salepglucomannan didn't change the pH of ice cream treatments, whereas results of Ürkek (2021) showed that higher pH values than the previous researchers.

At 30 days, the physicochemical properties were recorded the same trends between all ice milk treatments, but the specific gravity and weight per gallon values of all ZICMtreatments were significantly ($p < 0.05$) higher than that at 1 day of storage periods due to the reduction of overrun values created shrinkages in ice milk

TABLE 5. Physicochemical properties of ZICM with dried mucilage

Treatments	Physicochemical properties of Zebda-mango ice milk treatments▼				
	1 day				
	Specific gravity	Weight per gallon (kg)	Overrun (%)	Freezing time (min)	pH value
C*	0.7417±0.0014^{Ba}	3.3718±0.0021^{Ba}	50.15±0.36^{Ae}	14.10±0.12^{e}	6.29±0.01^{Ae}
C**	0.7419±0.0012^{Ba}	3.3728±0.0037^{Ba}	50.07±0.28^{Ae}	14.00±0.18^{e}	6.33±0.02^{Ad}
T1	0.7361±0.0010^{Bb}	3.3465±0.0035^{Bb}	51.20±0.18^{Ad}	15.12±0.16^{d}	6.34±0.03^{Acd}
T2	0.7206±0.0008^{Bd}	3.2758±0.0012^{Bd}	54.50±0.20^{Ab}	17.06±0.15^{b}	6.40±0.02^{Ab}
T3	0.7166±0.0011^{Be}	3.2576±0.0028^{Be}	55.35±0.40^{Aa}	17.40±0.11^{a}	6.45±0.01^{Aa}
T4	0.7318±0.0009^{Bc}	3.3269±0.0033^{Bc}	52.10±0.31^{Ac}	16.10±0.10^{c}	6.37±0.02^{Abc}
Treatments			30 days		
C*	0.7516±0.0010^{Aa}	3.4170±0.0031^{Aa}	48.18±0.22^{Be}	–	6.24±0.02^{Bd}
C**	0.7517±0.0019^{Aa}	3.4175±0.0027^{Aa}	48.10±0.31^{Be}	–	6.28±0.01^{Bc}
T1	0.7459±0.0013^{Ab}	3.3911±0.0026^{Ab}	49.21±0.16^{Bd}	–	6.30±0.02^{Bc}
T2	0.7317±0.0010^{Ad}	3.3264±0.0031^{Ad}	52.15±0.27^{Bb}	–	6.34±0.02^{Bb}
T3	0.7257±0.0014^{Ae}	3.2990±0.0042^{Ae}	53.40±0.18^{Ba}	–	6.38±0.02^{Ba}
T4	0.7416±0.0012^{Ac}	3.3713±0.0048^{Ac}	50.10±0.24^{Bc}	–	6.31±0.03^{Bbc}

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.

treatments, and then led to heavy and dense of treatments (Singh et al., 2014). Likewise, the shrinkage in ice cream through the storage periods explained by the air loss due to weakened films collapse which in turn leading to the volume loss (Potter and Hotchkiss, 1995). The pH values during 30 days appeared the ZICM treatments acquired significant ($p < 0.05$) decreases in the pH values compared that at 1 day, owing of the slowly progress of acidity during the storage.

It is clear that the relation between viscosity and overrun of ice milk treatments was positive (Akalın et al., 2008). Campos et al. (2016) showed that the overrun of ice cream increased with the increase ChSM amount. Moreover, Bahramparvar and Mazaheri Tehrani (2011) exhibited that the increase ice cream volume related to stabilizers, besides the viscosity increment, and air bubbles maintaining. Moeenfard and Mazaheri Tehrani (2008) observed that the overrun-lower ice cream treatments were harder than that has high overrun, while it's melted more rapidly. It's could be noted that the mucilage addition in ice milk preparation can be increased protein and ash contents, air volume, and the melting rates (Goksen et al., 2023).

Radical scavenging activity and total phenolic compounds

The polyphenols are ingredients of yellow, red, orange, green, and purple pigments existed in plants, interacted with protein,lipid and carbohydrate; therefore lipid absorption and oxidation will be declined, moreover created as antioxidant that prevents the influences of reactive oxygen (Elmastaş et al., 2006). The RSA and TPC of ice milk treatments supported with dried seeds mucilage are presented in Fig. 1 (A and B). Both the first control, and second control were involved antioxidant activities owing of their casein and whey proteins has prospective bioactive peptides besides its acquired substantial antioxidant activities (Ibrahim et al., 2018). Noteworthy, the second control compared the first control was higher in the RSA and TPC values due to the bioactive components such as alkaloids, steroids, and glycosides of camel's milk compared to cow's milk was higher (Musa et al., 2022). Moreover, Salami et al. (2010) reported that the bioactive peptides of camel's milk had higher antioxidant activity, antimicrobial activity, and antihypertension effect compared with cow's milk.

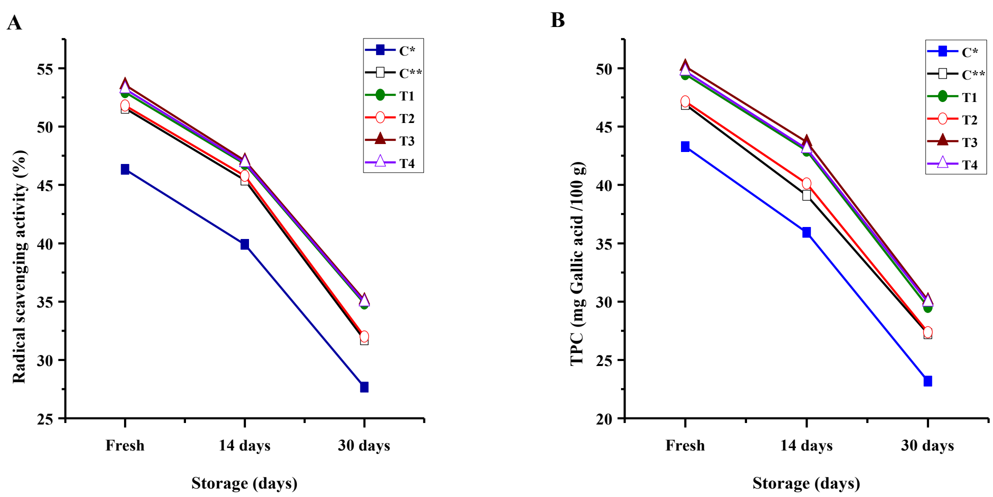

Fig. 1. Radical scavenging activity (A) and total phenolic compounds (B) of Zebda-mango ice milk

The T1, T2, T3, and T4 recorded higher significant ($p < 0.05$) in RSA and TPC values than the C** because of the mucilage addition in ice milk preparations, furthermore the changes between the mucilage treatments in RSA and TPC values were significant ($P < 0.05$) which related to BaSM, ChSM, CrSM and FlSM (refer to Table 1) which in turn have high RSA and TPC values, moreover the RSA and TPC values were ordered as the follows: T3 ≈ T4 ≈ T1 > T2 ≈ C** > C*. Stępień et al. (2021) showed that the ChSM exhibited better antioxidant properties compared to guar mucilage. Also, Kim et al. (2020) foundthe variations between BaSM and control treatments were related to the TPC of BaSM. Moreover, the high BaSM amounts of phenolic acids have antioxidant activity; in addition the BaSM resemble to red and black raspberries with regard to its antioxidant activity (Wang and Lin, 2000; Kwee and Niemeyer, 2011). Through the storage periods, the controls, T1, T2, T3 and T4 showed substantial ($P < 0.05$) decreases in the RSA and TPC values, presumably due to the declination of bioactive ingredients as storage periods proceeding (Singh et al., 2014).

Melting rates of ZICM with dried mucilage

Noticeable, the melting behaviour is affected by overrun (Sofjan and Hartel, 2004), fat content, fat replacers (Karaca et al., 2009) and milk type (Correia et al., 2008). As shown in Fig. 2, the differences in the melting rates between C* and C** at 1 day and 30 days were insignificant ($p > 0.05$). Moreover, the significant ($p < 0.05$) differences were observed between the BaSM, ChSM, CrSM and FlSM based ice milk treatments from one hand, and the C** from other hand during the storage periods of 1 and 30 days. In addition, the mucilage based ice milk treatments were recorded lower melting rates than the C** due to the mucilage addition instead of CMC caused the increase of melting resistance owing of their protein and fiber contents which has high WBC, besides their interactions with other ingredients of ice milk formulations. On the other hand, the melting rates of T3 > T2 > T4 > T1 > C* ≈ C**. BahramParvar and Goff (2013) reported that the BaSM compared with CMC or guar in ice cream preparations was responsible for the reduced melting rate.The early study of Chavan et al. (2017) mentioned that the ice cream with ChSM melts slowly compared with control ice cream due to the mucilage slows the heat transfer rate throughout ice cream.

The relation between the melting rates, overrun (see Table 5), and rheological properties (see Table 4) were positive, but the relation between melting rates, specific gravity, and weight per gallon was inversely. Previously, Muse and Hartel (2004) concluded that the relation among the overrun and melting resistance of ice cream were positive, besides the melt-down rate impacted by incorporated air, ice crystals nature, and fat globules network formed through freezing process. Also, the increase overrun of ice cream caused slowly melting compared to ice cream of low overrun as reported by Sakurai et al. (1996).

The melting rates of all treatments at 30 days were lower than its at 1 day, which attributed to the increase of ice crystal size, due to the process of ice recrystallization (BahramParvar et al., 2013; Muse and Hartel, 2004), besides the overrun declining through the storage periods. Our results are in agreement with that mentioned by Sofjan and Hartel (2004), they noticed that the ice cream treatments with lower overrun were melted quickly than overrun-higher treatments which melted slowly. Also, the slowly melting rate related with high overrun or high air cells which reduced heat transfer rate owing of the large air volume. The early study of Feizi et al. (2021) showed that the level of 0.2% ChSM increased the viscosity of ice cream treatments, whereas the declining in overrun and melting rate was observed. The melting resistance of ice milk has a strong relationship with the overrun, consequently the involved ice cream more air followed by a high melting resistance (Abu-Lehia et al., 1989). The increase of overrun for ice cream caused slowly melting compared to ice cream of low overrun as reported by Sakurai et al. (1996); Hartel et al. (2004), their results attributed to the air cells behavior that reduced the heat transfer. Moreover, Akbari et al. (2016) stated that the melting and portability rates influenced by heat penetrate of ice cream, in addition the rising overrun reduces ice cream-melting rate; due to the overrun reduces heat penetrate ability in ice cream. As showed by Marshall et al. (2003), the viscosity when increased, the melting resistance increased, whilst the whipping rate decreased. It is clear that the milk proteins has substantial effect on the texture via ice crystal size limiting, and then the desirable stability has been occurred in parallel with polysaccharides existence, likewise an overrun increase retarded ice crystals growth (Flores and Goff, 1999).

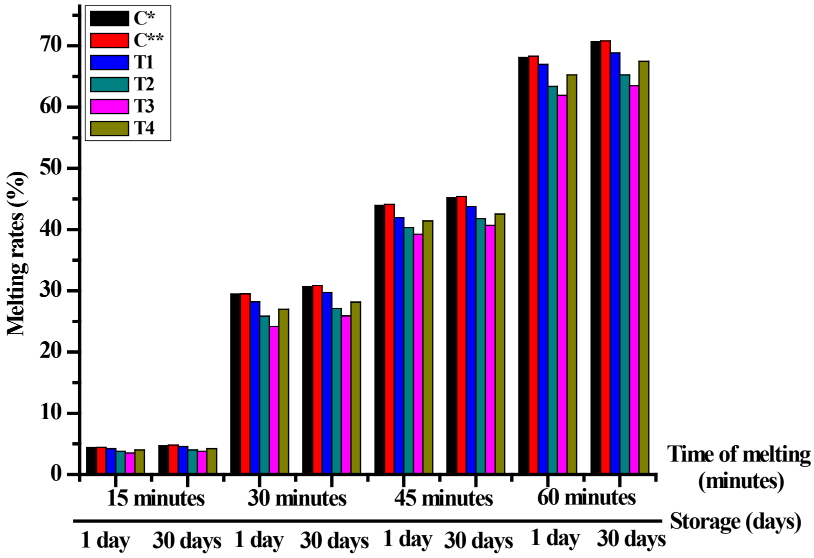

Fig. 2. Melting rates of ZICM with dried mucilage

Instrumental colour of ZICM with dried mucilage

Table 6 shows the instrumental colours of mucilage based ice milk treatments. Obviously, the parameters of instrumental colour showed that no significant ($p > 0.05$) effects were recorded between the two controls along the storage periods from 1 till 30 days, while the ZICM treatments with dried mucilage exhibited significant ($p < 0.05$) decreases in their lightness and yellowness (+b* value), but the redness (+a value) significantly ($p < 0.05$) increased compared to the second control, due to the drying step was carried out at 65 °C for the resultant seeds mucilage. Also, the variations in the mucilagecolourwere attributed to the release of tannic or pigments materials from seed coat, extraction with high temperature, and long stirring time will be more colour materials spread into water; therefore the darker colour will be resulted (Koocheki et al., 2009). Arabshahi et al. (2020) reported that the lightness of yoghurt treatment decreased in parallel the increase of FlSM, because of the mucilage donates yoghurt treatments darkening colour, besides the parameters of +a* and +b* increased with the increase of FlSM. According to Kim et al. (2020), the BaSM supplementation increased the darkness of yoghurt treatments compared to control treatment, while values of +a* and +b* slightly increased. The variations between the dried mucilage were attributed to the mucilage ingredients, especially protein and fiber contents. Furthermore, the lightnessand +b* valueof C* ≈ C** > T1 > T4 > T2 > T3, whereas the +a value of T3 > T2 > T4 > T1 > C** ≈ C*. During the storage periods, the instrumental colours parameters of ice milk treatments significantly ($p < 0.05$) decreased. Abdel-Maqsoud et al. (2021) declared that the lightness of ice cream treatments substantially decreased, whereas the +a value and+b* value increased as the storage periods proceeding

Sensory evaluation of ZICM with dried mucilages

The sensory evaluation of ice milk treatments areshowed in Fig. 3. Evidently, no significant ($p > 0.05$) effects were observed between the C* and C** in their colour and appearance, flavour, body and texture, and overall-acceptability. Colour and appearance of mucilage basedZICM treatments showed significant ($p < 0.05$) differences between the C** and T1, T2, T3, and T4, in addition the colour and appearance scores of T2 and T3 were close to the second control, while both T1 and T4 ordered after the previous treatments. In spite of the mucilagescolour changed through the drying treatment to the light brown (e.g. T2 and T3), but it's supported the resultant treatments by the chocolate colour, which considered desirable for a large sector of consumers. Kamel et al. (2020) showed that the high temperature of maceration, and extended stirring time caused high coloured mucilage, which created an industrial usage unacceptable. Maestrello et al. (2018) showed that the increase of mucilage resulted darkening in ice cream treatments.With regard to the flavour parameter, the changes between the C** and other treatments were significant ($p < 0.05$), in addition the arrangement of flavour scores were T1, (C* ≈ C** ≈ T2 ≈ T3) and then T4. The body and texture and melting quality showed the same trends with ZICMtreatments which contained dried mucilage, therefore the best treatments were T3 > T2 ≈ T4 > T1 ≈ C* ≈ C** from the panelists point view. According to Schmidt and Smith (1992), the improvement in body and texture and melting quality had been related to the increment in viscosity or overrun, therefore the declining in ice cream iciness was observed. Donhowe et al. (1991) stated that the icy sensation decreased via stabilizers, as it's influenced on the re-crystallization process, and organoleptic properties of ice crystals. Feizi et al. (2021) showed that the resemble and desirable properties in ice cream treatments were obtained by replacing 0.2% guar gum with 0.1 to 0.3 % ChSM, in addition the percentage of 0.2 % ChSM was exhibited smooth texture, attractive hardness, and creamy mouthfeel without off flavours or perception of ice crystals, moreover the mucilage increased the viscosity, whereas the declining in overrun and melting rate was observed.

The obtained scores of overall-acceptability recorded the same trends of flavour parameter; there the best treatment was the basil ice camel's milk (T1), in spite of the other treatments according to the panelists point view were acceptable. Goksen et al. (2023) reported that the application of ChSM didn't influenced on the chemical analysis and overall- acceptability of chocolate ice cream, whilst the high level of ChSM resulted darker colour, besides the decline in the firmness and melting resistance. Also, the ice cream comprising 0.05% guar gum or 0.025% CrSM recorded highest panelist's scores, besides its distinguished in the creaminess and smoothness compared with other treatments (El-Aziz et al., 2015). As the storage period proceeding, all ice milk treatments significantly ($p < 0.05$) decreased.Azarpazhooh et al. (2021) found that the FlSM addition didn't change the mouth feel of treatments; in addition the FlSM has flavour and taste resemble nuts.

TABLE 6. Instrumental colour of ZICM with dried mucilage.

Treatments	Storage (days)	L* value	a* value	b* value
C*	1	74.93±0.37^{Aa}	5.81±0.06^{Ae}	15.85±0.14^{Aa}
	30	73.46±0.43^{Ba}	5.54±0.09^{Be}	15.40±0.10^{Ba}
C**	1	75.10±0.40^{Aa}	5.86±0.07^{Ae}	15.80±0.12^{Aa}
	30	74.17±0.38^{Ba}	5.50±0.09^{Be}	15.37±0.09^{Ba}
T1	1	69.50±0.43^{Ab}	6.65±0.06^{Ad}	13.54±0.13^{Ab}
	30	68.38±0.26^{Bb}	6.30±0.08^{Bd}	13.12±0.11^{Bb}
T2	1	64.76±0.31^{Ad}	8.13±0.05^{Ab}	11.80±0.15^{Ad}
	30	63.11±0.56^{Bd}	7.80±0.04^{Bb}	11.25±0.16^{Bd}
T3	1	59.57±0.25^{Ae}	9.19±0.09^{Aa}	10.75±0.10^{Ae}
	30	57.43±0.20^{Be}	8.82±0.03^{Ba}	10.13±0.14^{Be}
T4	1	67.12±0.34^{Ac}	7.32±0.08^{Ac}	12.85±0.08^{Ac}
	30	65.95±0.52^{Bc}	7.06±0.07^{Bc}	12.41±0.17^{Bc}

L* value: denotes lightness-to-darkness from 100 to 0 units, respectively; a* value: represents redness (+ a) to greenness (− a), and b* value: represents yellowness (+ b) to blueness (−b).
Capital letters: mean values with different letters are significant ($p < 0.05$) for the columns of same treatments; small letters: mean values with different letters are significant ($p < 0.05$) for columns of same storage periods; *: Control; **: Control

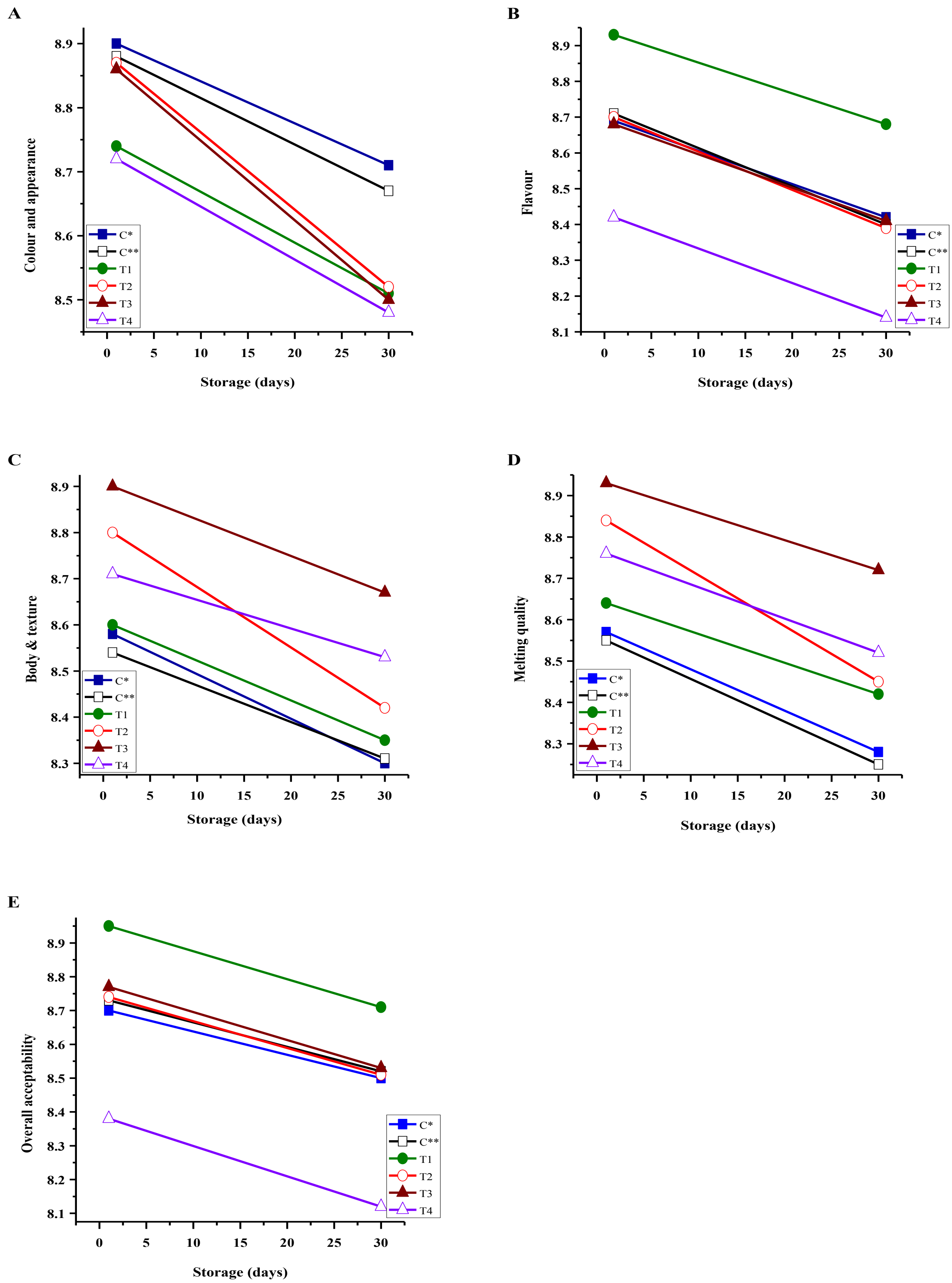

Fig. 3. Sensory evaluation of ZICM with dried mucilages
A) Colour and appearance, B) Flavour, C) Body & texture, D) Melting quality, E) Overall acceptability

Conclusion

Replacement ofBaSM, ChSM, CrSM and FlSMwith CMC in ZICM preparations showed that the significant differences ($p < 0.05$) in the physicochemical properties of ZICM mixtures and resultant ZICM treatments. The RSA and TPC of T3 ≈ T4 ≈ T1 > T2 ≈ C** > C* were observed in parallel the mucilage addition instead of CMC. Also, the mucilage addition resulted that the lightness and yellowness values of C* ≈ C** > T1 > T4 > T2 > T3, whereas the redness values of T3 > T2 > T4 > T1 > C** ≈ C*.The noticeable improvement in the rheological properties, melting behaviour and sensory evaluation of resultant treatments was observed with addition of BaSM, ChSM, CrSM and FlSM. In addition, the best treatmentwas ranked for basil ice milk according to the panelists' scores. According to the obtained results, the storage periods shouldn't be more than one month.

References

Abd El-Aziz, M., Haggag, H.F., Kaluoubi, M.M., Hassan, Laila K., El-Sayed, M.M. and Sayed, A.F. (2015) Physical properties of ice cream containing cress seed and flaxseed mucilages compared with commercial guar gum. *International Journal of Dairy Science*, **10**(4),160 – 172.https://doi.org/10.3923/ijds.2015.160.172

Abd El-Aziz, M., Kassem, J.M., Assem, F.M., Abbas, H.M. and Aziz, J.M.K. (2022)Physicochemical properties and health benefits of camel's milk and its applications in dairy products: A review. *Egyptian Journal of Chemistry*, **65**(5), 101 – 118. https://doi.org/10.21608/ejchem.2021.92589.4383

Abdel-Maqsoud, N.M., Elshaghabee, F.M., Metwally, A.M. and Anis, S.M. (2021) Impact of nano-stabilizers on the technological, texture and rheological properties of ice cream. *Egyptian Journal of Chemistry*, **65**(6), 283 – 291. https://doi.org/10.21608/ejchem.2021.102692.4761.

Akalın, A.S., Karagözlü, C. and Ünal, G. (2008) Rheological properties of reduced-fat and low-fat ice cream containing whey protein isolate and inulin. *European Food Research and Technology*, **227**, 889 – 895. https://doi.org/10.1007/s00217-007-0800-z.

Akbari, M., Eskndasi, M.H., Niakosari, M. and Bedeltavana, A. (2016) The Effect of inulin on the physicochemical properties and sensory attributes of low-fat ice cream. *International Dairy Journal*, **57**, 52 – 55. https://doi.org/10.1016/j.idairyj.2016.02.040.

Al-Saleh, A.A., Metwalli, A.A., Ismail, E.A. and Alhaj, O.A. (2014)Antioxidative activity of camel milk casein hydrolysates. *Journal of Camel Practice and Research*, **21**(2), 229 – 237. https://doi.org/10.5958/2277-8934.2014.00041.1.

AOAC (2016) Official methods of analysis. Association of Official Analytical Chemists (20thed.). M. Horwitz W. (Ed.). Academic Press.

Arabshahi-Delouee, S., Rahati Ghochani, S. and Mohammadi, A. (2020) Effect of flaxseed (*Linum usitatissimum*) mucilage on physicochemical and sensorial properties of semi-fat set yoghurt. *Journal of Food Biosciences and Technology*, **10**(2), 91 – 100.https://journals.srbiau.ac.ir/article_15738_ee8e9d0e4fa9ada0da581daa96637b84.pdf

Arbuckle, W.S. (1987) Ice cream, 4th ed. AVIP publishing company, Inc. Westport, Connecticut, USA.(pp.197–199).https://doi.org/10.1002/star.19870390716.

Azarpazhooh, E., Rashidi, H., Sharayei, P., Behmadi, H. and Ramaswamy, H.S. (2021) Effect of flaxseed-mucilage and Stevia on physico-chemical, antioxidant and sensorial properties of formulated cocoa milk. *Food Hydrocolloids for Health*, **1**, 100017. https://doi.org/10.1016/j.fhfh.2021.100017.

BahramParvar, M. and Goff, H.D. (2013) Basil seed gum as a novel stabilizer for structure formation and reduction of ice recrystallization in ice cream. *Dairy Science & Technology*, **93**, 273 – 285. https://doi.org/10.1007/s13594-013-0122-9.

Bahramparvar, M. and Mazaheri Tehrani, M. (2011) Application and functions of stabilizers in ice cream. *Food Reviews International*, **27**(4), 389 – 407. https://doi.org/10.1080/87559129.2011.563399.

BahramParvar, M., Razavi, S.M. and Mazaheri Tehrani, M. (2012) Optimizing the ice cream formulation using basil seed gum (*Ocimum basilicum* L.) as a novel stabilizer to deliver improved processing quality. *International Journal of Food Science & Technology*, **47**(12), 2655 – 2661. https://doi.org/10.1111/j.1365-2621.2012.03148.x.

BahramParvar, M., Tehrani, M.M. and Razavi, S.M. (2013) Effects of a novel stabilizer blend and presence of κ-carrageenan on some properties of vanilla ice cream during storage. *Food Bioscience*, **3**, 10 – 18.https://doi.org/10.1016/j.fbio.2013.05.001.

Barros, L., Dueñas, M., Ferreira, I.C., Carvalho, A.M. and Santos-Buelga, C. (2011) Use of HPLC-DAD-ESI/MS to profile phenolic compounds in edible wild greens from Portugal.*Food Chemistry*,**127**(1), 169 – 173.https://doi.org/10.1016/j.foodchem.2011.01.009.

Campos, B.E., Ruivo, T.D., da Silva Scapim, M.R., Madrona, G.S. and Bergamasco, R. D.C. (2016) Optimization of the mucilage extraction process from chia seeds and application in ice cream as a stabilizer and emulsifier. *LWT-Food Science and Technology*, **65**, 874 – 883.https://doi.org/10.1016/j.lwt.2015.09.021.

Chavan, V.R., Gadhe, K.S., Sharma, D. and Hingade, S.T. (2017) Studies on extraction and utilization of chia seed gel in ice cream as a stabilizer. *Journal of Pharmacognosy and Phytochemistry*, **6**(5), 1367 – 1370.DOI: 10.19080/ARTOAJ.2017.08.555733.

Cheng, J., Ma, Y., Li, X., Yam, T. and Cui, J. (2015). Effects of milk protein–polysaccharide interactions on the stability of ice cream mix model systems. *Food Hydrocolloids*, **45**, 237 – 336.https://doi.org/10.1016/j.foodhyd.2014.11.027.

Correia, R., Magalhaes, M., Pedrini, M., Cruz, A. and Clementino, I. (2008) Sorvetes elaborados com leite caprino e bovino: composição química e propriedades de derretimento. *Revista Ciência Agronômica*, **39**, 251 – 256. https://www.redalyc.org/pdf/1953/195317754010.pdf.

Cuomo, F., Iacovino, S., Cinelli, G., Messia, M.C., Marconi, E. and Lopez, F. (2020) Effect of additives on chia mucilage suspensions: A rheological approach. *Food Hydrocolloids*, **109**, 106118. https://doi.org/10.1016/j.foodhyd.2020.106118.

Donhowe, D.P., Hartel, R.W. and Bradley, R.L. (1991) Determination of ice crystal size distributions in frozen desserts. *Journal of Dairy Science*, **74**, 3334 – 3344.https://doi.org/10.3168/jds.s0022-0302(91)78521-4.

Elmasta□, M., Gülçin, I., I□ildak, Ö., Küfrevio□lu, Ö.İ., İbao□lu, K. and Aboul-Enein, H.Y. (2006). Radical scavenging activity and antioxidant capacity of bay leaf extracts. *Journal of the Iranian Chemical Society*, **3**, 258 – 266.https://doi.org/10.1007/bf03247217.

Farahmandfar, R., Asnaashari, M., Salahi, R. and Rad, T.K. (2017) Effects of basil seed gum, cress seed gum and quince seed gum on the physical, textural and rheological properties of whipped cream. *International Journal of Biological Macromolecules*, **98**,820-828.https://doi.org/10.1016/j.ijbiomac.2017.02.046.

Feizi, R., Goh, K.K.T. and Mutukumira, A.N. (2021) Effect of chia seed mucilage as stabiliser in ice cream. *International Dairy Journal*, **120**, 105087. https://doi.org/10.1016/j.idairyj.2021.105087.

Fernandes, S.S. and Salas-Mellado, M. de las M. (2017) Addition of chia seed mucilage for reduction of fat content in bread and cakes. *Food Chemistry*, **227**, 237 – 244.https://doi.org/10.1016/j.foodchem.2017.01.075.

Ferraro, G., Fratini, E., Sacco, P., Asaro, F., Cuomo, F., Donati, I. and Lopez, F. (2022) Structural characterization and physical ageing of mucilage from chia for food processing applications. *Food Hydrocolloids*, **129**, 107614 https://doi.org/10.1016/j.foodhyd.2022.107614.

Ferreira, B., Montesinos, D. and Sales, F. (2020) Mucilage in Portuguese Lamiaceae. *Botany Letters*, **167**(4), 430 – 438. https://doi.org/10.1080/23818107.2020.1790035.

Flores, A.A. and Goff, H.D. (1999) Ice crystal size distributions in dynamically frozen model solutions and ice cream as affected by stabilizers. *Journal of Dairy Science*, **82**, 1399 – 1407.https://doi.org/10.3168/jds.S0022-0302(99)75366-X.

Frøst, M.B., Heymann, H., Bredie, W.L.P., Dijksterhuis, G.B. and Martens, M. (2005) Sensory measurement of dynamic flavor intensity in ice cream with different fat levels and flavorings. *Food Quality and Preference*, **16**, 305–314.https://doi.org/10.1016/j.foodqual.2004.05.009.

Ghumman, S.A., Mahmood, A., Noreen, S. and Aslam, A. (2022) Chitosan-linseed mucilage polyelectrolyte complex nanoparticles of methotrexate: in vitro cytotoxic efficacy and toxicological studies. *Arabian Journal of Chemistry*, 104463.https://doi.org/10.1016/j.arabjc.2022.104463.

Goff, H.D. (2002) Formation and stabilisation of structure in ice-cream and related products.*Current Opinion in Colloid & Interface Science*, **7**(5-6), 432 – 437.https://doi.org/10.1016/S13596-00076(02)0294-.

Goksen, G., Demir, D., Dhama, K., Kumar, M., Shao, P., Xie, F. and Lorenzo, J.M. (2023) Mucilage polysaccharide as a plant secretion: Potential trends in food and biomedical applications. *International Journal of Biological Macromolecules*, 123–146.https://doi.org/10.1016/j.ijbiomac.2023.123146.

Hartel, R.W. (2001) Crystallization in foods. Gaithersburg, Md.: Aspen Publishers, p 325.

Hartel, R.W., Muse, M. and Sofjan, R. (2004) Effects of structural attributes on hardness and melting rate of ice cream. In ice cream II. *Proceedings of the second IDF International Symposium on Ice Cream, Thessaloniki,* Greece, 14 – 16 May 2003 (pp. 124 – 139). *International Dairy Federation*.

Hashim, I.B., Khalil, A.H. and Habib, H. (2009) Quality and acceptability of a set-type yogurt made from camel›s milk. *Journal of Dairy Science*, **92**(3), 857 – 862.https://doi.org/10.3168/jds.2008-1408.

Hassan, L.K., Haggag, H.F., ElKalyoubi, M.H., Abd EL-Aziz, M., El-Sayed, M.M. and Sayed, A.F. (2015) Physico-chemical properties of yoghurt containing cress seed mucilage or guar gum. *Annals of Agricultural Sciences*, **60**(1), 21 – 28.https://doi.org/10.1016/j.aoas.2014.11.021.

Ho, T.M., Zou, Z. and Bansal, N. (2022) Camel milk: A review of its nutritional value, heat stability, and potential food products. *Food Research International*, **153**, 110870.https://doi.org/10.1016/j.foodres.2021.110870.

Hwang, E.S. and Do Thi, N. (2014) Effects of extraction and processing methods on antioxidant compound contents and radical scavenging activities of laver (*Porphyratenera*). *Preventive Nutrition and Food Science*, **19**(1), 40 – 48.https://doi.org/10.3746/pnf.2014.19.1.040.

Ibrahim, M.A., Bester, M.J., Neitz, A.W. and Gaspar, A.R. (2018) Structural properties of bioactive peptides with α-glucosidase inhibitory activity. *Chemical Biology and Drug Design*, **91**(2), 370 – 379.https://doi.org/10.1111/cbdd.13105.

Jafarpour, A. (2017) Feasibility of manufacture and investigation of physicochemical properties of camel milk-based ice cream. *Journal of Scientific Agriculture*, **1**, 300 – 302.https://doi.org/10.25081/jsa.2017.v1.873.

Kamel, R., Afifi, S.M., Kassem, I.A.A., Elkasabgy, N.A. and Farag, M.A. (2020) Arabinoxylan and rhamnogalacturonan mucilage: Outgoing and potential trends of pharmaceutical, environmental, and medicinal merits. *International Journal of Biological Macromolecules*, **165**, 2550 – 2564. https://doi.org/10.1016/j.ijbiomac.2020.10.175.

Karaca, O.B., Guven, M.Y., Kaya, S. and Kahyaoglu, A. (2009) The functional,rheological and sensory characteristics of ice creams with various fat replacers. *International Journal of Dairy Technology*, **62**, 93 – 99.https://doi.org/10.1111/j.1471-0307.2008.00456.x.

Kaur, M., Kaur, R. and Punia, S. (2018) Characterization of mucilages extracted from different flaxseed (*Linum usitatissiumum* L.) cultivars: A heteropolysaccharide with desirable functional and rheological properties. *International Journal of Biological Macromolecules*, **117**, 919 – 927.https://doi.org/10.1016/j.ijbiomac.2018.06.010.

Kim, S.Y., Hyeonbin, O., Lee, P. and Kim, Y.S. (2020) The quality characteristics, antioxidant activity, and sensory evaluation of reduced-fat yogurt and nonfat yogurt supplemented with basil seed gum as a fat substitute. *Journal of Dairy Science*, **103**(2), 1324 – 1336.https://doi.org/10.3168/jds.201917117-.

Konuspayeva, G. and Faye, B. (2021) Recent advances in camel milk processing. *Animals*, **11**(4), 1045.https://doi.org/10.3390/ani11041045.

Koocheki, A., Taherian, A.R., Razavi, S.M. and Bostan, A. (2009) Response surface methodology for optimization of extraction yield, viscosity, hue and emulsion stability of mucilage extracted from *Lepidium perfoliatum* seeds. *Food Hydrocolloids*, **23**(8), 2369 – 2379.https://doi.org/10.1016/j.foodhyd.2009.06.014.

Kurt, A., Cengiz, A. and Kahyaoglu, T. (2016) The effect of gum tragacanth on the rheological properties of salep based ice cream mix. *Carbohydrate Polymers*, **143**, 116 – 123.https://doi.org/10.1016/j.carbpol.2016.02.018.

Kwee, E.M. and Niemeyer, E.D. (2011) Variations in phenolic composition and antioxidant properties among 15 basil (*Ocimum basilicum* L.) cultivars. *Food Chemistry*, **128**(4), 1044 – 1050.https://doi.org/10.1016/j.foodchem.2011.04.011.

Lan, Y., Ohm, J.B., Chen, B. and Rao, J. (2020) Physicochemical properties and aroma profiles of flaxseed proteins extracted from whole flaxseed and flaxseed meal. *Food Hydrocolloids*, **104**, 105731.https://doi.org/10.1016/j.foodhyd.2020.105731.

Maestrello, C., de Lima Figueiredo, I., Caroline de Souza Takahashi, G., Pimentel, T.C., Visentainer, J.V., de Cassia Bergamasco, R. and Madrona, G.S. (2018) Replacing emulsifier in a prebiotic ice cream: physical and chemical evaluation and acceptance. *Journal of Culinary Science & Technology*, **16**(1), 76 – 87.https://doi.org/10.10801/5428052.2017.1333934.

Marand, M.A., Amjadi, S., Marand, M.A., Roufegarinejad, L. and Jafari, S.M. (2020) Fortification of yogurt with flaxseed powder and evaluation of its fatty acid profile, physicochemical, antioxidant, and sensory properties. *Powder Technology*, **359**, 76 – 84.https://doi.org/10.1016/j.powtec.2019.09.082.

Marshall, R.T. and Arbuckle, W.S. (1996) Ice cream, 5th ed. Chapman & Hill, New York. Marshall, R., Goff. H.D. and Hartel, R.W. (2003) Ice cream. Kluwer Academic Press. New York, NY, USA.

Marshall, R.T., Douglas G.H. and Richard, R.W. (2003) Ice cream. 6th. ed. pp 44 – 49 and 139 – 142. Kluwer Academic / Plenum Publishers, New York, USA.

Moeenfard, M. and Tehrani, M.M. (2008) Effect of some stabilizers on the physicochemical and sensory properties of ice cream type frozen yogurt. *American-Eurasian Journal of Agricultural & Environmental Sciences*, **4**, 584 – 589.https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=afad0903b732497b741b9a874d4ea7b126cba83b.

Mukherjee, T., Lerma-Reyes, R., Thompson, K.A. and Schrick, K. (2019) Making glue from seeds and gums: Working with plant-based polymers to introduce students to plant biochemistry. *Biochemistry and Molecular Biology Education*, **47**(4), 468 – 475.https://doi.org/10.1002/bmb.21252.

Musa, A., Bello, Z., Ibrahim, L., Musa, M. and Muhammad, I.B. (2022) Evaluation of nutrients composition, minerals, vitamins and bioactive components of camel and cow milk sold in Katsina Metropolis. *Journal of Biochemistry, Microbiology and Biotechnology*, **10**(1), 46 – 51. https://doi.org/10.54987/jobimb.v10i1.663.

Musaad, A.M., Faye, B. and Al-Mutairi, S.E. (2013) Seasonal and physiological variation of gross composition of camel›s milk in Saudi Arabia. *Emirates Journal of Food and Agriculture*, **25**(8), 618 – 624.https://doi.org/10.9755/ejfa.v25i8.16095.

Muse, M.R. and Hartel, R.W. (2004) Ice cream structural elements that affect melting rate and hardness. *Journal of Dairy Science*, **87**(1), 1 – 10.https://doi.org/10.3168/jds.S00225-73135(04)0302-.

Naji-Tabasi, S. and Razavi, S.M.A. (2017) Functional properties and applications of basil seed gum: An overview. *Food Hydrocolloids*, **73**, 313 – 325. https://doi.org/10.1016/j.foodhyd.2017.07.007.

Nayak, A.K., Pal, D., Pradhan, J. and Hasnain, M.S. (2013) Fenugreek seed mucilage-alginate mucoadhesive beads of metformin HCl: Design, optimization and evaluation. *International Journal of Biological Macromolecules*, **54**, 144 – 154.https://doi.org/10.1016/j.ijbiomac.2012.12.008.

Nazir, S., Wani, I. and Masoodi, F.A. (2017) Extraction optimization of mucilage from basil (*Ocimum basilicum* L.) seeds using response surface methodology. *Journal of Advanced Research*, **8**, 235 – 244.https://doi.org/10.1016/j.jare.2017.01.003.

Patel, D., Pinto, S. and Pal, M. (2022) A comprehensive review on the properties of camel milk and milk products. *International Journal of Food Science and Agriculture*, **6**(2), 200 – 207.https://doi.org/10.26855/ijfsa.2022.06.010.

Pereira, G.A., Silva, E.K., Araujo, N.M.P., Arruda, H.S., Meireles, M.A.A. and Pastore, G.M. (2019)Mutamba seed mucilage as a novel emulsifier: Stabilization mechanisms, kinetic stability and volatile compounds retention. *Food Hydrocolloids*, **97**, 105190.https://doi.org/10.1016/j.foodhyd.2019.105190.

Potter, N.N. and Hotchkiss, J.H. (1995) Food Science, 5th ed.; Springer Science+Business Media, Inc.: Berlin/Heidelberg, Germany, **292**.https://doi.org/10.1007/978-1-4615-4985-7.

Punia, S. and Dhull, S.B. (2019) Chia seed (*Salvia hispanica* L.) mucilage (a heteropolysaccharide): Functional, thermal, rheological behaviour and its utilization. *International Journal of Biological Macromolecules*, **140**, 1084 – 1090.https://doi.org/10.1016/j.ijbiomac.2019.08.205.

Saeedi, M., Morteza-Semnani, K., Akbari, J., Bazargani, M.H. and Amin, G. (2015) Evaluation of *Ocimum basilicum* L. seed mucilage as rate controlling matrix for sustained release of propranolol HCl. *Pharmaceutical and Biomedical Research*, **1**(1), 18 – 25.https://doi.org/10.18869/acadpub.pbr.1.1.18 .

Sahan, N.U.R.A.Y., Yasar, K. and Hayaloglu, A.A. (2008) Physical, chemical and flavour quality of non-fat yogurt as affected by a β-glucan hydrocolloidal composite during storage. *Food Hydrocolloids*, **22**(7), 1291 – 1297.https://doi.org/10.1016/j.foodhyd.2007.06.010.

Sakurai, K., Kokubo, S., Hakamata, K., Tomita, M. and Yoshida, S. (1996) Effect of production conditions on ice cream melting resistance and hardness. *Milchwissenschaft*, **51**, 451 – 454.

Salami, M., Moosavi-Movahedi, F., Ehsani, M.R., Yousefi, R., Niasari-Naslaji, A. and Moosavi-Movahedi, A.A. (2010) Functional properties of bioactive peptides produced from camel milk. *Conference on Camel and Biomolecular Sciences*, *University of Tehran, Tehran,* 22 December 2010, Iran.

Schmidt, K.A. and Smith, D.E. (1992) Rheological properties of gum and milk protein interactions. *Journal of Dairy Science*, **75**, 36 – 42.https://doi.org/10.3168/jds.S0022-0302(92)77735-2.

Segall, K.I. and Goff, H.D. (2002)A modified ice cream processing routine that promotes fat destabilization in the absence of added emulsifier. *International Dairy Journal*, **12**(12), 1013 – 1018.https://doi.org/10.1016/S0958-6946(02)00117-6.

Singh, A., Bajwa, U. and Goraya, R.K. (2014) Effect of storage period on the physicochemical, sensory and microbiological quality of bakery flavoured ice cream. *International Journal of Engineering Research and Applications*, **4**, 80 – 90.https://didatticagelato.it/wp-content/uploads/simple-file-list/Effect-of-Storage-Period-on-the-Physicochemical-Sensory-and-Microbiological-Quality-of-Bakery-Flavoured-Ice-Cream.pdf.

Singh, R. and Barreca, D.N. (2020) Analysis of gums and mucilages. In recent advances in natural products analysis; Silva, A.S., Nabavi, S.F., Saeedi, M., Nabavi, S.M., Eds., Elsevier: Amsterdam, *The Netherlands*, 663 – 676.https://doi.org/10.1016/B978-0-12-816455-6.00021-4.

Sofjan, R.P. and Hartel, R.W. (2004) Effects of overrun on structural and physical characteristics of ice cream. *International Dairy Journal*, **14**(3), 255 – 262.https://doi.org/10.1016/j.idairyj.2003.08.005.

Soni, V. and Goyal, M. (2013) Potential of using camel milk for ice cream making. *Journal of Camel Practice and Research*, **20**(2), 271 – 275.

St□pień, K., Otlewska, A., Gó□d□, P. and Piotrowska, M. (٢٠٢١) The renaissance of plant mucilage in health promotion and industrial applications: A review. *Nutrients*, **13**(10), 3354.https://doi.org/10.3390/nu13103354.

Stone, H. and Sidel, J.L. (2004) Introduction to sensory evaluation. Sensory Evaluation Practices (3^{rd}). Academic Press, San Diego, 1 – 19.

Tavares, L.S., Junqueira, L.A., de Oliveira Guimarães, Í.C. and de Resende, J.V. (2018) Cold extraction method of chia seed mucilage (*Salvia hispanica* L.): Effect on yield and rheological behavior. *Journal of Food Science and Technology*, **55**, 457 – 466.https://doi.org/10.1007/s13197-017-2954-4 .

Tosif, M.M., Najda, A., Bains, A., Kaushik, R., Dhull, S.B., Chawla, P. and Walasek-Janusz, M. (2021) A comprehensive review on plant-derived mucilage: characterization, functional properties, applications, and its utilization for nanocarrier fabrication. *Polymers*, **13**(7), 1066.https://doi.org/10.3390/polym13071066.

Ürkek, B. (٢٠٢١) Effect of using chia seed powder on physicochemical, rheological, thermal and texture properties of ice cream. *Journal of Food Processing and Preservation*, **45**(5), e15418.https://doi.org/10.1111/jfpp.15418.

Wang, S.Y. and Lin, H.S. (2000) Antioxidant activity in fruits and leaves of blackberry, raspberry, and strawberry varies with cultivar and developmental stage. *Journal of Agricultural and Food Chemistry*, **48**(2), 140 – 146.https://doi.org/10.1021/jf9908345.

Wang, W.H., Lu, C.P. and Kuo, M.I. (2022) Combination of ultrasound and heat in the extraction of chia seed (*Salvia hispanica* L.) mucilage: Impact on yield and technological properties. *Processes*, **10**(3). https://doi.org/10.3390/pr10030519.

Winton, A.L. (1958) Analysis of Foods 3rd. Printing PO John Wiley and Sons Inc. New York, USA, 80 – 81.

Yang, X., Baskin, J.M., Baskin, C.C. and Huang, Z. (2012) More than just a coating: Ecological importance, taxonomic occurrence and phylogenetic relationships of seed coat mucilage. *Perspectives in Plant Ecology, Evolution and Systematics*, **14**, 434 – 442.https://doi.org/10.1016/j.ppees.2012.09.002.

Zhang, K., Zhang, Y., Ji, Y., Walck, J.L. and Tao, J. (2020) Seed Biology of *Lepidium apetalum* (Brassicaceae), with particular reference to dormancy and mucilage development. *Plants*, **9**, 333. https://doi.org/10.3390/plants9030333.