J. of Food and Dairy Sci., Mansoura Univ., Vol. 14(12): 301 - 308 , 2023

Journal of Food and Dairy Sciences

Journal homepage & Available online at: www.jfds.journals.ekb.eg

Effect of Adding β-cyclodextrin and Cinnamon Oil on the Quality Characteristics of Goat's Milk-Based Ice Cream

Alosily, N.[1]; M. Hassan[1, 2]; H. Barakat[1, 3]; A. Al-Hassan [1] and Samar Aly[1, 4]*

[1] Department of Food Science and Human Nutrition, College of Agriculture and Veterinary Medicine, Qassim University, Buraydah 51452, Saudi Arabia

[2] Department of Dairy Science, Faculty of Agriculture, Sohag University, Sohag 82755, Egypt

[3] Food Technology Department, Faculty of Agriculture, Benha University, Moshtohor 13736, Egypt

[4] Department of Food Science and Technology, Faculty of Agriculture, Tanta University, Tanta31733 , Egypt

Cross Mark

ABSTRACT

This study aimed to create ice cream from goat's milk using β-cyclodextrin (β-CD) or cinnamon essential oil (CEO) to mask the unpleasant taste of goat milk. The ice cream was made with different amounts of β-CD (0.25%), 0.50%, and 1.00%, and cinnamon essential oil (0.02%, 0.03%, and 0.04%), along with a control sample without additives (TC). The resulting ice cream was analyzed for chemical, rheological, nutritional, and organoleptic properties. Results showed that β-CD-ice creams had an increased concentration of total solids, decreased moisture content, increased ash, crude protein, and carbohydrates. CEO-ice had higher melting resistance and lower overrun percentage. The sensory evaluation indicated that the best addition rate for beta-cyclodextrin was 1.00%, and the best addition rate for cinnamon oil was 0.02%. These additions effectively mask the fatty acids that cause the goat flavor. Ice β3 and Ice C1 received high acceptance. This approach allows for the preservation of goat milk's benefits while effectively masking its strong flavor, resulting in a distinct and enjoyable ice cream with improved sensory acceptance.

Keywords: Ice cream, goat's milk, β-cyclodextrin, Cinnamon essential oil

INTRODUCTION

The rising demand for novel goods with improved functional qualities has given innovative processing methods a prominent role in the food industry. Especially in dairy product development, ice cream holds a special place as a beloved treat associated with moments of rest and joy. Milk is one of the main ingredients used to manufacture ice cream. One of these methods of developing dairy products is using goat milk to manufacture ice cream, resulting in products differentiated in taste and nutritional value. One of the fastest-growing food trends worldwide is the increasing popularity of ice cream (López *et al*., 2021).

Goats occupy the third place in terms of global milk production of various species, after cows and buffaloes. Goat's milk exhibits a relatively higher surplus of calcium, magnesium, and phosphorus than cow's milk and human milk. Medium-chain fatty acids (MCFAs) and proteins, constituents of goat's milk, have health-enhancing properties. According to Zenebe *et al.* (2014), goat milk plays an essential role in preventing cardiovascular disease, malignant growth, sensitization, and microbial contamination, and improving the immune response.

Compared to bovine milk, goat's milk is more easily digestible, has a larger buffer capacity, and contains less αs_1-casein, a protein that can cause allergic reactions. Goat's milk also differs from cow's milk because it has higher quantities of selenium and the glutathione peroxidase enzyme, giving it more potent antioxidant qualities (Biadała *et al*., 2018). One major factor in the limited market acceptance of goat-based products is the low demand stemming from the unpleasant "goat" flavor present in goat's milk. (Legowo *et al*., 2016).

Goat and sheep milk taste different from cow milk, and their dairy products have a unique flavor. There are two acids, namely 4-ethyloctanoic acid and 4-ethyloctanoic acid, which significantly impact the taste when they are not combined with other substances. (Young *et al*., 2012).

Practically, it is possible to improve the taste and flavor of ice cream by incorporating ingredients to improve the acceptability of goat ice cream, such as beta-cyclodextrin. Cyclodextrins are a class of non-toxic oligopolymers composed of glucose; they can effectively conceal the disagreeable odors emanating from malodorous compounds (Poulson *et al.*, 2021).

Cinnamon oil enhances food taste, scent, and acceptance. Cinnamon is a key spice used worldwide. Besides its antioxidant, anti-inflammatory, antidiabetic, antibacterial, anti-cancer, and hypolipidemic properties, cinnamon contains vital oils and other compounds such as cinnamaldehyde, cinnamic acid, and cinnamate (Rao and Gan 2014).

A frozen dairy treat is ice cream. It is a microcrystalline liquid-solid network. This phase includes proteins, fat globules, stabilizers, sugar, soluble and insoluble salts, and air cells trapped in a liquid phase. The formation of this network involves a challenging physicochemical process (Syed *et al*., 2018). Beta-cyclodextrin and cinnamon essential oil can be converted to value-added products when appropriately processed and incorporated into ice cream desserts. This incorporation aims to improve consumer

* **Corresponding author.**
E-mail address: samar.aly@agr.tanta.edu.eg
DOI: 10.21608/jfds.2023.248633.1138

acceptance and enhance the physical and nutritional properties. Therefore, the current study aimed to examine the possibility of producing a new ice cream product by incorporating beta-cyclodextrin (β-CD) and cinnamon essential oil (CEO) without any added flavoring agent. To commercially scale up such ice cream production, comprehensive evaluations of the chemical, rheological, and nutritional properties, as well as organoleptic properties of prepared ice cream, were carried out on the prepared ice cream.

MATERIALS AND METHODS

Materials

- Fresh raw goat's milk (4% fat) (*Murciano*) was obtained as a gift from Al-Nawader Farm, Al-Zulfi Governorate, Saudi Arabia. Fresh cream was obtained by separating fresh goat's milk, and cream (50% fat) was collected at the Department of Food Science and Human Nutrition processing unit. Goat skim milk powder (95% solids, not fat), the Meyenberg Goat Milk brand, was purchased online through the i-herb website.
- Sugar and gelatin were purchased from the local market at Buraydah, Al-Qassim region, Saudi Arabia (SA). Nutritional Cinnamon Oil, Now Foods brand, was purchased online through the iHerb website. β-cyclodextrin was purchased from AraChem, a fine chemicals company in the Netherlands. Liquid sunflower lecithin, the Now Foods brand, was purchased from Amazon.
- All chemicals used in the study were of analytical grade. Chemicals for each experimental method will be elaborated upon in detail in the subsequent descriptions of their respective analysis methods. All chemicals were purchased from Sigma-Aldrich Co. (St Louis, MO, USA).

Methods

The chemical composition of goat's milk:

The chemical composition was measured with a device called LactoStar (Funke Gerber). The average composition is shown in Table (1)

Table 1. The average composition of goat's milk used in the study

Ingredient	Content
Fat	4.00%
SNF	8.70%
Protein	3.18%
Lactose	4.77%
Minerals	0.71%
Density	1.02947
Freezing Point	-0.557˚C

Formulation of Different Ice Cream Mixes and Preparation of Ice Cream Samples

The ice cream was made according to the protocol of Arbuckle, 2013 at Qassim University's Department of Food Science and Human Nutrition at the College of Agriculture and Veterinary Medicine. Formulated ice cream batches were calculated basically as 12% fat, 11% SNF, 0.3 % Gelatin, 0.2 % lecithin, and 14% sugar. Seven ice cream mixes were formulated using the ingredients listed in Table 2.

Table 2. Ingredients of different ice cream formulas

Formula	Ingredients (g 100 g−1)								
	FGM (4% fat)	Cream (50% fat)	GMP (95%SNF)	Sugar	Gelatin	Lecithin	β - CD	CEO	total
TC	61.30	19.10	5.10	14	0.30	0.20	0	0	100
Ice β1	60.96	19.16	5.13	14	0.30	0.20	0.25	0	100
Ice β2	60.70	19.15	5.15	14	0.30	0.20	0.50	0	100
Ice β3	60.10	19.20	5.20	14	0.30	0.20	1.00	0	100
Ice C1	61.28	19.10	5.10	14	0.30	0.20	0	0.02	100
Ice C2	61.27	19.10	5.10	14	0.30	0.20	0	0.03	100
Ice C3	61.26	19.10	5.10	14	0.30	0.20	0	0.04	100

The liquid components of both mixtures (Fresh Goat milk [FGM] and cream mix]) were heated to a temperature of around 60° C. The dry components (dried skim milk powder and sugar) were added afterward. In addition, the solubilized gelatin was added, which was made by dissolving gelatin in the right amount of water with a little shaking. After 15 min at 85 °C, the mixture was immediately chilled in preparation for the aging process and stirred continuously throughout. The liquid components of both mixtures (Fresh Goat milk [FGM] and cream mix]) were first heated to a temperature of around 60 °C. We then added the dry components, which were a combination of skim milk powder and sugar that had been dried. Solubilized gelatin, made by dissolving gelatin in the right amount of water and stirring gently, was also added to the mixture. After 15 minutes at 85 °C, the mixture was immediately chilled in preparation for the aging process and stirred continuously throughout. The aging process is carried out to increase the viscosity and spread of the material in the mixture, which in turn helps to improve the whipping process). Cooled ice cream mixes were stored overnight at 4 ± 1 ºC (aging) before the whipping process. The seven prepared ice cream mixes were whipped successively at a speed of 6 and −7 ◦C for 5–6 min. The whipping process was carried out using an automated ice cream whipping machine (Finamac, Pro 16, Made by Renan Florencio Correia Silva, Santo André, Brazil). The seven ice cream samples (TC, Ice β1, Ice β2, Ice β3, Ice C1, Ice C2, and Ice C3), each containing different β-Cyclodextrin or Cinnamon oil amounts, were filled manually into plastic cups with a capacity of 150 ml. The filled cups were then kept at −18 ◦C until further analysis. Fatty acid analysis by GC Mass was also performed, therefore a piece of each ice cream sample was freeze-dried (CHRIST, Alpha 1-2 L.D. plus, Germany) for 96 h. at 48 C under a pressure of 0.032 mbar. Different tests were performed on samples at 1, 15, and 30 days after production.

Methods of Analysis

The total protein, fat, total solids (TS), moisture, and ash contents were determined according to (A.O.A.C., 2012). The amount of total carbohydrates was calculated using the following equation:

Carbohydrates % = Total solids - (Fat + Protein + Ash)(A.O.A.C, 2012).

pH and Titratable Acidity (TA%)

Different ice cream samples' pH levels were measured with a meter (Jenway 3505, Staffordshire, UK). The titratable acidity (in milligrams of lactic acid per one hundred milliliters) was measured using AOAC-approved protocols.

Overrun

Different ice cream samples had their overrun calculated. The overrun percent was calculated by comparing the weight of the ice cream to the weight of the ice cream mix after it had been freshly prepared but before it had been frozen (Hassan and Barakat, 2018), using the following formula:

$$\textbf{Overrun (\%)} = \frac{\textbf{weight of ice cream mix} - \textbf{weight of ice cream}}{\textbf{weight of ice cream}} \times 100$$

Melting point and Melting resistance

To assess melting point and melting resistance, three batches of both types of ice cream, namely cinnamon essential oil ice cream (CEO-ice cream) and β-Cyclodextrin ice cream (BC-ice cream), were prepared. Additionally, a typical control ice cream (TC-ice cream) was included in the analysis. Ice cream samples' melting point and melting resistance were measured by melting 50 g at 22±1ºC. Drippings from the samples were collected in a beaker by placing them on a fine wire screen over a glass funnel. The melting point was determined by the number of minutes after the first drop. The drainage weight was checked every 60 and 90 minutes. The percentage of relative melted amount at each period was used to compute melting resistance (Muse, and Hartel, 2004)

Rheological Properties

The rheological characteristics of ice cream samples with varying concentrations of -Cyclodextrin or Cinnamon oil were evaluated using the Discovery Hybrid Rheometer (DHR-2; T.A. Instrument, New Castle, DE, USA). All conditions specified in the description of the method used were met (Atalar *et al.* 2021). After being stored at 4°C for 5 minutes, ice cream samples were analyzed for their flow behavior and rheological parameters. For this analysis, we used a sensor with a 1 mm gap and a parallel geometry (40 nm diameter, 2 cone plate, Peltier plate Aluminum) setup. The viscosity measurement function was produced as a function of shear rate between 0.1 and 100 s1. While experimenting, the time was set at 120 seconds. A total of 32 points were gathered, and there was less than 10% variation between duplicates. For this data analysis, Power law models were fitted using Trios Software, version 3.1.0.3538.

Quantification of volatile components by GC-MS

The GC-MS equipment used in this research was a Thermo Scientific Trace GC Ultra/ISQ Single Quadrupole MS with a TG-5MS fused silica capillary column (30 m, 0.251 mm, 0.1 mm film thickness). A 70 eV ionization energy was used in the electron ionization system for GC-MS detection. There was a constant flow of helium gas at a rate of 1 mL min^{-1} as the carrier gas. The injectors and MS transfer lines were heated to a comfortable 280 °C. Starting with 50°C, the oven was set to rise to 150°C at a rate of 7°C min^{-1} (hold for 2 min), then to 270°C at a rate of 5°C min^{-1} (hold for 2 minutes), and finally to 310°C at a rate of 3.5 °C min^{-1} as the final temperature (hold 10 min). Calculating the relative peak area as a percentage allowed us to probe the indicated components' quantification. According to Odeh and Allaf, 2017, tentative identification of the compounds was accomplished by comparing their relative retention time and mass spectra with the GC-MS system's NIST and WILLY library data.

Organoleptic Properties

After one day of frozen storage, the organoleptic attributes of the ice cream of Odor (20), Taste (20), Aftertaste (10), Body and Texture (30), melting quality (10), Color (10), and overall acceptability (100) were judged by a panel of 12 staff members at the Department of Food Science and Human Nutrition, Faculty of Agriculture, Qassim University, KSA. Different flavors of ice cream were each assigned a unique three-digit code and presented to the panelists at random. For statistical purposes, we collected data by having panelists fill out scorecards (Arbuckle, 2013).

Statistical Analysis

Two-way analysis of variance (ANOVA) in SPSS version 22 was used for the statistical analysis (IBM Corp. Armonk, NY, USA, Released 2013). According to Steel *et al.*, 1997, the rules of a full randomization design, the data were. Multiple comparisons were carried out by applying the Duncan test. The significance level was set at <0.05, and means ± SD were presented

RESULTS AND DISCUSSION

Approximate chemical composition of different prepared ice cream formulas

Table 3 illustrates the chemical composition of prepared ice cream. It was observed that the formulas of β-CD ice cream were characterized by an increase in the concentration of total solids (P < 0.05).

Table 3. Approximate chemical composition and relative energy value of prepared ice cream formulas supplemented with β-CD and CEO (Mean ± SE), n = 3

Chemical Composition (g 100 g^{-1})	Storage period (day)	Ice cream formulas						
		TC	Ice β1	Ice β2	Ice β3	Ice C1	Ice C2	Ice C3
Moisture	1	62.34±0.04^{bC}	62.35±0.03^{bA}	62.16±0.02^{cA}	61.95±0.05^{dC}	62.19±0.06^{cB}	62.54±0.09^{aC}	62.39±0.04^{bC}
	15	62.39±0.08^{dB}	62.16±0.02^{eB}	62.13±0.02^{eA}	62.10±0.03^{eA}	62.72±0.05^{aA}	62.63±0.02^{bB}	62.52±0.14^{cB}
	30	62.47±0.12^{dA}	62.17±0.02^{eB}	62.12±0.01^{eA}	62.01±0.05^{fB}	62.71±0.08^{bA}	62.83±0.07^{aA}	62.60±0.21^{cA}
TS	1	37.66±0.04^{cA}	37.65±0.03^{cB}	37.84±0.02^{bA}	38.05±0.05^{aA}	37.81±0.06^{bA}	37.46±0.09^{dA}	37.61±0.04^{cA}
	15	37.61±0.08^{bB}	37.84±0.02^{aA}	37.87±0.02^{aA}	37.90±0.03^{aC}	37.28±0.05^{eB}	37.37±0.02^{dB}	37.48±0.14^{cB}
	30	37.53±0.12^{cC}	37.83±0.02^{bA}	37.88±0.01^{bA}	37.99±0.05^{aB}	37.29±0.08^{eB}	37.17±0.07^{fC}	37.40±0.21^{dC}
protein	1	4.64±0.03^{bB}	4.63±0.03^{bB}	4.77±0.06^{aB}	4.78±0.05^{aA}	4.61±0.03^{bAB}	4.38±0.04^{cC}	4.17±0.03^{dC}
	15	4.78±0.05^{abA}	4.76±0.13^{bA}	4.83±0.05^{aA}	4.79±0.14^{abA}	4.64±0.06^{cdA}	4.68±0.11^{cB}	4.60±0.06^{dA}
	30	4.63±0.03^{bB}	4.77±0.06^{aA}	4.81±0.04^{aAB}	4.76±0.11^{aA}	4.59±0.08^{bB}	4.82±0.06^{aA}	4.44±0.08^{cB}
Fat	1	11.97±0.03^{abA}	11.95±0.03^{abA}	11.93±0.09^{bA}	11.95±0.03^{aA}	11.87±0.03^{cB}	12.00±0.06^{aA}	11.97±0.09^{abAB}
	15	11.90±0.06^{bB}	11.87±0.03^{B}	11.90±0.15^{bA}	11.88±0.04^{bB}	11.90±0.06^{bA}	11.97±0.09^{aA}	11.93±0.07^{abB}
	30	11.90±0.06^{cB}	11.87±0.09^{cB}	11.93±0.09^{bcA}	11.87±0.03^{cB}	11.93±0.09^{bcA}	11.97±0.03^{abA}	12.00±0.06^{aA}
Ash	1	0.73±0^{eC}	0.75±0^{cB}	0.76±0^{bB}	0.78±0^{aA}	0.74±0^{dB}	0.74±0^{dB}	0.74±0^{dB}
	15	0.74±0^{dB}	0.75±0^{cB}	0.77±0^{bA}	0.78±0^{aA}	0.74±0^{dB}	0.74±0^{dB}	0.74±0^{dB}
	30	0.75±0^{dA}	0.76±0^{cA}	0.77±0^{bA}	0.78±0^{aA}	0.76±0^{cA}	0.77±0.01^{bA}	0.76±0^{cA}
Total carbohydrate	1	20.33±0.09^{cA}	20.32±0.03^{cB}	20.37±0.07^{cA}	20.54±0.07^{bA}	20.59±0.07^{bA}	20.34±0.12^{cA}	20.73±0.11^{aA}
	15	20.19±0.08^{bB}	20.46±0.17^{aA}	20.37±0.09^{aA}	20.45±0.21^{aB}	20.00±0.09^{cB}	19.98±0.18^{cB}	20.20±0.20^{bB}
	30	20.25±0.08^{cB}	20.44±0.11^{bA}	20.38±0.08^{bA}	20.58±0.11^{aA}	20.01±0.05^{dB}	19.62±0.10^{eC}	20.20±0.23^{cB}

$^{a,b\&c}$: No significant difference (P>0.05) between any two means, within the same row that has the same superscript letter. $^{A,B\&C}$: No significant difference (P>0.05) between any two means, within the same column that has the same superscript letter

This resulted in a significant decrease in moisture as compared to the TC sample. Additionally, the addition of β-CD and CEO to the TC sample during the storage period of 30 days resulted in significant increases in ash. Furthermore, the addition of β-CD also led to significant increases in carbohydrates. Cyclodextrins are cyclic oligosaccharides formed by glucose. One study suggests that the reason for the relative decrease in the percentage of carbohydrates during the storage period could be due to the presence of beta-cyclodextrin, which is a breakdown product of carbohydrates (Loftsson et al., 2007; Wadhwa et al., 2017).

In contrast, when compared to TC and β-CD, adding CEO resulted in significant decreases in crude protein during the 30-day storage period. This could be due to the higher percentage of protein in beta-cyclodextrin than in cinnamon oil.

Lokhande et al. (2011) found that the protein content in ice cream significantly increased with an increase in goat milk. Goat milk generally contains more protein than cow milk, resulting in the highest protein content of 4.83% and the lowest of 4.17%.

There was no significant change in fat in the formulas β-CD and CEO compared to TC, except for formula Ice β3, which recorded a significant decrease in fat content compared to the rest of the formulas during the storage periods of 15 and 30 days. This result is consistent with Maskooki et al. (2013) who reported that the fat content of milk significantly decreased with an increase in the amount of beta-cyclodextrin due to the smaller size of fat globules.

pH and Titratable Acidity (TA%)

Table 4 displays the pH and Titratable acidity % (TA %) values of the β-CD-ice cream and CEO-ice cream preparations. The addition of β-CD and CEO led to lower pH values in all formulas as compared to the TC-ice cream sample during the storage period. On the other hand, the addition of β-CD resulted in significant increases in acidity as compared to the TC and CEO ice cream sample during the 30-day storage period.

The acidity of goat milk ice cream containing 4% fat was found to be 0.16, which is consistent with the results of TC during the 15-day storage period, as reported by Lokhande et al. (2011). The addition of 1.00% beta-cyclodextrin in the formula Ice β3 led to a significant increase in acidity reaching 0.21% across all storage periods. This may be attributed to the findings of Afkhami et al. (2006) where the conditional acidity increases.

Table 4. Changes in pH and TA % during Storage period (mean ±SE), n = 3

	Storage period (day)	Ice cream formulas						
		TC	Ice β1	Ice β2	Ice β3	Ice C1	Ice C2	Ice C3
pH	1	6.30±0aA	6.27±0cA	6.27±0cA	6.25±0eC	6.28±0.01^{bA}	6.28±0^{bA}	6.26±0^{dC}
	15	6.30±0aA	6.27±0dA	6.27±0dA	6.26±0eB	6.28±0^{cA}	6.28±0^{cA}	6.29±0^{bB}
	30	6.30±0.01aA	6.26±0dB	6.25±0eB	6.27±0cA	6.28±0^{bA}	6.28±0^{bA}	6.30±0^{aA}
TA	1	0.17±0dA	0.18±0cA	0.19±0^{bB}	0.20±0.01^{aB}	0.17±0^{dB}	0.17±0^{dB}	0.17±0^{dB}
	15	0.16±0eB	0.18±0cA	0.19±0^{bB}	0.21±0^{aA}	0.17±0^{dB}	0.17±0^{dB}	0.17±0^{dB}
	30	0.17±0eA	0.17±0eB	0.20±0.01^{bA}	0.21±0^{aA}	0.19±0^{cA}	0.18±0^{dA}	0.18±0^{dA}

$^{a, b, c, d \& e}$: No significant difference (P>0.05) between any two means, within the same have the same row superscript letter. $^{A, B \& C}$: No significant difference (P>0.05) between any two means, within the same column that has the same superscript letter

Overrun %

Overrun refers to the degree of expansion resulting from the amount of air incorporated into the product during the freezing process. Table 5 shows that the overrun of the β-CD-ice cream and CEO-ice cream formulas fell within the range of 42.63% to 50.00% and 47.50% to 56.50%, respectively while TC overrun was 58.43%. There was a significant reduction (P < 0.05) in the overrun when β-CD and CEO were added. Factors such as the contents of fat, emulsifier, and stabilizer and processing conditions (whipping temperature and freezing power) can affect air cell development. Cyclodextrins are primarily used to improve the physicochemical stability, solubility, and dissolution rate, as mentioned by Jacob and Nair in 2018. A higher melting strength is associated with a lower overrun. (Figure 1, 2).

Table 5. The overrun % of prepared ice cream formulas incorporated β - CD and CEO (Mean ± SE), n = 3

Formulas	Overrun %
TC	58.43±0.30^{a}
Ice β1	50.00±1.15^{d}
Ice β2	49.47±0.29^{d}
Ice β3	42.63±0.32^{f}
Ice C1	56.50±0.29^{b}
Ice C2	52.40±0.31^{c}
Ice C3	47.50±0.29^{e}

$^{a, b, c, d, e \& f}$: No significant difference (P>0.05) between any two means, within the same column that has the same superscript letter.

Melting point and Melting resistance

In Figures 1 and 2, the melting resistance of the β-CD and CEO-ice cream formulas were recorded. Compared to the control sample TC, there was a significant increase in melting temperature when β-CD and CEO were added at a ratio of more than 0.25% and 0.02, respectively. The addition of CEO resulted in a higher melting temperature than the β-CD addition. This may be due to CEO formulas having higher solubility due to interactions between phenolic compounds in essential oils and proteins in Goat's milk. Also, a β-CD addition at 1.00% showed a slower melting rate than other samples. According to Jacob and Nair (2018), cyclodextrins have multiple uses, mainly to make the product more stable.

However, many variable factors affect the physical properties of ice cream, such as structural elements, composition, additives, and fat globule size. The amount and size of ice crystals and air bubbles also significantly contribute to the melting behavior (Koxholt et al., 2001; Goff, 2013; Hyvönen et al., 2003; Scholten, 2013).

Figure 3 presents the melting resistance of the β-CD-ice cream and CEO-ice cream samples. The weight loss % of TC-ice cream samples was significantly (P < 0.05) higher than β-CD-ice cream and CEO-ice cream formulas. β-CD ice cream was more resistant to melting than CEO-ice cream. Low overrun with a high concentration of beta-cyclodextrin indicates a compact structure that is highly resistant to melting. This may be due to preventing ambient air from entering the ice cream matrix, as shown in Figure 3. β-CD ice cream was more resistant to melting than CEO-ice cream at both 60 and 90 minutes. Figure 3 also shows that storage at -18°C for 30 days significantly affected the resistance to melting, as the melting resistance decreased for all samples with increasing storage period. This decrease was evident in the control sample TC. In general, the first drop of ice cream took a long time, ranging from 69.33 to 33.67 minutes, and this is considered a good indicator of the product quality for all treatments, as this time is ideal for melting.

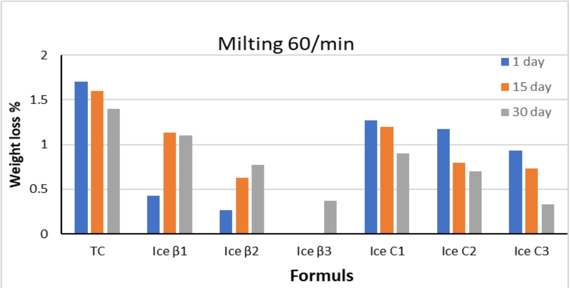

Figure 1. Melting resistance of prepared ice cream formulas incorporated β - CD and CEO after 60 min, (Mean ± SE), n = 3. TC control ice cream, Ice β1 ice cream added β-CD (0.25%), Ice β2 ice cream added β-CD (0.50%), Ice β3 ice cream added β-CD (1.00%),
Ice C1 ice cream added CEO (0.02%), Ice C2 ice cream added CEO (0.03%), and Ice C3 ice cream added CEO (0.04%).

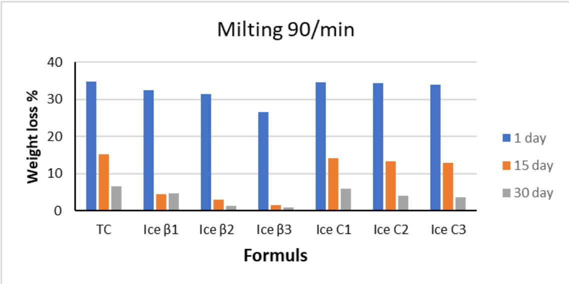

Figure 2. Melting resistance of prepared ice cream formulas incorporated β - CD and CEO after 90 min, (Mean ± SE), n = 3. TC control ice cream, Ice β1 ice cream added β-CD (0.25%), Ice β2 ice cream added β-CD (0.50%), Ice β3 ice cream added β-CD (1.00%),
Ice C1 ice cream added CEO (0.02%), Ice C2 ice cream added CEO (0.03%), Ice C3 ice cream added CEO (0.04%).

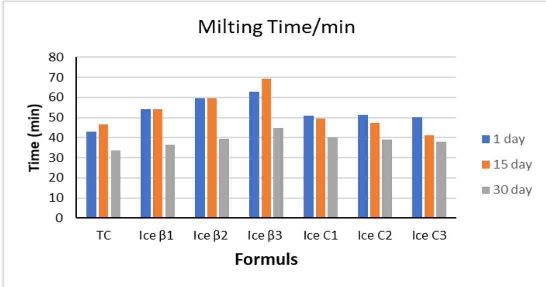

Figure 3. Melting time of prepared ice cream incorporated β - CD and CEO (Mean ± SE), n = 3. TC control ice cream, Ice β1 ice cream added β-CD (0.25%), Ice β2 ice cream added β-CD (0.50%), Ice β3 ice cream added β-CD (1.00%),
Ice C1 ice cream added CEO (0.02%), Ice C2 ice cream added CEO (0.03%), and Ice C3 ice cream added CEO (0.04%).

Rheological Parameters of Different Prepared Ice Cream Formulas

Figure 4 shows the viscosity of various ice cream samples as a function of shear rate, and Table 6 displays their rheological parameters (η0: zero-rate viscosity, η00: infinite-rate viscosity, K: consistency, r2: regression, n: rate index). Ice cream is a non-Newtonian fluid with a pseudoplastic flow, meaning its viscosity decreases as shear increases (Atalar *et al.*, 2021).The cross-model used in this study indicated a decrease in the apparent viscosity of all ice cream samples with increasing shear rate, demonstrating pseudoplastic behavior (Figure 4). The highest viscosity in the entire shear rate range (100-101) belonged to the TC ice cream sample, while the lowest was observed in Ice C2.

These results are consistent with previous findings (Carvalho *et al.*, 2022; McGhee *et al.*, 2015) that reported higher viscosities of goat's milk ice cream mixes than cow's milk ice cream mixes.

Table 6. Rheological properties (mean ±SD) of ice cream samples with different amounts of β-Cyclodextrin and Cinnamon oil

Ice cream sample	Cross Model				
	η_0 (Pa. s)	η_{00} (Pa. s)	K (Pa.s^n)	r^2	n
TC	18.05±1.21	0.829±0.011	0.096±0.002	0.99±0.000	2.04 ±0.041
Ice β1	1.17±0.523	0.066±0.010	1.881 ±0.016	0.99±0.000	0.742±0.012
Ice β2	16.72±1.014	0.852±0.012	0.088± 0.012	0.99±0.000	2.128± 0.044
Ice β3	2.44±0.372	0.119±0.013	1.686 ± 0.142	0.99±0.000	0.661±0.028
Ice C1	17.43±1.651	0.014±0.001	4.85±0.831	0.98±0.014	0.188±0.006
Ice C2	0.591±0.011	0.122±0.031	0.132±0.026	0.98±0.003	0.691±0.017
Ice C3	16.61±1.351	0.762±0.033	0.227±0.031	0.96±0.004	0.475±0.013

η0: zero-rate viscosity, η00: infinite-rate viscosity, K: consistency, r2: regression, n: rate index, TC control ice cream, Ice β1 ice cream added β-CD (0.25%), Ice β2 ice cream added β-CD (0.50%), Ice β3 ice cream added β-CD (1.00%), Ice C1 ice cream added CEO (0.02%), Ice C2 ice cream added CEO (0.03%), Ice C3 ice cream added CEO (0.04%).

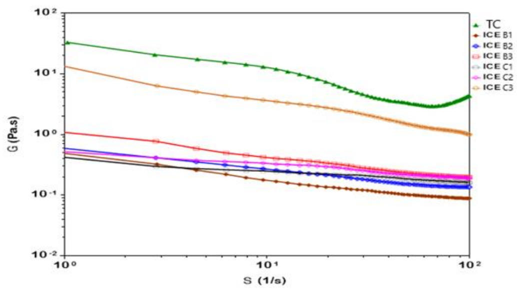

Figure 4. Changes in viscosity of ice cream samples with different amounts of β-CD and CEO vs. shear rate (Mean ± SE), n = 3. TC control ice cream, Ice β1 ice cream added β-CD (0.25%), Ice β2 ice cream added β-CD (0.50%), Ice β3 ice cream added β-CD (1.00%), Ice C1 ice cream added CEO (0.02%), Ice C2 ice cream added CEO (0.03%), Ice C3 ice cream added CEO (0.04%).

Moreover, cohesiveness and index of viscosity were found to be elevated in all types of goat's milk ice cream.

Samples that contained cinnamon oil (Ice C1, Ice C3) had higher viscosities than those containing β-CD, except for the Ice β2 sample. The addition of β-Cyclodextrin at a concentration of 0.50% significantly increased the infinite rate viscosity (η00) compared to the other samples and the TC sample. The cinnamon oil sample (0.02%) had the lowest final viscosity. Samples Ice C1 (4.85 Pa·sn) and Ice β1 (1.881 Pa·sn) had the highest consistency coefficient (K) among all the samples, while the opposite trend was observed in the other samples. No differences were observed in K values between Ice β2, Ice C2, and Ice C3 compared to the TC sample. A decrease in rate index was observed in all samples compared to the TC sample, except for Ice β2, which had the highest level (2.128). The regression coefficient (r2) of the ice creams showed no significant differences between β-CD-ice cream and TC formulas. On the contrary, the CEO formulas recorded the lowest values.

Quantification of volatile components by GC-MS

The GC/MS analysis of the components of β-CD and CEO ice cream is shown in Table 7. Thirty-two compounds were identified in the ice cream sample, with areas ranging from 0.06% to 32.24% in the TC sample and 36.26% in Ice β1. The major constituent area of the TC sample was Hexadecanoic acid, methyl ester (32.24%), followed by 9-Octadecenoic acid (Z)-, methyl ester (20.23%), Tetradecanoic acid, methyl ester (12.26%), and Methyl stearate (8.39%). The lowest constituent area was Heptadecanoic acid, 16-methyl-, methyl ester (0.06%). The results for the rest of the treatments showed differences in the concentrations of the different compounds, where the highest concentration was for the compound Hexadecanoic acid, methyl ester in the sample Ice β1 (36.26) and the lowest concentration of the same compound was in the sample Ice C2 (33.52).

Table 7. GC-MS identification and quantification of volatile compounds in prepared ice cream formulas supplemented with β-CD and CEO their 30-day. (Mean ± SE), n = 3.

Peak	Name	Formula	Area Sum %						
			TC	Ice β1	Ice β2	Ice β3	Ice C1	Ice C2	Ice C3
1	Butanoic acid, methyl ester	C5H10O2	0.33	0.35	0.39	0.36	0.31	0.18	0.31
2	Hexanoic acid, methyl ester	C7H14O2	0.75	0.8	0.82	0.65	0.82	0.62	0.87
3	Octanoic acid, methyl ester	C9H18O2	1.39	1.54	1.62	2.84	1.42	1.16	1.62
4	Decanoic acid, methyl ester	C11H22O2	6.56	6.81	6.75	6.24	6.65	6.1	6.87
5	Dodecanoic acid, methyl ester	C13H26O2	5.51	5.81	5.43	5.58	5.31	4.98	5.21
6	Tridecanoic acid, 12-methyl-, methyl ester	C15H30O2	0.12				0.07		0.07
7	Tetradecanoic acid, methyl ester	C15H30O2	12.26	12.29	11.92	12.26	12.28	11.94	12.35
8	Methyl myristoleate	C15H28O2	0.25				0.21		0.24
9	Pentadecanoic acid, methyl ester	C16H32O2	0.32	0.08			0.21	0.13	
10	Tetradecanoic acid, 12-methyl-, methyl ester	C16H32O2	0.46		0.26	0.31	0.39	0.3	0.31
11	methyl 13-methyltetradecanoate	C16H32O2	1.25	0.81	0.89	0.9	0.88	0.94	0.88
12	Methyl (Z)-10-pentadecenoate	C16H30O2	0.13						0.15
13	Pentadecanoic acid, 14-methyl-, methyl ester	C17H34O2	0.32	0.15			0.17	0.27	0.22
14	Hexadecanoic acid, methyl ester	C17H34O2	32.24	36.26	34.63	34.8	34.48	33.52	34.7
15	9-Hexadecenoic acid, methyl ester, (Z)-	C17H32O2	1.42	2.18	0.96	0.54	0.74	2.32	1.25
16	Hexadecanoic acid, 14-methyl-, methyl ester	C18H36O2	0.71	0.64	0.4	0.33	0.43	0.78	0.39
17	Hexadecanoic acid, 15-methyl-, methyl ester	C18H36O2	0.59	0.41	0.35	0.21	0.56	0.64	0.9
18	Heptadecanoic acid, methyl ester	C18H36O2	0.77	0.44	0.45	0.34	0.57	0.63	0.38
19	cis-10-Heptadecenoic acid, methyl ester	C18H34O2	0.41	0.22	0.23		0.32	0.28	0.33
20	Heptadecanoic acid, 16-methyl-, methyl ester	C19H38O2	0.06						
21	Methyl stearate	C19H38O2	8.39	7.34	7.85	6.78	7.12	7.92	7
22	9-Octadecenoic acid (Z)-, methyl ester	C19H36O2	20.23	20.83	23.82	22.61	23.1	23.34	22.97
23	13-Octadecenoic acid, methyl ester	C19H36O2	0.73						
24	Methyl 12,13-tetradecadienoate	C15H26O2	0.28						
25	9,12-Octadecadienoic acid (Z, Z)-, methyl ester	C19H34O2	2.76	2.34	2.36	2.67	2.63	2.53	2.36
26	Nonadecanoic acid, methyl ester	C20H40O2	0.07						
27	10-Undecenoic acid, methyl ester	C12H22O2	0.08						
28	9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-	C19H32O2	0.52	0.22	0.35		0.36	0.42	0.29
29	Methyl 9-cis,11-trans-octadecadienoate	C19H34O2	0.44	0.48	0.32		0.25	0.42	0.34
30	Eicosanoic acid, methyl ester	C21H42O2	0.24			2.58		0.59	
31	5,8,11,14-Eicosatetraenoic acid, methyl ester,(all-Z)-	C21H34O2	0.22						
32	Docosanoic acid, methyl ester	C23H46O2	0.18				0.72		

Although goat milk is known to contain high amounts of short and medium-chain fatty acids causing goat flavor, the greatest level of Hexadecanoic acid and methyl ester observed in this study sets it apart not only among the short-chain and medium-chain fatty acids but also among all fatty acids of the ice creams. This finding presents a unique and unusual phenomenon. Changes in the composition of the most abundant components and the introduction of newly synthesized ones were the results of GC-MS analysis.

Interestingly, the components Tridecanoic acid, 12-methyl-, methyl ester, Methyl myristoleate, Methyl (Z)-10-pentadecenoate, Docosanoic acid, and methyl ester disappeared in the β-CD formulas, while they appeared in the CEO and TC formulas.

It was also discovered that each 1.00% in the addition level of beta-cyclodextrin (Ice β3) led to the disappearance of more acids, including cis-10-Heptadecenoic acid, methyl ester, 9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z).)-, Methyl 9-cis, 11-trans-octadecadienoate, Pentadecanoic acid, 14-methyl-, methyl ester, Pentadecanoic acid, 14-methyl-, and methyl ester. This may be because the addition of β-CD to goat milk ice cream led to a disappearance in short-chain fatty acids compared to the control TC and CEO.

These results are supported by the findings of Sadooghy-Saraby (2011), who found that although the addition of lipase to goat milk generated free fatty acids (FFAs), the presence of β-CD trapped them and made them intangible and undetectable by gas chromatography. Thus, the goat flavor has disappeared significantly.

Organoleptic Properties of Different Prepared Ice Cream Formulas

The sensory scores of ice cream samples fortified with β-CD and CEO at successive levels are shown in Table (8), compared to TC. The color, odor, taste, texture, melting, and overall acceptability of the ice cream were all significantly affected by the addition of β-CD and CEO. However, the appearance and color scores were not significantly affected ($P > 0.05$). Adding beta-cyclodextrin and cinnamon oil significantly reduced the smell of goat milk, resulting in higher odor scores for ice cream samples with higher addition levels of both β-CD and CEO ($P < 0.05$). Cyclodextrins are known to have the capacity to mask and reduce unwanted flavors, odors, or bitterness, as mentioned by (Astray *et al.*, 2020) and (Cardoso-Ugarte *et al.*, 2016). Cinnamon essential oil, due to the presence of phenolic and volatile compounds, acts as a natural flavor and aroma enhancer. The taste and aftertaste of ice cream without β-CD and CEO showed the lowest scores, while Ice β3 and Ice C1 showed the highest scores.

Table 8. Organoleptic properties of prepared ice cream formulas supplemented with β-CD and CEO (Mean ± SE), n = 3.

Organoleptic parameters	Storage period (day)	Ice cream formulas						
		TC	**Ice β1**	**Ice β2**	**Ice β3**	**Ice C1**	**Ice C2**	**Ice C3**
Color	1	9.00 ± 0.39^{bcA}	9.25 ± 0.35^{abA}	9.42 ± 0.29^{abA}	9.58 ± 0.15^{aA}	9.58 ± 0.19^{aA}	9.00 ± 0.37^{bcB}	8.50 ± 0.61^{cB}
	15	8.17 ± 0.41^{dA}	8.25 ± 0.45^{cdA}	8.75 ± 0.37^{bcA}	9.17 ± 0.27^{abB}	9.50 ± 0.19^{aA}	8.42 ± 0.43^{cdA}	8.50 ± 0.34^{cdB}
	30	9.33 ± 0.36^{aA}	9.58 ± 0.29^{aA}	9.42 ± 0.26^{aA}	9.58 ± 0.19^{aA}	9.50 ± 0.23^{aA}	9.33 ± 0.38^{aAB}	9.17 ± 0.47^{aA}
Odor	1	15.50 ± 0.69^{cA}	17.58 ± 0.58^{bA}	17.92 ± 0.54^{bA}	18.83 ± 0.21^{aA}	19.17 ± 0.24^{aA}	17.42 ± 0.87^{bB}	17.42 ± 0.63^{bB}
	15	15.42 ± 0.34^{dA}	17.92 ± 0.48^{cA}	18.42 ± 0.40^{abA}	18.75 ± 0.39^{aA}	19.25 ± 0.41^{aA}	18.42 ± 0.43^{abA}	18.17 ± 0.34^{bA}
	30	15.33 ± 0.31^{eA}	18.00 ± 0.59^{cdA}	18.42 ± 0.84^{bcdA}	19.17 ± 0.21^{abA}	19.42 ± 0.19^{aA}	18.25 ± 0.60^{cdA}	17.83 ± 0.89^{dAB}
Taste	1	13.42 ± 0.96^{eB}	16.83 ± 0.61^{cdA}	17.42 ± 0.67^{bc}	18.58 ± 0.34^{ab}	18.67 ± 0.45^{a}	15.75 ± 0.98^{d}	16.08 ± 0.91^{d}
	15	15.25 ± 0.51^{dA}	16.42 ± 0.45^{cA}	17.17 ± 0.49^{bc}	18.33 ± 0.43^{ab}	19.25 ± 0.28^{a}	17.33 ± 0.58^{bc}	17.42 ± 0.40^{bc}
	30	15.33 ± 0.67^{dA}	17.00 ± 0.96^{bcA}	17.83 ± 0.80^{ab}	18.42 ± 0.54^{a}	18.67 ± 0.33^{a}	15.92 ± 1.12^{c}	15.75 ± 1.43^{d}
After taste	1	6.08 ± 0.43^{dC}	7.92 ± 0.43^{bcB}	8.42 ± 0.38^{bB}	9.17 ± 0.24^{aC}	9.33 ± 0.26^{aA}	8.17 ± 0.41^{bAB}	7.33 ± 0.56^{cB}
	15	6.92 ± 0.26^{cB}	7.92 ± 0.34^{bB}	8.08 ± 0.36^{bB}	8.83 ± 0.30^{aB}	9.00 ± 0.28^{aA}	7.83 ± 0.42^{bB}	7.50 ± 0.38^{bcB}
	30	7.58 ± 0.47^{dA}	8.92 ± 0.42^{aA}	8.92 ± 0.36^{aA}	9.42 ± 0.23^{aA}	9.17 ± 0.27^{abA}	8.58 ± 0.48^{bcA}	8.00 ± 0.63^{cdA}
Body and Texture	1	23.75 ± 1.22^{bA}	24.67 ± 1.03^{bA}	26.33 ± 0.86^{aA}	27.67 ± 0.57^{aA}	27.75 ± 0.71^{aA}	24.67 ± 0.92^{bA}	24.92 ± 0.56^{bAB}
	15	24.75 ± 1.05^{bA}	25.25 ± 0.96^{bA}	25.50 ± 1.00^{bA}	27.58 ± 0.83^{aA}	28.67 ± 0.81^{aA}	25.25 ± 1.02^{bA}	25.42 ± 0.84^{bA}
	30	23.17 ± 0.76^{cA}	25.00 ± 1.32^{bA}	25.17 ± 1.22^{bA}	27.17 ± 1.22^{aA}	27.83 ± 1.09^{aA}	24.17 ± 1.27^{bcA}	23.92 ± 1.26^{bcB}
Melting quality	1	8.00 ± 0.39^{cA}	8.08 ± 0.38^{cA}	8.33 ± 0.38^{bcAB}	9.00 ± 0.25^{aB}	8.83 ± 0.32^{abA}	7.75 ± 0.39^{cB}	7.08 ± 0.57^{dB}
	15	7.83 ± 0.46^{bA}	7.58 ± 0.50^{bcB}	8.17 ± 0.37^{bB}	8.92 ± 0.34^{aB}	9.17 ± 0.27^{aA}	7.33 ± 0.48^{cB}	7.42 ± 0.38^{cA}
	30	7.83 ± 0.46^{cA}	8.33 ± 0.40^{bcA}	8.75 ± 0.39^{abA}	9.50 ± 0.26^{aA}	9.08 ± 0.26^{aA}	8.25 ± 0.51^{bcA}	7.83 ± 0.52^{cA}
Overall acceptability	1	75.75 ± 3.04^{dB}	84.33 ± 2.32^{bcB}	87.83 ± 2.37^{bAB}	92.83 ± 1.27^{aA}	93.33 ± 1.70^{aA}	82.75 ± 3.01^{cA}	81.33 ± 2.77^{cA}
	15	78.33 ± 1.18^{cA}	83.33 ± 1.60^{bB}	86.08 ± 1.69^{bB}	91.58 ± 1.14^{aA}	94.83 ± 1.04^{aA}	84.58 ± 1.72^{bA}	84.42 ± 1.11^{bA}
	30	78.58 ± 1.52^{eA}	86.83 ± 2.57^{bcA}	88.50 ± 2.27^{bA}	93.25 ± 1.15^{aA}	93.67 ± 1.34^{aA}	84.50 ± 3.21^{cdA}	82.50 ± 3.58^{dA}

[a, b, c & d]: No significant difference (P>0.05) between any two means, within the same row that have the same superscript letter. A & B: No significant difference (P>0.05) between any two means, within the same column that have the same superscript letter.

The texture score of TC was the lowest. Adding β-CD at a concentration of 1.00% resulted in the highest solubility values because it slowed the melting of ice cream. According to a study by (Hidalgo et al., 2019), ice cream fortified with β-CD and CEO (Ice β3 and Ice C1) showed the highest overall acceptability scores compared to TC. This indicates that panelists preferred the ice cream formulas with β-CD and CEO and gave them high scores.

CONCLUSION

The ice cream made with β-CD was analyzed and found to have a higher concentration of total solids, leading to less moisture compared to traditional ice cream. Similarly, adding β-CD and CEO resulted in significant increases in ash. All formulas recorded significant increases in crude protein, whereas the CEO-ice showed significant increases in carbohydrates during the storage period after one day. The ice cream with a high β-CD concentration of 1.00% had higher melting resistance and lower overrun %, whereas the traditional ice cream sample had the highest viscosity among others.

We discovered essential fatty acids that contribute to the goat flavor, such as Tridecanoic acid, 12-methyl-, methyl ester, Methyl myristoleate, Methyl (Z)-10-pentadecenoate, and Docosanoic acid, methyl ester. We have successfully been able to bind and mask these compounds by adding β-CD and CEO. We found that the best addition percentage for beta-cyclodextrin was 1.00%, as it could significantly mask more fatty acids contributing to the goat flavor. Interestingly, only the ice cream made with 1.00% β-CD and 0.02% CEO was highly accepted.

Thus, we can use β-CD and CEO to produce ice cream up to 1.00% and 0.02%, respectively. This approach preserves the benefits of goat milk, masks its strong flavor, and provides a unique and enjoyable ice cream flavor with better sensory acceptance.

REFERENCES

Afkhami, A., & Khalafi, L. (2006). Spectrophotometric determination of conditional acidity constant as a function of β-cyclodextrin concentration for some organic acids using rank annihilation factor analysis. Analytica chimica acta, 569(1-2), 267-274.

AOAC. (2012). Official Methods of Analysis (9th Ed., AOAC international, Gaithersburg, MD, USA ed.).

Arbuckle, W.S. (2013). Ice Cream; Springer: Berlin/Heidelberg, Germany.

Astray, G., Mejuto, J. C., & Simal-Gandara, J. (2020). Latest developments in the application of cyclodextrin host-guest complexes in beverage technology processes. Food Hydrocolloids, 106, 105882.

Atalar, I., Kurt, A., Gul, O., & Yazici, F. (2021). Improved physicochemical, rheological and bioactive properties of ice cream: Enrichment with high pressure homogenized hazelnut milk. International Journal of Gastronomy and Food Science, 24, 100358.

Biadała, A., & Konieczny, P. (2018). Goat's milk-derived bioactive components-a review. Mljekarstvo: časopis za unaprjeđenje proizvodnje i prerade mlijeka, 68(4), 239-253.

Cardoso-Ugarte, G. A., López-Malo, A., & Sosa-Morales, M. E. (2016). Cinnamon (Cinnamomum zeylanicum) essential oils. In Essential oils in food preservation, flavor and safety (pp. 339-347). Academic Press.

Carvalho, C. C. D., Bodini, R. B., Sobral, P. J. D. A., & Oliveira, A. L. D. (2022). Ice creams made from cow's and goat's milks with different fat concentrations: physical-chemical and sensory properties. Food Science and Technology, 42, e79721.

Chang, Y., & Hartel, R. W. (2002). Development of air cells in a batch ice cream freezer. Journal of Food Engineering, 55(1), 71-78.

Goff, H. D. (2013). Ice cream. In Advanced dairy chemistry volume 2 lipids (pp. 441-450). Boston, MA: Springer US.

Haenlein, G. F. W. (2004). Goat milk in human nutrition. Small ruminant research, 51(2), 155-163.

Hassan, M. F., & Barakat, H. (2018). Effect of carrot and pumpkin pulps adding on chemical, rheological, nutritional and organoleptic properties of ice cream. Food and Nutrition Sciences, 9 (8), 969-982.

Hidalgo, M. E., Bordino, J., Acciarri, G., Fernández, J. M., Rozycki, S., & Risso, P. H. (2019). Effects of cholesterol extraction process and fat and whey protein additions on ice cream mixes. Journal of food science, 84(5), 980-989.

Hyvönen, L., Linna, M., Tuorila, H., & Dijksterhuis, G. (2003). Perception of melting and flavor release of ice cream containing different types and contents of fat. Journal of Dairy Science, 86(4), 1130-1138.

Jacob, S., & Nair, A. B. (2018). Cyclodextrin complexes: Perspective from drug delivery and formulation. Drug development research, 79(5), 201-217.

Koxholt, M. M., Eisenmann, B., & Hinrichs, J. (2001). Effect of the fat globule sizes on the meltdown of ice cream. Journal of Dairy Science, 84(1), 31-37.

legowo, a. m., & al-baarri, a. n. (2016). Investigation dicarbonyl compounds generated from the maillard reactions of methionine with reducing sugars to enfold off flavor in goat's milk.

Loftsson, T., & Duchene, D. (2007). Cyclodextrins and their pharmaceutical applications. International journal of pharmaceutics, 329(1-2), 1-11.

Lokhande, A. T., Matkar, A. B., Adangale, S. B., & Mandakmale, S. D. (2011). Goat milk ice cream: A value added milk product for livelihood. Indian Journal of Fundamental and Applied Life Sciences, 1(2), 170-172.

López-Martínez, M. I., Moreno-Fernández, S., & Miguel, M. (2021). Development of functional ice cream with egg white hydrolysates. International Journal of Gastronomy and Food Science, 25, 100334.

Maskooki, A. M., Beheshti, S. H. R., Valibeigi, S., & Feizi, J. (2013). Effect of cholesterol removal processing using β-cyclodextrin on main components of milk. International Journal of Food Science, 2013.

McGhee, C. E., Jones, J. O., & Park, Y. W. (2015). Evaluation of textural and sensory characteristics of three types of low-fat goat milk ice cream. Small Ruminant Research, 123(2-3), 293-300.

Muse, M. R., & Hartel, R. W. (2004). Ice cream structural elements that affect melting rate and hardness. Journal of dairy science, 87(1), 1-10.

Odeh, A., & Allaf, A. W. (2017). Determination of polyphenol component fractions and integral antioxidant capacity of Syrian aniseed and fennel seed extracts using GC–MS, HPLC analysis, and photochemiluminescence assay. Chemical Papers, 71, 1731-1737. doi: 10.1007/s11696-017-0169-9.

Poulson, B. G., Alsul ami, Q. A., Sharfalddin, A., El Agammy, E. F., Mouffouk, F., Emwas, A. H., ... & Jaremko, M. (2021). Cyclodextrins: Structural, Chemical, and Physical Properties, and Applications. Polysaccharides, 3(1), 1-31.

Rao, P. V., & Gan, S. H. (2014). Cinnamon: a multifaceted medicinal plant. Evidence-Based Complementary and Alternative Medicine, 2014.

Sadooghy-Saraby, S. (2011). Assessment of the entrapment of free fatty acids in goat milk by β-cyclodextrin and reduction of goaty flavour (Doctoral dissertation, Auckland University of Technology).

Scholten, E. (2013). Ice cream. In Particulate products: Tailoring properties for optimal performance (pp. 273-294). Cham: Springer International Publishing.

Steel, R.G. (1997) Pinciples and Procedures of Statistics a Biometrical Approach, 3rd ed.; McGraw-Hill: Boston, MA, USA.

Syed, Q. A., Anwar, S., Shukat, R., & Zahoor, T. (2018). Effects of different ingredients on texture of ice cream. Journal of Nutritional Health & Food Engineering, 8(6), 422-435.

Wadhwa, G., Kumar, S., Chhabra, L., Mahant, S., & Rao, R. (2017). Essential oil–cyclodextrin complexes: An updated review. Journal of inclusion phenomena and macrocyclic chemistry, 89, 39-58.

Young, O. A., Gupta, R. B., & Sadooghy-Saraby, S. (2012). Effects of cyclodextrins on the flavor of goat milk and its yogurt. Journal of food science, 77(2), S122-S127.

Zenebe, T., Ahmed, N., Kabeta, T., & Kebede, G. (2014). Review on medicinal and nutritional values of goat milk. Academic Journal of Nutrition, 3(3), 30-39.

تأثير إضافة بيتا سيكلودكسترين وزيت القرفة على صفات جودة الآيس كريم المصنع من حليب الماعز

نوف العسيلي[1]، محمد حسن [1,2]، حسن بركات [1,3]، أحمد الحسن[1] وسمر علي[4، 1*]

[1] قسم علوم الأغذية وتغذية الإنسان، كلية الزراعة والطب البيطري، جامعة القصيم، بريدة 51452، المملكة العربية السعودية
[2]قسم علوم الألبان، كلية الزراعة، جامعة سوهاج، سوهاج 82755، مصر
[3]قسم تكنولوجيا الأغذية، كلية الزراعة، جامعة بنها، مشتهر 13736، مصر
[4]قسم علوم وتكنولوجيا الأغذية، كلية الزراعة، جامعة طنطا، طنطا 31733، مصر

الملخص

تهدف هذه الدراسة إلى تصنيع الآيس كريم من حليب الماعز باستخدام β-cyclodextrin (β-CD) أو زيت القرفة الأساسي (CEO) لإخفاء الطعم غير مرغوب لحليب الماعز. تم تصنيع الآيس كريم بكميات مختلفة منβ-CD 0,25%، 0.50%، و1.00%، وزيت القرفة العطري (0.02%، 0.03%، و0.04%)، بالإضافة إلى عينة مراقبة بدون إضافات (TC) .تم تحليل الآيس كريم الناتج من حيث الخصائص الكيميائية والريولوجية والغذائية والحسية. أظهرت النتائج أن آيس كريم β-CD يحتوي على زيادة في تركيز المواد الصلبة الكلية، وانخفاض محتوى الرطوبة، وزيادة الرماد، والبروتين الخام، والكربوهيدرات. كان لدى الايس كريم المصنع باضافه زيت القرفه مقاومة ذوبان أعلى ونسبة هواء أقل. وأشار التقييم الحسي إلى أن أفضل نسبة إضافة لبيتا سيكلودكسترين كانت 1.00%، وأفضل نسبة إضافة لزيت القرفة كانت 0.02%. تعمل هذه الإضافات على إخفاء الأحماض الدهنية التي تسبب نكهة الماعز بشكل فعال. تلقى Ice β3 و Ice C1 قبولًا عاليًا. يسمح هذا الأسلوب بالحفاظ على فوائد حليب الماعز مع إخفاء نكهته القوية بشكل فعال، مما يؤدي إلى الحصول على آيس كريم مميز وممتع مع قبول حسي مرتفع.