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Original Article

Measurement of dental caries activity of commercial frozen desserts in Korea

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ABSTRACT

Objectives: This study was conducted to analyze the sugar content, acidity, and viscosity of the Korean frozen desert. **Methods:** A total of 60 types of frozen desserts marketed in Korea were randomly selected and classified into frozen desserts, milk-fat ice cream group, and non-fat ice cream group according to the classification criteria for frozen desserts. Each product was treated under the same conditions to investigate the component of each product, and sugar content, acidity, and viscosity were measured. Frequency analysis and one-way ANOVA were performed. **Results:** As a result of analyzing the characteristics related to dental caries activity by group, the frozen dessert had the lowest average pH of 3.67, and the sugar content was significantly higher in the milk-fat group (33.22) and non-fat group (32.89) than in the frozen dessert. The viscosity was also the highest in the milk-fat group at 32.62, and the frozen dessert was significantly lower at 9.42. **Conclusions:** Due to the abnormal temperature and spread of the coronavirus, consumption of frozen desserts at home is on the rise. To prevent dental caries in children, education is needed for children and their guardians for proper oral care after eating frozen desserts.

Key Words: Dental caries, Hydrogen-ion concentration, Ice cream, Sugars, Viscosity

Introduction

Frozen desserts are defined in the food product standard and specification of the Ministry of Food and Drug Safety as the frozen products of raw milk, processed milk, and drinking water to which other foods or food additives are added, including ice creams, ice cream mix products, ice cakes, and edible ice. The types of frozen desserts; ice creams, ice cream mix products, ice cakes, and edible ice, are subcategorized further. Particularly, ice creams are divided into ice cream, low-fat ice cream, ice milk, sherbet, and non-fat ice cream [1]. The regulations in South Korea require commercial frozen desserts to have their type marked on the packaging. In addition, as frozen desserts are stored in a frozen state that prevents changes in quality or microbial growth; hence only the date of manufacture should be marked without shelf life or best before date [2].

The frozen dessert market size in South Korea has shown a trend of decrease from 2.02 trillion KRW in 2015 to 1.43 trillion KRW in 2019 [3]. This may be due to the reduced sales caused by a fall in the population of children, the main consumers of frozen desserts. However, the sales in the first half of 2020 showed a slight increase compared to the same time in 2019. In addition, the trend of social media buzz volume of *ice cream* increased from January to April 2020, compared to the same period in 2018 and 2019. This has been attributed to the increased home purchase of desserts including ice creams under the influence of abnormal temperatures and the COVID-19 pandemic that began in 2020 [4].

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In 2018, the percentage of children aged 5 years with the experience of childhood caries was 68.5% showing a steadily increasing trend from 61.5% in 2010, while the caries prevalence in primary dentition also increased from 2.99 in 2010 to 3.43 in 2018. The percentage of children aged 12 years with caries of permanent tooth was 56.4% in 2018 exhibiting a decrease compared to 60.5% in 2010, while the caries prevalence in permanent dentition also slightly decreased from 2.08 in 2010 to 1.84 in 2018 [5]. However, the experience of caries in primary dentition is rising and that in permanent dentition is falling.

Dental caries is caused by the complex action of a diversity of factors including bacteria, host, diet, and time [6]. As dental caries is an irreversible condition, an emphasis is placed on its prevention in growing children to maintain oral health. Notably, oral health is influenced by the nutritional contents and food intake; thus, dietary control is an essential part of the prevention of dental caries in early childhood. In a study investigating the correlation between dental caries and intake of desserts in elementary school children, the prevalence of dental caries was shown to be correlated with the frequency of dessert intake after lunch and the number of tooth brushing after lunch [7] to suggest the need for the management of the dental plaque and the dietary control to restrict the time and frequency of dessert intake.

Frozen desserts are foods with high sugar contents that may influence the incidence of dental caries in children as the main consumers. As they are readily available in various forms at ice cream shops and discount shops whose numbers have recently increased, and considering the increased consumption of ice creams at homes related to the COVID-19 pandemic [8], care should be taken by the general public in the management of oral health.

While numerous studies have analyzed the influence of energy drinks on dental erosion [9] and enamel surface [10,11], and the characteristics of beverages in relation to dental caries such as carbonated drinks and their effects on enamel erosion [12], no study has yet examined the characteristics of frozen desserts by type regarding the causal factors of dental caries. This study thus aimed to determine the effects of the different types of frozen desserts on dental caries in children by analyzing the sugar content, acidity, and viscosity of each type of frozen dessert.

Methods

1. Materials

Sixty commercial frozen dessert products in South Korea were randomly selected and purchased from hypermarkets and convenience stores from August to December 2020. The frozen dessert classification criteria [13] categorizes frozen desserts into ice cream, ice milk, sherbet, low-fat ice cream, non-fat ice cream, and ice cake. Among them, low-fat ice cream was excluded from this study due to its rarity, while ice cream and ice milk were grouped as milk-fat ice cream and sherbet and non-fat ice cream as non-milk-fat ice cream, to leave three final experimental groups; ice cake, milk-fat ice cream, and non-milk-fat ice cream <Table 1>.

2. Methods

1) Nutritional contents of frozen desserts

Using the nutritional values indicated on the frozen dessert products in this study, the calorie and contents of sodium, carbohydrate, sugar, and fat were converted based on 100 g.

2) Sugar content, acidity, and viscosity of frozen desserts

For complete defrosting of the frozen dessert products before measuring the sugar content, acidity, and viscosity, the products were kept at room temperature, and afterward, the dried fruit, chocolate, and jelly contained in these products were sieved using a fine net to prepare them in the liquid state for analyses. Notably, as it is characteristic of viscosity to decrease with increasing temperature [14], all frozen dessert products were kept at room temperature for 4 h to ensure equal temperature among the products prior to measuring the viscosity.

Table 1. General characteristics of frozen desserts

Group	Product group	Product name	Manufacturer	Total content (mL)
Frozen dessert group	Frozen dessert	Babambar	HAI TAI	63
		Papico soda	LOTTE	130
		Jaws bar	LOTTE	75
		Polapo grape	HAI TAI	120
		Polapo strawberry	HAI TAI	120
		Shine muscat green grape	LOTTE	75
		Totomama	HAI TAI	120
		Screw bar strawberry & apple	LOTTE	75
		Subark bar	LOTTE	75
		Green plum	Others	75
		Seolleim Lemon ade	LOTTE	160
		Vita 500 big bead ice	Others	62
		Jewel ice bar	LOTTE	80
		Mogu mogu peach ice	LOTTE	130
		Mogu mogu pine ice	LOTTE	130
		Baekdu mountain	LOTTE	75
		Dipping dots soda	Others	70
		Jjyujjyu bar watermelon	LOTTE	130
		Cool shot watermelon	LOTTE	200
		Into the mango bar	LOTTE	75
Butterfat group	Ice cream	Rare roasted sweet potato	LOTTE	140
		Supercon	Binggrae	150
		Crunky bar mint	LOTTE	90
		Gugukon madagascar vanilla	LOTTE	160
		Hershey's choco bar	Others	90
		Nougat bar	HAI TAI	70
		Together original vanilla	Binggrae	270
	Ice milk	Ppangttoa	Binggrae	180
		World con	LOTTE	160
		Asinayo	Samlip	180
		Melona	Binggrae	82
		Gugukon	LOTTE	165
		Burabocon vanilla	HAI TAI	150
		Seolleim milk shake	LOTTE	170
		Double bianco	LOTTE	195
		Ssangssang bar	HAI TAI	67
		Rich milk ice bar	LOTTE	70
		Walnut maroo	HAI TAI	63
		Cherry maroo	HAI TAI	63
		Appleberry bar	Others	80
Non-fat group	Sherbet	Crispy crunch ice bar	LOTTE	75
		Red bean ice bar	Binggrae	70
		Bravo watermelon	HAI TAI	140
		Pasitongtong	HAI TAI	70
		Bravo pistachiorevolution	HAI TAI	140
		Wa	LOTTE	190
		Candy bar	Binggrae	75
		Yomamttea strawberry	Binggrae	70
		Banana boy	Binggrae	130
		Duet chocobanana	HAI TAI	70
		Yomamttea peach	Binggrae	70
		Injeolmi-tongtong	HAI TAI	63
		Littele ten grape	HAI TAI	35
	Low-fat ice cream	Tteogbungeossamanko	Binggrae	150
		Ku and keu	Binggrae	70
		Bravo sand	HAI TAI	180
		Chambungeossamanko classic	Binggrae	150
		Babambar ice sand	HAI TAI	180
		Bravo choco chunk mild	HAI TAI	140
		Choco bungeossamanko	Binggrae	150

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The acidity of frozen desserts was measured using the pH meter (Thermo Scientific, Orion Versa Star Pro, USA). Prior to measurement, the pH meter was calibrated using standard buffer solutions of pH 4.0, 7.0, and 10.0, and 40 mL of each defrosted product was placed in a conical tube. The mean of triplicate measurements was estimated. The sugar content was measured three times using the portable digital Brix meter (PAL-1, ATAGO®), and the mean Brix value was estimated. For both acidity and sugar content, all products were kept at room temperature for 4 h to allow measurements in the liquid state, and the raw solutions without dilution were used.

The viscosity was measured using the Ostwald Viscometer (OV). For each frozen dessert, the time taken for the drop of 2 mL was measured three times, while the viscosity of distilled water was also measured three times. The mean time (sec) of the drop of 2 mL of frozen dessert was divided by the time (sec) of the drop of 2 mL of distilled water to calculate the specific viscosity. The OV was washed after each use to remove any residues of the previous product, and in case of incomplete removal, a fresh OV was used. The viscosity could not be measured for five frozen dessert products that were trapped in the pipette without flow due to high viscosity.

3. Statistical analysis

To analyze the sugar content, acidity, and viscosity of the commercial frozen desserts in South Korea, a well-known statistical program (IBM SPSS Statistics version 23.0, Chicago, USA) was used. Frequency analysis was performed for the general characteristics of the target products, while one-way ANOVA was performed for the differences in nutritional contents and the characteristics related to dental caries based on product type. The level of significance (α) was set to 0.05.

Results

1. Nutritional contents of commercial frozen desserts

The sixty target frozen dessert products comprised 20 products in each group; ice cake, milk-fat ice cream, and non-milk-fat ice cream. The product with the highest sugar content showed 25.3 g and that with the lowest sugar content showed 1.5 g. Among the milk-fat ice creams, the highest sugar content was 83.3 g in 'Bbangttoa', and among the non-milk-fat ice creams, 'Crispy Crunky Ice Bar' showed the highest sugar content of 25.3 g, per 100 g product <Table 2>.

For the nutritional values, the sodium content was the highest (59.94 mg) in the non-milk-fat group, while the ice cake group displayed a significantly lower mean content at 15.94 mg. The carbohydrate and sugar contents displayed no significant difference, while the fat content was the highest (7.07 g) in the milk-fat group (p<0.001) <Table 3>.

2. Characteristics of commercial frozen desserts in relation to dental caries activity

The dental caries activity of commercial frozen desserts was estimated based on acidity, viscosity, and Brix value. Among the analyzed products, the lowest acidity was 2.70, with the mean acidity of 4.83 in the milk-fat group and 5.16 in the non-milk-fat group. The highest Brix value measured using the digital Brix meter was 32.53 in ice cakes, 42.3 in milk-fat ice creams, and 43.3 in non-milk-fat ice creams. The specific viscosity increased from ice cakes 19.75 to milk-fat ice creams 71.67 to non-milk-fat ice creams 119.70. To calculate the specific viscosity, the viscosity of each product (in terms of time) was measured, and there was one produce of ice cake, one milk-fat product, and three non-milk-fat products that could not be measured due to the lack of flow inside the OV <Table 4>.

Analyzing the characteristics of each product type in relation to dental caries activity showed that the acidity, viscosity, and Brix value all varied with significant differences. The mean acidity was the lowest for ice cakes (3.67), while the Brix value was significantly higher for milk-fat (33.22) and non-milk-fat (32.89) ice creams than ice cakes. The specific viscosity was the highest for milk-fat ice creams (32.62) and the lowest for ice cakes (9.42) <Table 5>.

Table 2. Nutritional components of the frozen desserts

Unit : per 100 g

Group (N)	Product group (N)	Product name	Sodium (mg)	Carbohydrate (g)	Sugar (g)	Fat (g)	Calories (kcal)
Frozen dessert group (20)	Frozen dessert (20)	Babambar	31.7	27.0	19.0	4.0	150.8
		Papico soda	7.7	25.4	13.1	0.6	103.8
		Jaws bar	1.3	28.0	20.0	0.0	113.3
		Polapo grape	29.2	14.2	10.0	0.4	58.3
		Polapo strawberry	20.8	13.3	9.2	0.3	58.3
		Shine muscat green grape	0.0	32.0	21.3	1.1	126.7
		Totomama	20.8	14.2	11.7	1.1	66.7
		Screw bar strawberry & apple	1.3	29.3	16.0	0.0	120.0
		Subark bar	33.3	25.3	20.0	2.1	120.0
		Green plum	93.3	18.7	17.3	0.7	80.0
		Seolleim Lemon ade	3.1	22.5	15.0	0.4	93.8
		Vita 500 big bead ice	24.2	22.6	16.1	0.8	96.8
		Jewel ice bar	0.0	22.5	17.5	0.9	87.5
		Mogu mogu peach ice	1.5	25.4	15.4	1.1	111.5
		Mogu mogu pine ice	0.8	25.4	15.4	1.1	111.5
		Baekdu mountain	13.3	26.7	21.3	0.0	106.7
		Dipping dots soda	28.6	20.0	12.9	1.1	92.9
		Jjyujjyu bar watermelon	7.7	23.8	13.1	0.6	100.0
		Cool shot watermelon	0.0	1.5	1.5	0.0	7.5
		Into the mango bar	0.0	30.7	25.3	0.0	126.7
Butterfat group (20)	Ice cream (7)	Rare roasted sweet potato	28.6	22.9	17.1	3.1	128.6
		Supercon	40.0	16.7	12.7	9.3	160.0
		Crunky bar mint	44.4	25.6	17.8	15.6	250.0
		Gugukon madagascar vanilla	37.5	19.4	12.5	8.8	165.6
		Hershey's choco bar	62.2	31.1	26.7	18.9	311.1
		Nougat bar	57.1	18.6	15.7	12.9	200.0
		Together original vanilla	44.4	11.1	10.0	5.2	98.1
	Ice milk (13)	Ppangttoa	83.3	18.9	12.8	3.3	111.1
		World con	37.5	23.8	16.3	9.4	187.5
		Asinayo	47.2	16.1	9.4	2.6	94.4
		Melona	67.1	24.4	17.1	6.1	158.5
		Gugukon	36.4	24.8	12.1	9.1	187.9
		Burabocon vanilla	10.0	22.0	13.3	7.3	163.3
		Seolleim milk shake	44.1	17.1	14.7	3.5	105.9
		Double bianco	20.5	17.9	13.8	2.3	97.4
		Ssangssang bar	52.2	25.4	23.9	7.2	179.1
		Rich milk ice bar	78.6	32.9	28.6	5.6	200.0
		Walnut maroo	55.6	20.6	15.9	5.6	142.9
		Cherry maroo	39.7	22.2	20.6	3.7	127.0
		Appleberry bar	31.3	20.0	17.5	2.1	106.3
Non-fat group (20)	Sherbet (13)	Crispy crunch ice bar	60.0	29.3	25.3	13.3	246.7
		Red bean ice bar	92.9	40.0	21.4	1.9	192.9
		Bravo watermelon	25.0	22.1	17.9	3.6	125.0
		Pasitongtong	100.0	31.4	22.9	1.3	150.0
		Bravo pistachiorevolution	39.3	24.3	12.9	3.6	139.3
		Wa	44.7	15.8	15.3	5.3	115.8
		Candy bar	53.3	18.7	17.3	2.0	100.0
		Yomamttea strawberry	85.7	25.7	21.4	3.1	135.7
		Banana boy	53.8	20.0	16.9	2.5	107.7
		Duet chocobanana	50.0	22.9	18.6	4.6	142.9
		Yomamttea peach	85.7	25.7	21.4	3.1	135.7
		Injeolmi-tongtong	47.6	28.6	23.8	9.5	206.3
		Littele ten grape	14.3	22.9	15.1	3.7	128.6
	Low-fat ice cream (7)	Tteogbungeossamanko	53.3	24.7	16.0	4.7	146.7
		Ku and keu	135.7	27.1	21.4	8.6	200.0
		Bravo sand	66.7	18.3	11.7	2.7	105.6
		Chambungeossamanko classic	53.3	23.3	16.0	4.7	140.0
		Babambar ice sand	55.6	19.4	12.2	2.9	113.9
		Bravo choco chunk mild	28.6	26.4	16.4	5.7	167.9
		Choco bungeossamanko	53.3	23.3	16.0	4.7	140.0

Table 3. Differences in nutritional content by frozen desserts items

Unit : per 100 g / Mean±SD

Group	Sodium (mg)	Carbohydrate (g)	Sugar (g)	Fat (g)	Calories (kcal)
Frozen dessert group	15.94 ± 21.98[a]	22.41 ± 7.22	15.56 ± 5.26	0.82 ± 0.092[a]	96.64 ± 31.52[a]
Butterfat group	45.89 ± 18.07[b]	21.57 ± 5.11	16.42 ± 5.14	7.07 ± 4.54[b]	158.74 ± 55.57[b]
Non-fat group	59.94 ± 28.31[b]	24.50 ± 5.38	18.00 ± 3.91	4.57 ± 2.91[b]	147.02 ± 38.12[b]
p^*	< 0.001	0.287	0.273	< 0.001	< 0.001

*by one-way ANOVA

[a,b]Values in the same row with different superscript small letters are significantly different at $p<0.05$.

Table 4. Characteristics related to dental caries activity by frozen desserts product

Group (N)	Product group (N)	Product name	pH	Sugar content	Viscosity
Frozen dessert group (20)	Frozen dessert (20)	Babambar	6.04	32.53	5.64
		Papico soda	3.18	24.40	2.66
		Jaws bar	2.88	25.63	18.36
		Polapo grape	2.94	16.27	6.49
		Polapo strawberry	3.92	14.73	6.58
		Shine muscat green grape	3.22	29.83	19.75
		Totomama	4.16	16.07	7.01
		Screw bar strawberry & apple	2.70	27.93	6.14
		Subark bar	4.45	24.67	5.32
		Green plum	2.94	16.60	28.46
		Seolleim Lemon ade	2.84	29.40	16.14
		Vita 500 big bead ice	3.01	27.23	32.56
		Jewel ice bar	3.96	21.87	2.49
		Mogu mogu peach ice	2.75	23.77	2.59
		Mogu mogu pine ice	2.86	25.07	2.88
		Baekdu mountain	4.75	25.27	5.55
		Dipping dots soda	3.93	16.27	1.87
		Jjyujjyu bar watermelon	4.55	22.17	7.54
		Cool shot watermelon	3.94	2.03	1.02
		Into the mango bar	4.49	32.07	-
Butterfat group (20)	Ice cream (7)	Rare roasted sweet potato	6.73	32.77	21.76
		Supercon	6.48	36.80	15.69
		Crunky bar mint	6.42	36.67	59.50
		Gugukon madagascar vanilla	6.46	34.77	10.05
		Hershey's choco bar	6.65	40.03	26.46
		Nougat bar	6.61	34.80	18.59
		Together original vanilla	6.67	30.27	39.96
	Ice milk (13)	Ppangttoa	6.78	33.27	10.66
		World con	5.90	40.23	-
		Asinayo	6.66	28.40	32.17
		Melona	6.68	29.23	65.12
		Gugukon	6.22	42.33	56.41
		Burabocon vanilla	6.51	36.23	9.53
		Seolleim milk shake	6.60	28.73	5.15
		Double bianco	5.35	30.43	40.56
		Ssangssang bar	6.64	34.13	34.29
		Rich milk ice bar	6.69	33.00	23.87
		Walnut maroo	6.87	29.13	35.03
		Cherry maroo	5.69	28.27	71.67
		Appleberry bar	4.83	24.97	43.23
		Choco bungeossamanko	6.65	39.27	-

Table 4. To be continued

Group (N)	Product group (N)	Product name	pH	Sugar content	Viscosity
Non-fat group (20)	Sherbet (13)	Crispy crunch ice bar	6.24	43.30	99.66
		Red bean ice bar	6.18	33.03	119.70
		Bravo watermelon	5.24	35.17	12.56
		Pasitongtong	6.57	27.77	9.35
		Bravo pistachiorevolution	6.66	31.50	19.60
		Wa	6.55	25.77	2.12
		Candy bar	6.54	23.37	2.57
		Yomamttea strawberry	5.16	27.23	14.67
		Banana boy	6.71	38.37	6.01
		Duet chocobanana	6.84	32.00	14.99
		Yomamttea peach	5.27	27.50	9.20
		Injeolmi-tongtong	6.56	33.40	42.55
		Littele ten grape	5.37	23.47	4.45
	Low-fat ice cream (7)	Tteogbungeossamanko	6.33	38.83	24.42
		Ku and keu	6.69	35.43	17.93
		Bravo sand	6.48	34.13	-
		Chambungeossamanko classic	6.50	36.03	30.84
		Babambar ice sand	6.61	32.23	7.46
		Bravo choco chunk mild	6.60	40.03	-
		Choco bungeossamanko	6.65	39.27	-

Table 5. Characteristics related to dental caries activity by frozen desserts item

Unit : Mean±SD

Group	Sodium (mg)	Carbohydrate (g)	Sugar (g)
Frozen dessert group	3.67 ± 0.89[a]	22.69 ± 7.30[a]	9.42 ± 9.20[a]
Butterfat group	6.37 ± 0.53[b]	33.22 ± 4.61[b]	32.62 ± 19.86[ab]
Non-fat group	6.29 ± 0.55[b]	32.89 ± 5.66[b]	25.77 ± 33.47[b]
p^*	< 0.001	0.287	0.273

*by one-way ANOVA

[a,b] Values in the same row with different superscript small letters are significantly different at $p<0.05$.

Discussion

With the changes in population structure due to low birth rate and aging, the commercial frozen dessert market size in South Korea has steadily decreased until 2019 from the peak of 2 trillion KRW in 2015. In 2020, however, the frozen dessert sales suddenly increased with the prolonged time of stay at home since the winter of 2019 due to abnormal temperatures and the COVID-19 pandemic [8]. In other words, as the number of people enjoying home meals and desserts increased, the sales of frozen desserts increased.

On the part of the consumers, frozen desserts are advantageous in allowing relatively low cost to enjoy a variety of tastes and types, while simultaneous concerns on the high calorie and sugar content that could negatively affect the health may be raised [4]. The intake of frozen desserts may also affect oral health as the sugars and other factors such as viscosity could cause dental caries or periodontal diseases.

In this study, the risk of dental caries was determined for frozen desserts by comparing the risk factors including acidity, specific viscosity, and sugar content among the different groups of commercial frozen desserts, in line with the increased consumption of frozen desserts at homes.

Sixty frozen dessert products were divided into three groups and analyzed, and the results showed that the ice cake group had the lowest mean acidity (3.67) among the characteristics related to dental caries. In a study investigating beverages for children, the mean pH of commercial beverages was 3.41, while that of beverages sold by cooperative associations was 3.67, indicating similar pH levels between beverages and ice cakes [15]. Ice cakes are produced by mixing drinking water with food or food additives to be frozen, and they do not belong to ice creams or ice cream mix products [1]. Ice creams are produced by adding food or food additive to the basic ingredient of raw or processed milk to be frozen or hardened [1] so that naturally, the contents of raw or processed milk of ice cakes are lower than ice creams. In addition, most ice cakes are characterized by unique fruit taste or flavor, which may reduce the acidity compared to other frozen dessert products. The correlation of food acidity with dental health has been identified across numerous studies, and energy drinks and carbonated drinks with low acidity are a known cause of dental caries [10,16]. Kim et al. [16] reported that the mean acidity of seven beverage types including juice, ion drinks, and carbonated drinks, was 3.01, which was similar to the acidity of ice cakes. These commercial beverages were also reported to induce the risk of dental caries by reducing the enamel surface hardness. Thus, it is recommended that a straw be used in drinking beverages with low acidity to minimize contact with the tooth surface and that the mouth be rinsed with water after drinking [10,17]. Most ice cakes are ingested after they melt in the mouth so that the retention time in the oral cavity is longer than beverages. Thus, the mouth must be rinsed with water immediately after the intake of an ice cake product to minimize the retention time in the oral cavity.

The Brix value and viscosity were higher for milk-fat and non-milk-fat ice creams than ice cakes. The milk-fat and non-milk-fat ice creams belong to the category of ice creams among frozen desserts [1], and in this study, the milk-fat group included ice cream and ice milk products whereas the non-milk-fat group included sherbet and non-milk-fat ice cream products. Ice creams are produced from the basic ingredient of raw or processed milk; therefore, they all contain (milk) fat. Thus, compared to ice cakes produced based on drinking water [1], the viscosity and sugar content appear to be comparatively high. The high viscosity indicates the longer time of retention in the oral cavity such as on the tooth surface upon intake due to low flow ability. The increase in retention time of foods with high sugar contents, in turn, increases the dental caries activity. The mean acidity of milk-fat and non-milk-fat ice creams was 6.37 and 6.29, respectively, a level similar to water. Thus, for these products, the dental caries activity increases with an increase in viscosity or sugar content rather than acidity.

In a study conducted on children, the generally preferred dessert type was soft ice creams (51.1%), followed by crispy snacks (30.0%) and semi-solid yoghurts (14.5%) [7]. In another study regarding food preference of pre-school children, the most preferred food was ice creams for both boys and girls [18]. As such, frozen desserts exhibit high preference by children, with easy availability based on accessibility at close markets and relatively low cost for children. Thus, it is necessary to increase the direct awareness in children regarding the potential impact of frozen dessert intake on oral health, while continuous education should be given regarding the appropriate oral health management after frozen dessert intake and control of the frequency of intake. In addition, as home meals and desserts have increased with the COVID-19 pandemic, the parents and guardians should also be guided to assist their children with proper oral health management after the intake of frozen desserts at home.

Not every commercial frozen dessert product could be analyzed in this study, while only the viscosity, acidity, and sugar content among the dental caries risk factors were examined. This prevents the results in this study from generalization to the association between frozen desserts and dental caries or oral health. In addition, although all products were equally kept at room temperature for 4 hours prior to measurement, all products could not be analyzed at the same temperature condition, which poses a limitation. However, considering the general lack of studies regarding the correlation of the characteristics of frozen desserts with oral health as well as the current increase in the intake of frozen desserts, this study is significant in having analyzed the association between frozen desserts and oral health. Further studies should examine more variables such as the CFU of acid-forming bacteria and salivary buffering capacity in analyzing the correlation of the intake of frozen desserts with oral health.

Conclusions

This study investigated the nutritional contents as well as sugar content, acidity, and viscosity of sixty frozen dessert products produced and marketed in South Korea, after random selection and categorization in accordance with the classification criteria into ice cake, milk-fat ice cream, and non-milk-fat ice cream. The findings in this study are as follows:

1. Analyzing the nutritional contents showed that the sodium content was the highest (59.94 mg) in non-milk-fat ice creams and significantly low (15.94 mg) in ice cakes. The fat content was the highest (7.07 g) in milk-fat ice creams.

2. The lowest acidity was 2.70 for ice cakes, 4.83 for milk-fat ice creams, and 5.16 for non-milk-fat ice creams. The highest Brix value as measured using the digital Brix meter was 32.53 for ice cakes, 42.3 for milk-fat ice creams, and 43.3 for non-milk-fat ice creams. The viscosity increased from 19.75 for ice cakes to 71.67 for milk-fat ice creams to 119.70 for non-milk-fat ice creams.

3. Analyzing the characteristics related to dental caries activity per product type showed that the pH was the lowest (3.67) for ice cakes, while the sugar content was significantly higher for milk-fat ice creams (33.22) and non-milk-fat ice creams (32.89) than ice cakes ($p<0.05$). The specific viscosity was also the highest for milk-fat ice creams (32.62) and significantly low for ice cakes (9.42) ($p<0.05$).

The intake of frozen desserts at homes has shown a trend of increase with abnormal temperatures and the COVID-19 pandemic. To prevent childhood caries at home, education for the children and their parents and guardians should be provided regarding appropriate oral health management methods such as reducing the frequency of frozen dessert intake and rinsing the mouth with water immediately after intake.

Conflicts of Interest

The authors declared no conflict of interest.

Authorship

Conceptualization: HS Jeon, SJ Mun; Data collection: HS Jeon, SJ Mun; Formal analysis: SJ Mun; Writing - original draft: HS Jeon, SJ Mun; Writing - review & editing: HS Jeon, SJ Mun

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국내 시판 빙과류의 치아우식 활성 위험도 측정

초록

연구목적: 본 연구는 아동의 치아우식증 발생에 영향을 줄 수 있는 빙과류를 종류에 따라 구분하고, 당도와 산도, 비점조도를 조사하여 분석하고자 시행하였다. **연구방법:** 국내에서 생산 및 시판되는 빙과류 60종을 무작위로 선택하여 빙과류 분류 기준에 따라 빙과, 유지방군아이스크림, 비유지방군아이스크림으로 구분하였다. 각 제품을 동일한 조건으로 처리하여 제품별 성분함량을 조사하였으며, 당도와 산도, 점조도를 측정하였고 비점조도를 계산하였다. 대상 빙과류의 일반적인 특성은 빈도분석을 시행하였고, 식품 유형에 따른 빙과류의 영양성분의 차이와 치아우식 관련 특성의 차이는 일원배치 분산분석을 수행하였다. 유의수준(α)은 0.05로 하였다. **연구결과:** 조사 대상 빙과류는 총 60개로 빙과, 유지방군, 비유지방군 각각 20개씩이었다. 품목별 영양성분에서 나트륨은 비유지방군이 59.94 mg으로 가장 높았고 빙과는 평균 15.94 mg으로 유의하게 낮았다. 지방 함량은 유지방군이 7.07 g으로 가장 높았다. 치아우식 활성도 관련 특성을 각 제품군에 따라 분석한 결과 pH는 빙과가 평균 3.67로 가장 낮았으며, 당도는 유지방군(33.22)과 비유지방군(32.89)이 빙과보다 유의하게 높았다. 비점조도 또한 유지방군이 32.62로 가장 높았고, 빙과는 9.42로 유의하게 낮았다. **결론:** 이상 기온 현상과 코로나바이러스 확산으로 인하여 가정 내 빙과류 섭취가 증가하는 추세이다. 가정 내에서 아동의 치아우식증 발생을 예방하기 위하여 빙과류 섭취 후 적절한 구강 관리를 할 수 있도록 아동과 보호자 대상의 교육이 필요하다.

색인: 당도, 빙과류, 산도, 점조도, 치아우식증