PHYSICOCHEMICAL AND RHEOLOGICAL PROPERTIES OF NON-FAT ICE CREAM

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Ice cream is a popular dessert in Latvia. At present, however, as consumers are watching their calorie intake, ice cream is starting to lose its leading position due to rich fat content. Therefore, development of low-fat or non-fat ice cream can provide a good alternative for consumers. At the same time, reduced fat is a challenge to a producer because it strongly affects the texture and sensory properties of ice cream. The aim of the current study was to assess the physicochemical and rheological properties of whey-based non-fat ice cream, depending on the ingredients used in the formulation. In total, 11 ice cream formulations were developed and evaluated, with differing proportions of the main ingredients. Chemical composition, hardness (after 6 h of hardening and subsequent two-week storage), overrun and rheological properties were analysed. Higher amounts of pumpkin puree, sugar and whey concentrate decreased the hardness of ice cream, and increased the overrun. Thus, higher proportions of pumpkin puree and whey concentrate significantly influenced product formulation by stabilising and strengthening air cells. Both an increased proportion of pumpkin puree and gelatine increased complex viscosity. There was a positive correlation between carbohydrate content and ice cream hardness after two-week storage, as well as between protein content and complex viscosity.

Keywords: pumpkin puree, whey concentrate, gelatine, texture, overrun, viscosity.

INTRODUCTION

Ice cream is a popular dessert in Latvia. Traditionally, fat content in dairy ice cream formulation ranges from 5.0–15%. Saturated fatty acids are associated with coronary heart disease, diabetes and other health problems (WHO, 2010). Nowadays, when consumers are watching their calorie intake (Da Silva *et al.*, 2014), ice cream has started to lose its leading position due to being rich in fats. Therefore, low-fat and non-fat ice cream development can provide a good alternative for consumers.

Fat is of importance for the flavour and for the structure formed during freezing of ice cream. Reduced fat content is a challenge to a producer because it strongly affects the texture and sensory properties of ice cream, usually causing different defects such as coarseness, iciness, low overrun and empty taste (Jardines *et al.*, 2020). Partially coalesced fat causes a fat network, which stabilises air bubble and foam structure in ice cream. Fat reduction increases formation of ice crystals and created a harder texture, which is not

acceptable for consumers (Akbari *et al.*, 2019). Therefore, ice cream manufacturers use fat replacers, stabilisers and various additives to improve the texture of the product.

Fat replacers are an alternative in ice cream production. They can improve the rheological and sensory properties of ice cream with reduced fat content. At the same time, the saturated fat concentration and energy value of the product would be lower. Fat replacers can be divided into three groups: plant-based lipids, protein-based additives (generally whey concentrate), and carbohydrate-based additives (modified starches, cellulose derivatives, inulin, pectin and others) (Akbari *et al.*, 2019).

Stabilisers are ingredients responsible for the rheological properties of ice cream — large molecules, which interact with water. Stabilisers control properties of the unfrozen water, making ice cream smoother and lengthening the time for ice crystals to grow during storage (Park and Haenlein, 2013, pp. 435–457).

Various natural functional ingredients are used to improve the nutraceutical value of ice cream. For example, ice creams are enriched with pomegranate by-products (Çam *et al.*, 2013), processed ginger (Gabbi *et al.*, 2018), quince seed (Kurt and Atalar, 2018), soy protein isolates (Liu *et al.* 2018), and agave fructans (Pintor-Jardines *et al.*, 2018), which improve its technological and functional qualities. Whey proteins play various functions in ice cream formulation like emulsification of fat, increase of overrun and viscosity of the mix, creation of a desirable interfacial behaviour (Park and Haenlein, 2013, pp. 435–457), as well as promotion of functional properties of ice cream (Camargo *et al.*, 2020). Pumpkin is a valuable ingredient for different food products, but traditionally it is not used in ice cream production. Pumpkin puree, being rich in pectin, could promote increase of water holding capacity, emulsification and/or gel formation, positively affecting the textural properties of ice cream (Akbari *et al.*, 2019). Moreover, pumpkin is a fruit that is rich in carotenoids, lutein, violaxanthine, phenols (Kampuse *et al.*, 2019), and has a positive influence on lowering the glucose level in blood and in defence against cancer (Jacobo-Valenzuela *et al.*, 2011).

It is expected that non-fat ice cream with satisfactory physicochemical properties, rheological and functional properties can be developed by selecting suitable ingredients (whey proteins, pumpkin puree, and gelatine), and their amounts and proportions in the formulation. Therefore, the aim of the current study was to assess the physicochemical and rheological properties of whey-based non-fat ice cream, depending on the ingredients used in the formulation.

MATERIALS AND METHODS

Materials. Ice cream mixes were produced from the following ingredients: cheese whey, whey concentrate (LTD Latvijas piens, Latvia), sugar (LTD Dansukker, Denmark), gelatine (LTD Orkla Foods Latvia, Latvia), pumpkin puree (100% pumpkin, LTD Keefa, Latvia), mango puree (LTD Thomas Rink, Germany), citric acid (LTD Valezs, Latvia), and water. Nutritional values of the main ingredients are presented in Table 1. In total, 11 ice cream formulations were developed, with the aim to decrease sugar and fat content, at the same time obtaining satisfactory texture of the ice cream.

Preparation of ice cream. The used proportions whey (W), whey concentrate (W), sugar (S), gelatine (G), and pumpkin puree (P) in the ice cream samples are shown in Table 2.

In ice cream preparation, first, the dry components were weighted and mixed. Then the liquid and dry components were combined into ice cream mix. The obtained mix was pasteurised at 85 °C for 20 ± 5 s, then cooled down, and aged for 8 h at 5 ± 1 °C. The main technological operation — freezing, when ice cream mix is frozen and whipped at the same time, was performed using a Taylor model 142 ice cream machine (Taylor, USA) at −8 ± 2 °C. Then, the ice cream was filled into plastic containers (500 ml) and hardened at −20 ± 2 °C for 6 h.

Table 1. Nutritional values of ingredients used in the ice cream formulations

Ingredients	Content of nutrient, g · 100 g ⁻¹			
	fat	carbohydrate	protein	ash
Whey	0.50	4.8	0.99	0.50
Sugar	–	100.0	–	–
Gelatine	0.10	–	85.63	–
Whey concentrate	0.50	21.2	4.01	0.90
Pumpkin puree	0.3	7.7	1.30	2.00
Mango puree	–	16.0	0.50	0.005

Table 2. Developed ice cream formulations

Sample	Ingredients, g · kg ⁻¹						
	whey	sugar	gelatine	whey concentrate	pumpkin puree	mango puree	citric acid
S1	520	130	5	50	191	100	4
S2	500	150	5	50	191	100	4
S2	450	200	5	50	191	100	4
G1	499	150	6	50	191	100	4
G2	497	150	8	50	191	100	4
G3	495	150	10	50	191	100	4
W2	470	150	5	80	191	100	4
W3	450	150	5	100	191	100	4
P1	500	150	5	50	210	81	4
P2	500	150	5	50	230	61	4
P3	500	150	5	50	245	46	4

Evaluation of physicochemical parameters and energy value of ice cream. Chemical composition, nutritional value, hardness (after 6 h of hardening and subsequent 336 h of storage), overrun and rheological properties of the developed ice cream were analysed.

Protein content was determined according to ISO 8968-1:2014 using a KjeltacTM 2100 (Foss, Denmark). Fat content was determined according to ISO 488:2008 using a centrifuge (Funke Gerber, Germany). Carbohydrates were determined by high-performance liquid chromatography (HPLC) (Shimadzu, Japan); the samples were filtered through a syringe filter with pore size of 0.45 µm. The content of individual sugars was determined using a LC 20 Prominence high-performance liquid chromatograph (Shimadzu, Japan), and total sugar concentration was estimated as a sum of individual sugars. Chromatographic parameters were set as follows: detector — refractive index RID-10A; column — Alltech NH2, 4.6 mm · 250.0 mm, 5 µm; temperature 25 °C; isocratic elution regime, mobile phase A — acetonitrile, B — deionised water (A70:B30); capacity of the injection sample 10 µL; total time of the analysis up to 15 min; and flow rate 1.0 ml · min⁻¹. The acquired data were processed using Shimadzu LabSolutions software (LCsolution Version 1.21 SP1).

Energy value was calculated according to the EU Regulation (EU) No. 1169/2011 on the provision of food information to consumers entered into application on 13 December 2014.

Analysis of ice cream hardness was performed by a penetration test using a TA.HD plus texture analyser (Stable Micro Systems, United Kingdom). The modified Varela *et al.* (2014) procedure was used. Ice cream samples (approximately 100 ml each, in triplicate) were filled into plastic cups and placed in a freezer for 6 hours. For evaluation of hardening, ice cream samples were filled in 500 ml plastic containers and placed in a freezer for 336 h. Each sample container was taken out of the freezer (−20 °C) and tested immediately. The samples were penetrated to a depth of 15 mm with a 3-mm diameter cylindrical probe at a speed of 2 mm·s^{−1}. The maximum force (N) applied was used as a measure of hardness.

To evaluate overrun, the mass of a fixed volume (50 ml) of aged ice cream mix was compared to the mass of the same volume of churned ice cream after freezing. The overrun was calculated according to the equation:

$$\text{overrun} = \frac{\text{weight of aged ice cream mix} - \text{weight of ice cream}}{\text{weight of ice cream}} \times 100$$

An oscillatory thermo-rheometry test for the ice cream samples was performed using a MSR-302 rheometer (Anton Paar, Switzerland) fitted with parallel plate geometry (diameter 25 mm); the gap between the plates was adjusted to a constant value of 2 mm. Prior to the oscillatory thermo-rheometry, a deformation amplitudes sweep test at a constant angular frequency ($\omega = 10 \text{ s}^{-1}$) was carried out in order to determine the linear viscoelastic region (LVR). The changes in storage and loss modulus, loss factor and complex viscosity were determined in the temperature range from −6 to 10 °C. The temperature interval was set at 1 °C per minute, data was recorded at 100 points, and thus the data point duration was 0.172 min.

Statistical analysis. The obtained data were processed using Microsoft Excel (Microsoft Office Enterprise 2007, License: Shareware N/A); differences among results were considered significant if p -value < 0.05. Significant differences among ice cream sample attributes were determined by the Tukey's test. For the interpretation of the results, it was assumed that $\alpha = 0.05$ with 95% confidence. In addition, correlations between composition and physico-chemical parameters of ice cream were evaluated, considering $r \geq 0.8$ strong correlation, $0.5 < r < 0.8$ moderate correlation.

RESULTS

Chemical composition. The chemical composition of the developed ice creams is shown in Table 3. Among the developed ice cream samples, significantly higher ($p < 0.05$) carbohydrate content was detected in S3 samples compared to other samples. By protein content our ice cream samples can be divided into two groups: significantly lower ($p < 0.05$) protein content was detected in control, S2, W2, and all P samples, and significantly higher ($p < 0.05$) in samples

Table 3. Nutritional and energy value of the developed ice cream

Sample code	Value per 100 g of ice cream				
	fat, g	carbohydrate, g	protein, g	solids, g	energy value, kJ
S1	0.34 a,b	19.63 f	1.44 d,e	21.41 j	370.77 j
S2	0.33 b,c	21.53 c,d,e	1.42 d,e	23.29 f,g	402.36 f
S3	0.31 c	26.29 a	1.37 e	27.97 a	481.69 a
G1	0.33 b,c	21.53 c,d,e	1.51 c,d	23.36 e,f	403.89 e
G2	0.33 b,c	21.52 d,e	1.68 b	23.52 d,e	406.61 c
G3	0.33 b,c	21.51 d,e	1.85 a	23.68 d	409.33 b
W2	0.33 b,c	22.02 b,c	1.51 c,d	23.87 c	412.22 d,e
W3	0.33 b,c	22.35 b	1.57 c	24.26 b	418.85 d
P1	0.34 a,b	21.37 d,e	1.44 d,e	23.15 g,h	400.35 g
P2	0.34 a,b	21.21 d,e	1.45 d,e	23.00 h,i	397.80 h
P3	0.35 a	21.08 e	1.47 d,e	22.90 i	396.30 i

a,b,c, Means with the same letters within a column are not significantly different ($p > 0.05$).

Table 4. Hardness and overrun of non-fat ice cream

Sample code	Hardness, N		Overrun, %
	after 6 h	after 336 h	
S1	1.04 d,e	554.41 a	31.86 d
S2	0.83 e	242.90 f,g	20.38 j
S3	0.41 f	213.40 g,h,i	25.03 i
G1	1.12 d,e	289.04 d,e	40.50 c
G2	0.65 e,f	385.58 c	27.19 h
G3	0.97 d,e	203.33 h,i	31.40 e
W2	2.46 b	305.48 d	27.58 g
W3	1.81 c	196.06 i	30.32 f
P1	11.13 a	436.69 b	18.91 k
P2	1.46 c,d	265.52 e,f	43.92 a
P3	1.18 d,e	230.70 g,h	42.92 b

Data are presented as mean values ($n = 10$ for hardness, $n = 3$ for overrun). a,b,c, Means with the same letters within a column are not significantly different ($p > 0.05$).

with gelatine (G) and whey concentrate (W) used in formulations.

Hardness and overrun. Hardness of the non-fat ice cream samples after 6-hour and 366-hour storage is presented in Table 4. The ingredients incorporated in the ice cream formulations demonstrated varied influence on the hardness. Among the ice cream samples analysed, the lowest hardness occurred in the sample with the highest sugar content (S3) and in the sample with medium gelatine content (G2).

Regardless of the ingredients used in the ice cream formulation, its hardness increased substantially from 6 hours to 336 hours of frozen storage. After 336 hour storage, the lowest hardness was observed in samples S3, G3, and W3. The hardness of ice cream during storage can be affected with increased proportion of sugar, whey concentrate and gelatine in the ice cream formulations.

Overrun is a very important factor, which should be considered during ice cream production, because it directly affects sensory qualities and consumer acceptance. In the current study, overrun was affected by formulation of the ice cream (Table 4). Overrun in the ice cream ranged from 18.91% (P1) to 43.92% (P2). Taking into account that the fat content in the ice cream samples was very low (0.31% to 0.35%), it can be concluded that the achieved overrun for non-fat ice cream was high.

Rheological properties. The storage and loss moduli measured by oscillatory thermo-rheometry are presented in Fig. 1. The temperature zone from $-6\text{ }^{\circ}\text{C}$ till $-1\text{ }^{\circ}\text{C}$ demonstrates ice cream melting. According to Wildmoser *et al.* (2004), a steep slope corresponds to a more pronounced sensorial impression of coldness. Among samples with varied sugar content, the steepest slope was observed for sample S1, which contained the highest amount of water and the smallest content of sugar. This may lead to an icy microstructure

Fig. 1. Storage modulus G' (filled markers) and loss modulus G'' (open markers) measured in a temperature sweep test depending on variable ingredient proportions in the formulations: A – varied sugar content (S); B – varied gelatine content (G); C – varied whey concentrate content (W), D – varied pumpkin puree content (P).

Table 5. Rheological properties of non-fat ice cream

Sample code	Complex viscosity at 10 °C, Pa s	Moduli and loss factor at -6 °C		
		storage modulus, Pa	loss modulus, Pa	loss factor
S1	3.97 g	15530 a	5505 a	0.354 b
S2	7.84 e	2236 f	550 e	0.246 d
S3	6.49 e,f	607 h	169 f	0.279 c
G1	6.09 f	4009 d	1352 c	0.337 b
G2	12.37 c	5228 c	1316 c	0.252 d
G3	20.05 b	5582 c	1113 d	0.199 f
W2	5.29 f,g	1242 g	286 d	0.230 e,d
W3	5.95 f	4009 g	1422 c	0.355 b
P1	9.57 d	8428 b	3804 b	0.451 a
P2	9.91 d	2386 f	532 e	0.223 e
P3	22.52 a	3551 e	698 e	0.197 f

a, b, c, means with the same letters within a column are not significantly different ($p > 0.05$).

with an increased level of ice crystal connectivity. Increased amounts of gelatine, whey concentrate and pumpkin puree caused reducing steepness of the slope.

The lowest values of G' and G'' were observed at temperatures above 0 °C. At these conditions, all ice is melted, and therefore compounds integrated in the ice cream formulation have the greatest influence on the rheological properties.

Both increased amount of pumpkin puree (samples P1–P3) and gelatine (samples G1–G3) increased complex viscosity (Table 5). However, viscosity was little affected by the content of the whey concentrate added (samples W1–W2). An increased proportion of pumpkin puree (samples P1–P3) changed the value of storage and loss modulus at -6 °C. The highest storage and loss modulus among ice creams studied was for the sample containing the smallest amount of sugar additive (S1), which was followed by sample with the lowest pumpkin puree content (P1).

DISCUSSION

Ice cream is a complex frozen food system that contains proteins, crystallised fat and water, air, minerals, additives, and sweeteners (Kaleda *et al.*, 2018). Traditional ice cream contains fat (5–15%), protein (4–5%), lactose (5–7%), other sugars (12–16%), stabilisers, emulsifiers (0.5%), total solids (28–40%), and water (60–72%) (Clarke, 2012). Compared to the traditional ice cream, the non-fat ice-cream developed in the current study contained significantly ($p < 0.05$) lower concentration of solids (from 21.41 to 27.97 g·100 g⁻¹), fat (0.31 to 0.35 g·100 g⁻¹) and protein (from 1.22 to 1.85 g·100 g⁻¹). The developed ice cream can be called a non-fat ice cream, because the concentration of fat is less than 0.5% (Park and Haenlein, 2013, pp. 435–457) (Table 3). According to the data from Park and Haenlein (2013) research, non-fat ice cream contains 35% total solids, which is significantly ($p < 0.05$) higher compared to the ice cream developed in our study.

As one of the main tasks of the current study was to decrease fat content in the product, milk or/and cream was replaced by whey, which was the base of formulation. Milk solids contribute to the flavour, and are responsible for increased viscosity (Walstra *et al.*, 2005). Compared with traditional ice cream, low-fat and non-fat ice creams have problems regarding poor flavour and textural qualities (Akalin *et al.*, 2008; Akbari *et al.*, 2019). According to Arbuckle and Marshall (2020), non-fat or low-fat ice cream typically contains higher carbohydrate concentration, which compensates for required solids content. To ensure good textural properties of ice cream with low total solids concentration, pumpkin puree, gelatine and whey protein concentrate were used in the formulations (Table 2).

Structure is one of the main parameters determining consumer acceptance of an ice cream. The structure of an ice cream is described as a three-component foam made up of a network of fat globules and ice crystals dispersed in a high viscosity aqueous phase. The air volume in ice cream can range from high, more than 50%, to low 10–15% (Goff, 2002). In the case of non-fat and low-fat ice creams, the fat globule network can either be disrupted or absent and this could seriously affect the texture of the product (Aime *et al.*, 2001; McGhee *et al.*, 2015). The hardness of ice cream can be affected by the formulation: content of solids, sugars, fats, proteins, amount and characteristics of the used emulsifiers and stabilisers. All these factors affect the amount of free water, as well as the freezing temperature of the ice cream. Our study revealed positive strong to medium correlation between carbohydrate content and ice cream hardness after 336 h storage ($r = 0.710$), as well as between protein content and complex viscosity ($r = 0.503$). Weak negative correlation was found between carbohydrate content and storage modulus ($r = -0.617$), and carbohydrate content and loss modulus ($r = -0.533$). Another factor negatively affecting ice cream structure and hardness, is storage time (McGhee *et al.* 2015), as also found in our study.

Increased proportion of **sugar** in the formulation was associated with significantly lower ($p < 0.05$) hardness of ice cream sample S3 compared to S1 (Table 4). The total solids content can also affect ice cream hardness (Akbari *et al.*, 2019), but in the present study this parameter had no significant effect ($p > 0.05$). This can be explained by the high proportion of sugar in solids, which decreased the hardness of ice cream. Increased sucrose content reduces ice crystal size (Arbuckle and Marshall, 2000) and this sugar positively influences consistency of the ice cream, making it softer (Chorafas, 2015). Decrease of sugar content in the formulation positively influenced overrun of ice cream; in sample S1 it was significantly higher ($p < 0.05$), compared to the sample S3 and S2. In the current study, other components in formulations and their proportion influenced the overrun of the ice cream samples analysed.

Proteins have two main functions in the ice cream production. First, as a surface active component it stabilises water continuous emulsion and foam, increasing viscosity, and second, they contribute to the flavour of product (Chorafas,

2015). Two protein sources, gelatine and whey concentrate, were used in the current study.

An increased amount of **gelatine** in formulations ($p < 0.05$) influenced hardness of ice cream. The highest content of gelatine used in the current research (sample G2 and G3) significantly ($p < 0.05$) increased complex viscosity of the ice cream, which may be associated with increased sensorial creaminess (Wildmoser *et al.*, 2004). It should be noted that between samples with different gelatine content, significant differences ($p < 0.05$) were found for ice cream hardness after 6 h. The effect of amount of gelatine on ice cream hardness during 336 h storage was different. The highest content of gelatine (G3) used in the current research was associated with significantly softer ice cream ($p < 0.05$) compared to the G1 and G2 samples.

The proportion of gelatine in formulations had significant effect on overrun; sample G1 showed significantly higher overrun ($p < 0.05$) compared to the samples G2 and G3. Such results are contradictory to a previous study (Mahdian, 2013), where higher overrun was associated with higher protein concentration in ice cream, but are in agreement with another study (Daw and Hartel, 2015).

Regarding content of **whey concentrate**, significantly higher ($p < 0.05$) hardness after 6 h was found in sample W2 with a lower content of protein, compared to sample W3. It should be noted that not only the specific fat replacer, but also the proportions applied in a formulation are significant for obtaining ice cream with acceptable quality. An increased amount of whey concentrate significantly decreased ($p < 0.05$) hardness of ice cream during storage. As a positive tendency, whey concentrate stabilised ice cream structure during storage protecting it from increased hardness, which can have a positive effect on consumer's choice. Whey concentrate, rich in whey proteins, helps to ensure air bubble structure, covering it with membrane (Park and Haenlein, 2013, pp. 435–457). An increased proportion of whey protein significantly ($p < 0.05$) promoted overrun of ice cream.

The removal or change in the proportion of one ingredient may affect the physical properties and structure of the ice cream, which was observed in the current study. Higher protein content resulted in softer texture of ice cream. However, the concentration and characteristics of protein had significant effect as well. Comparing G and W samples, better rheological properties (lower hardness, higher overrun) were obtained with use of gelatine as a stabiliser in ice cream production.

There are different opinions about protein and its influence on the hardness of ice cream. Some studies (Wille *et al* 2012) found that proteins have a positive influence on ice cream structure. The current found that protein had a positive influence on ice cream hardness. The samples with higher protein content (G3 and W3) had softer texture after 336 hours of storage.

We observed that the source of protein in ice cream mixture affects overrun, which is in agreement with other studies (Flores and Goff, 1999).

Higher pumpkin puree content in samples P2 and P3 was associated with significantly lower hardness ($p < 0.05$) of ice cream, compared to sample P1. During storage, the smallest changes were found for ice cream sample P1, compared to P2 and P3, but higher amount of pumpkin puree continued to reduce the hardness of ice cream. Pumpkin is rich in pectin (Yoo *et al.*, 2012; Ali, 2015), which may increase water holding capacity, emulsification and gel formation (Akbari *et al.*, 2019). Furthermore, gel formation of pumpkin pectin in very low concentrations can provide good gelation properties (Ptitchkina *et al.* 1994).

The amount of pumpkin puree had a significant effect on overrun. The highest overrun ($p < 0.05$) was observed in samples P2 and P3. Pumpkin puree in a concentration from 23 to 24.5% significantly increased ($p < 0.05$) the overrun of ice cream.

The ice cream samples with higher overrun had lower hardness, especially after hardening for 336 hours ($r = -0.655$). Previously (Rolon *et al.*, 2017), it was also observed that lower overrun in ice cream leads to a decrease in its hardness.

CONCLUSIONS

Non-fat ice cream structure and rheological properties can be improved by applying fat-replacers: gelatine, pumpkin puree, and whey concentrate.

An increased proportion of pumpkin puree, gelatine and whey concentrate decreased hardness of ice cream after 6 h hardening. After 336 h of storage, the softest samples were the ones with the highest content of carbohydrates and solids.

Significantly higher ($p < 0.05$) overrun was obtained when higher content of pumpkin puree was used in the formulation.

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BEZTAUKU SALDĒJUMA FIZIKĀLI ĶĪMISKĀS UN REOLOĢISKĀS ĪPAŠĪBAS

Saldējums ir viens no populārākajiem desertiem Latvijā. Tomēr mūsdienās, kad patērētāji aizvien biežāk seko līdzī uzturvielu daudzumam, saldējums sāk zaudēt savas līdera pozīcijas augstā tauku satura dēļ. Tāpēc beztauku saldējuma izstrāde var būt alternatīvs risinājums. Tauku satura samazināšana saldējumā ir izaicinājums ražotājiem, jo tā būtiski ietekmē produkta struktūru un sensorās īpašības. Darba mērķis ir vērtēt uz sūkalu bāzes gatavota beztauku saldējuma fizikāli ķīmiskās un reoloģiskās īpašības atkarībā no izmantoto sastāvdaļu daudzuma receptūrā. Mainot sastāvdaļu proporcijas maisījumā, kopumā tika izveidotas un vērtētas 11 saldējuma receptūras. Pētījuma laikā tika analizēts saldējuma ķīmiskais sastāvs, cietība (pēc sešām stundām un pēc divām uzglabāšanas nedēļām), uzputojamība un reoloģiskās īpašības. Palielinot ķirbju biezeņa, cukura un sūkalu koncentrāta daudzumu receptūrā, samazinājās saldējuma cietība un palielinājās tā uzputojamība. Lielāka ķirbju biezeņa un sūkalu koncentrāta proporcija būtiski ietekmēja saldējuma struktūru, stabilizējot un nostiprinot gaisa pūšļu apvalkus. Gan paaugstināts ķirbju biezeņa, gan želatīna īpatsvars receptūrā palielināja produkta viskozitāti. Pētījumā konstatēta pozitīva korelācija gan starp ogļhidrātu saturu saldējumā un cietību pēc divām uzglabāšanas nedēļām, gan starp olbaltumvielu saturu un viskozitāti.