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Original scientific paper

PHYSICAL CHANGES IN THE STRUCTURE OF ICE CREAM AND FROZEN FRUIT DESSERTS DURING STORAGE

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ice cream, whipped frozen fruit desserts, ice crystals, air phase, air cells, overrun, whey, whey protein concentrate, low-fat, storage, storage temperature

ABSTRACT

The results of studies of physical changes of the structure of milk ice cream at fat content of 4.0 % — 6.0 % and frozen whipped fruit desserts at different degree of overrun with/without addition of whey and whey protein concentrate are given in the paper. It is shown that the storage temperature affects the dispersion of structural elements of frozen whipped fruit desserts. An average size of air bubbles of frozen whipped desserts stored at minus 18 °C is 1.2 –1.4 times larger than the size of the bubbles of the samples stored at minus 25 °C. The average size of ice crystals increased 1.4 times after 9 months of storage at minus 18 °C. The average size of air bubbles of ice cream at 4 % fat content increased 1.5 times after 6 months of storage, and the ice crystals size increased 1.1 times. It is recommended to use the storage temperature below minus 25 °C to keep the quality of ice cream and frozen whipped desserts. Milk ice cream and frozen fruit desserts are recommended to be stored at minus 18 °C during not more than 6 months.

1. Introduction

In summer period there is a significant demand in ice cream produce containing fruits. Fruits may be used in all kinds of ice cream, but the most popular are low-fat products: milk ice cream and frozen whipped fruit desserts. It is known that during ice cream and similar products storage the chemical changes occur (oxidative processes in the fatty phase) as well as physical ones (crystals, air bubbles, lactose enlargement) [1]. Taking into account the composition of summer produce (milk ice cream and frozen whipped desserts) the most likely changes are physical ones, i.e. the ice crystals and air bubbles dispersion decreases.

All low-fat kinds of ice cream and frozen fruit desserts are subjected to structural changes at temperature fluctuations during storage, transportation and selling due to a higher water proportion as compared with conventional kinds of ice cream (high-fat ice cream and full-cream ice) [2]. These products change physically even at stably low storage temperatures, that is the dispersion of main structural elements (ice crystals and air bubbles) occurs [3,4]. This is due to the formation of initially larger ice crystals [5] and air bubbles [6] in comparison with high-fat ice cream and full-cream ice as well to the absence of a solid layer on the surface of the bubbles preventing their destruction. Introduction of dairy products such as dry whey, whey protein concentrate impacts positively on the ice cream structural indices [7,8,9] enhancing the ice cream hardness and its resistivity to thawing [10].

But the enterprises producing and selling ice cream and fruit desserts use the same storage conditions as well as impose the equal requirements as regards their thermal and shape stability. Taking into account that during storage structural elements of ice cream and frozen desserts are subjected to the greatest changes [11,12], it is necessary to ground the conditions and duration of storage to keep an acceptable quality of ice cream and frozen fruit desserts at low content of dry substances. The goal of this study is investigation of dispersion of ice crystals and air bubbles of milk ice cream and frozen fruit desserts at minus 18 °C and minus 25 °C storage temperatures.

2. Materials and methods

The objectives of the research were as follows:

- milk ice cream at 4.0 % — 6.0 % fat content with the most frequently used stabilization system including emulsifier (mono and diglycerides), composition of stabilizers (guar gum, locust bean gum and carrageenan);
- frozen whipped fruit desserts at 3.0 % fruit content;
- frozen whipped fruit desserts at 3.0 % fruit content with KSB–80 whey protein concentrate;
- frozen whipped fruit desserts at 3.0 % fruit content with 0.2 % whey solids.

The investigations were carried out in the laboratories of the All-Russian Scientific Research Institute of Refrigeration Industry — Branch of V.M. Gorbatov Federal Scientific Center for Food Systems of RAS.

The microscope CX41RF (Japan) with program control was used to obtain microphotographs of air phase and ice crystals. The sizes of air bubbles and ice crystals were defined, their average sizes were calculated. To improve the precision and validity of measurements up to 10 photographs were taken and treated for each sample. The results were processed using the ImageScope program.

Ice cream and frozen whipped fruit desserts were investigated during storage at minus 18°C and minus 25°C. The storage duration was from 1 to 12 months.

3. Results and Discussion

The dispersion of ice crystals and air bubbles of milk ice cream at 4.0 % — 6.0 % fat content and frozen fruit desserts at 3.0 % fruit content stored at minus 18 °C and minus 25 °C during up to 12 months was investigated. The studies resulted in conclusion that desserts were appreciably inferior to ice cream on the milk basis as regards the ice crystals and air phase dispersion (Table 1).

The data of Table 1 show that the storage temperature and an additional introduction of milk proteins (in this case whey proteins) impact on the dispersion of frozen whipped fruit desserts. In particular, at the stage of hardening and one month storage at minus 18 °C the mean diameter of air bubbles of frozen whipped desserts was larger 1.2–1.4 times in comparison with the frozen whipped desserts stored at minus 25 °C.

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Table 1

Dispersion of structural elements of frozen whipped fruit desserts and milk ice cream at storage

N	Desserts/ice cream composition	Storage temperature, °C	Shelf life, month	Mean diameter, µm	
				Air bubbles	Ice crystals
1	Sucrose 28.0 %, fruits 3.0%, stabilizer 0.2 %,	minus 18	1 6 8 9	94 114 134 207	69 72 84 100
		minus 25	1 2 6	69 85 98	53 59 67
2	Whey solids 0.2 %; sucrose 28.0 %, fruits 3.0%, stabilizer 0.2 %,	minus 18	2 5 9	64 80 91	84 101 174
		minus 25	1 4 9	55 88 100	56 65 79
3	Whey protein concentrate solids 0.2 %, sucrose 28.0 %, fruits 3.0 %, stabilizer 0.2 %,	minus 18	1 6 9	56 81 98	56 58 229
		minus 25	1 2 9	49 73 114	52 69 71
4	Fat content 4.0 %, sucrose 15.5 %	minus 18	1 3 6 9	21 27 31 35	32 34 36 37
5	Fat content 6.0 %, sucrose 14.5 %	minus 18	1 4 9 12	46 49 59 64	54 60 69 76

Introduction of whey proteins into the formulation leads to reduction of the air bubble mean diameter 1.3–1.7 times at the initial storage stage (up to one month) and 2.1–2.3 times after 9 months of storage. Also it should be noted that the air bubble mean diameters of the samples with whey proteins after 9 months of storage at minus 25 °C and of the samples of frozen whipped fruit desserts (sample 1) after 6 months of storage at minus 25 °C practically didn't differ.

It was determined that the air phase dispersion as regards the index «the air bubble mean diameter» decreased even at minus 35 °C, a sufficiently low storage temperature, 1.3; 1.4; 1.9 times after 2, 6 and 10 months of storage correspondingly that is may be explained by the absence of protective layer on the air bubbles (Figure 1).

During storage the ice crystal enlargement takes place in all samples of frozen whipped fruit desserts (Figure 2). The greatest mean linear size of ice crystals increased 1.2 and 1.4 times after 2 and 9 months of storage at minus 25 °C correspondingly (Figure 3).

It is defined that to a considerable degree the product air saturation (overrun) impacts on the ice crystals dispersion. In particular, the increase of the size of ice crystals even in fruit dessert samples with addition of whey proteins at extreme overrun more than 120 % after 9 months of storage at minus 18 °C was more than 4 times, while in the dessert without whey at 50 % overrun was more than 1.5 times. To no small degree it is due to the fact that at high overrun (for desserts more than 90 %) a friable structure is being formed.

In addition, based upon the composition of frozen whipped fruit desserts it is obvious that in their structure less crystallization centers will be formed when hardening in the freezer due to the absence of fatty particles intensifying nucleation [13] as compared with milk ice cream. In such a case lager crystals will be formed in frozen whipped fruit desserts at further freezing in comparison with milk ice cream. It leads to sense perception of ice crystals, and therefore the product quality decreases on the whole.

Hence, to avoid such defects it is necessary to observe carefully the overrun of the product and to not exceed the regulated values (90 %).

The temperature of storage of ice cream and desserts impacts significantly on the dispersion of structural elements. The difference of dispersion of ice crystals after 9 months of storage was noted (Figure 2). The ice crystals of the sample stored at minus 18 °C were large, the mean size was 85–116 µm, the ice crystals of the sample stored at minus 35 °C were visibly smaller; the average size was 66–68 µm.

To improve the objectivity of the research the dispersion of structural elements of frozen whipped fruit desserts was compared with those of milk ice cream at fat content of 4.0 % –6.0 % with the same (30.0 %) content of total solids.

According to the data cited in Table 1 small air bubbles are formed in the samples of milk ice cream at the initial stage that are smaller 1.1–4.5 times as compared with frozen whipped fruit desserts. The enlargement of air bubbles and ice crystals in milk ice cream as well as in frozen whipped fruit desserts occurs. Particularly, the mean diameter of an air bubble of the milk ice cream at 4.0 % fat content increased 1.3 times after 3 months of storage and 1.5 times after 6 months of storage (Figure 4). But the size of ice crystals (Figure 5) increased 1.1 times after 6 months of storage.

The mean diameter of an air bubble of the milk ice cream sample at 6.0 % fat content increased 1.1, 1.3, 1.4 times after 4, 9, 12 months of storage correspondingly.

At the same time the mean diameter of air bubbles of milk ice cream even after 12 months of storage was the same as the size of air bubbles of frozen whipped fruit desserts after making. The same regularity was noted relative to the ice crystals.

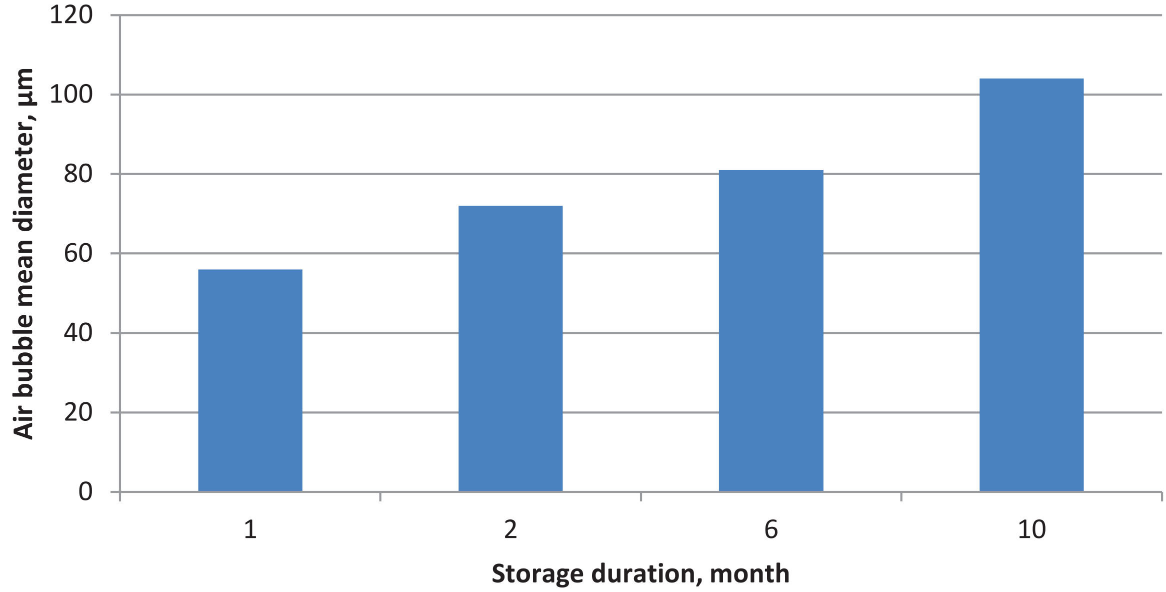

Figure 1. Mean diameter of air bubbles of frozen fruit desserts with whey at minus 35 °C storage

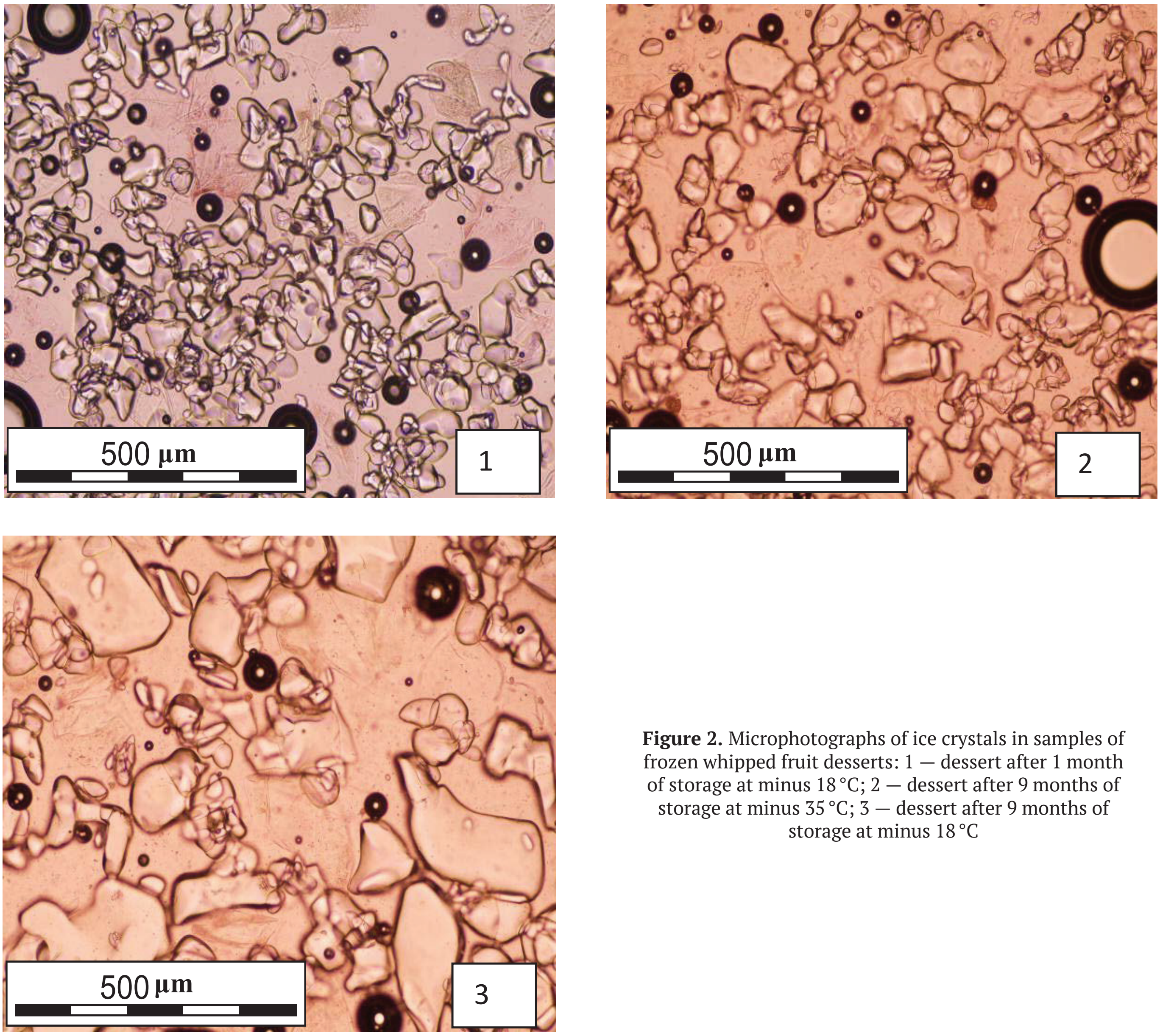

Figure 2. Microphotographs of ice crystals in samples of frozen whipped fruit desserts: 1 — dessert after 1 month of storage at minus 18 °C; 2 — dessert after 9 months of storage at minus 35 °C; 3 — dessert after 9 months of storage at minus 18 °C

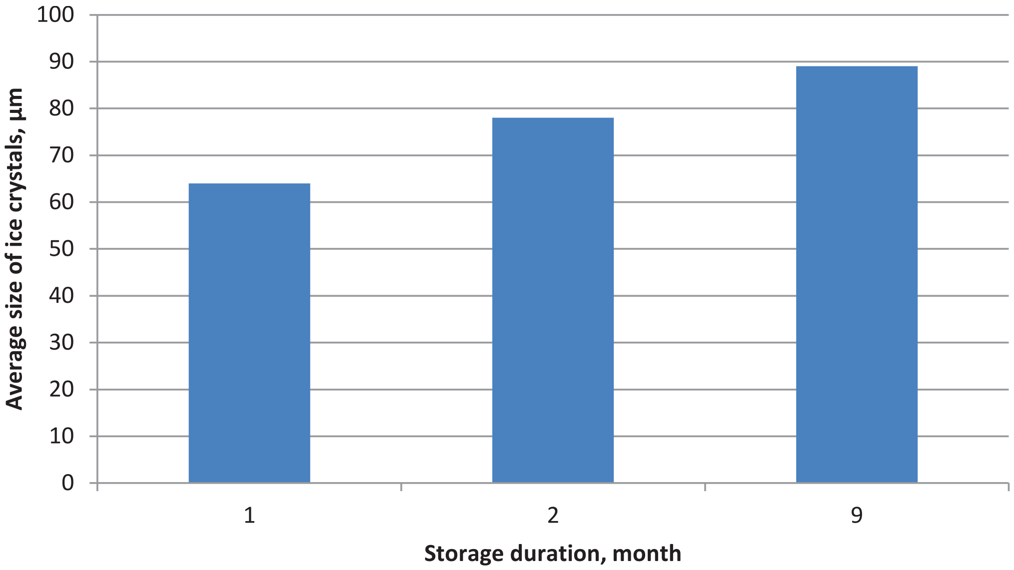

Figure 3. Average size of ice crystals of frozen fruit desserts with whey at minus 25 °C storage

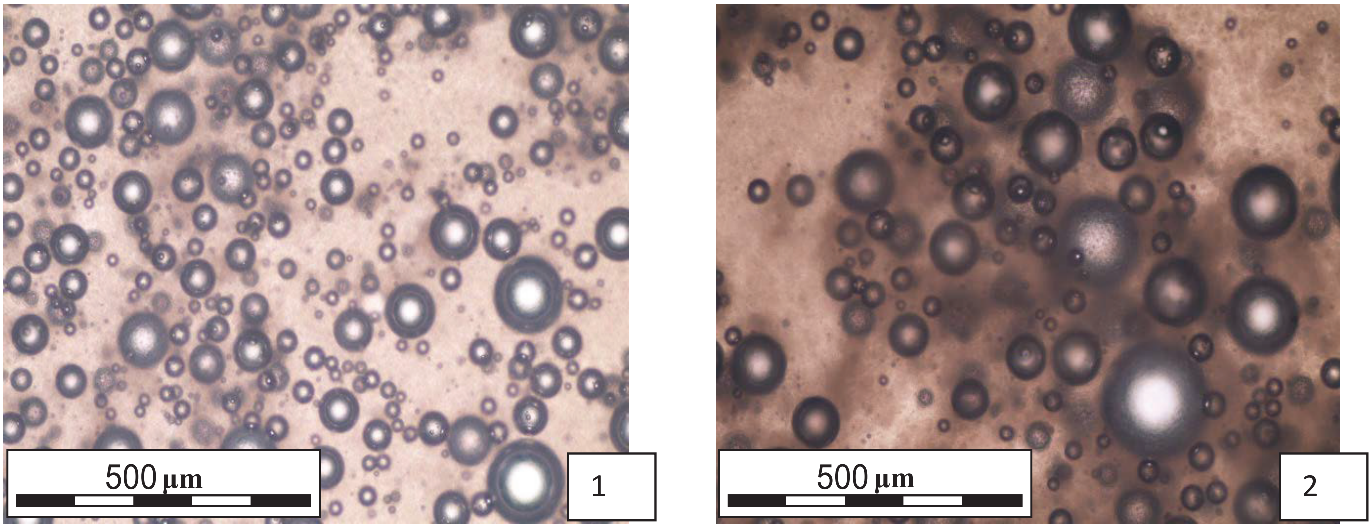

Figure 4. Microphotograph of dispersion of air bubbles of milk ice cream at 4.0 % fat content: 1 — after 1 month of storage; 2 — after 6 months of storage

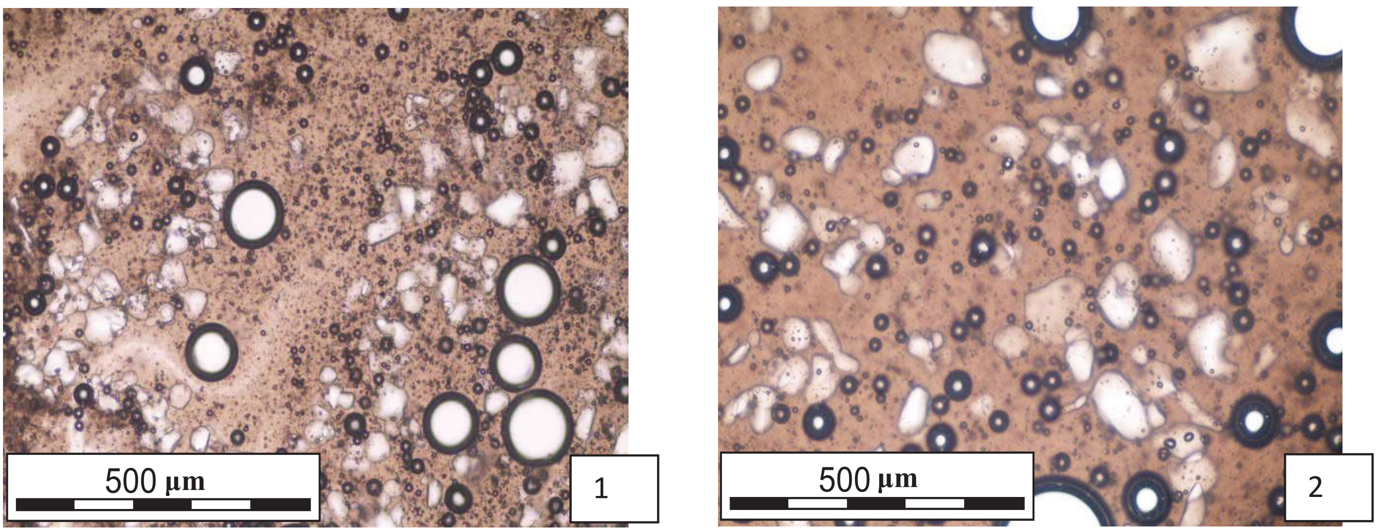

Figure 5. Microphotograph of dispersion of ice crystals of milk ice cream at 4.0% fat content: 1 — after 1 month of storage, 2 — after 8 months of storage

4. Conclusions

When studying the dispersion of ice crystals and air bubbles of milk ice cream and frozen whipped fruit desserts — the products of summer season during storage, it was defined that the decrease of dispersion of structural elements inevitably occurred owing to the fat absence or low-fat and dry substances content in such products. To a considerable degree the dispersion of structural elements decreased after 6 months of storage at minus18 °C. Consideration must be given to this fact when fixing shelf life of these products. Moreover, the initial state of structural elements impacts considerably on their dispersion.

A remarkable conclusion obtained is that it is possible to keep the dispersion of structural elements of milk ice cream and desserts by lowering the storage temperature and introducing whey proteins in the formulation of fruit desserts as well by limiting the overrun to no more than 90 %.

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