

## INFLUENCE OF STORAGE CONDITIONS ON CHANGES IN THE QUALITY OF FAMILY-SIZE ICE-CREAM

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The aim of this work is to specify the physical and chemical changes of vanilla ice-cream made by two manufacturers within a 9 month storage period under varying temperature conditions (-14°C; -22°C, changes initiated every 48 h), constant temperature of -18°C and constant temperature of -30°C. The evaluation of the ice-cream quality during storage was conducted based on the following commodity tests: indication of flakiness, potential acidity, active acidity, content of dry substance and melting. The physical and chemical changes depended on the type of ice-cream and storage temperature, the most dynamic changes occurred with ice-cream stored at varying temperatures (-14; -22°C). Among the tested qualities the most significant changes were reported in the case of flakiness. Evaluation of physical and chemical properties changed more dynamically in the case of ice-cream made by manufacturer Y. Of the storage conditions tested here, the most advisable temperature in terms of ice-cream quality was -30°C.

### INTRODUCTION

Ice-cream is a product made of emulsified oil and protein with the addition of other products and substances, according to suitable recipes; ice-cream is also a pasteurised and frozen product derived from a mixture of water, sugar and other products, in accordance with appropriate standards, and intended for direct consumption or consumption after storage [PN-A-86431]. The high nutritional, taste, aesthetic and dietary quality of ice-cream is the reason why it has become a product consumed not only during the summertime. Due to the large competition among manufacturers, consumers are used to a wide assortment and high quality of ice-cream. Therefore, it is necessary to manufacture ice-cream all year round and to store the production surplus. Very often, improperly stored ice-cream loses its quality and organoleptic properties.

Due to its nature, ice-cream is a labile product subject to a number of physical, chemical, biochemical, biological and microbiological changes. Transformation of ice-cream during storage significantly influences its sensory properties and nutritive value. Processes that occur in the ice-cream cause deterioration of its quality; such processes occur even under optimal storage conditions. The rate and extent of changes depend on: the type and initial quality of products and the composition of the mixture, sanitary and hygienic conditions, the technological process and the packaging used, as well as the conditions and periods of storage [Palich, 1994; Palich & Świtka, 1987].

Due to the product's nature, it is mainly the physical changes which may affect the ice-cream quality. These changes

may mean that the ice-cream is rejected after a very short storage period. The rate of physical changes occurring in ice-cream also depends on temperature stability during storage. Basic changes of this type include recrystallisation, loss of air and sublimation of water frozen out. The consequence of recrystallisation and the loss of air include sensory changes, especially in the ice-cream structure. The sublimation of water frozen out leads to the increase of dry substance, shrinkage, as well as the intensification of the lipolytic and oxidation changes in fat and proteolytic protein [Palich, 1991].

Family-size ice-cream is consumed not only during summertime; nevertheless, the greatest demand for this type of ice-cream occurs during the summer season. Ice-cream is stored at warehouses of distributors and wholesalers, as well as at retail outlets. Therefore, the question of whether it maintains stable quality during the whole storage period is very important. In connection to the above, it was decided to conduct tests to specify physical and chemical changes in ice-cream during a 9-month storage period.

### MATERIAL AND METHODS

**Material.** The tested material was a vanilla-flavour ice-cream in 1 L boxes produced by two different manufacturers. The ice-cream was delivered to the laboratory of the Gdynia Maritime University at the same time; it was divided into three equal portions and placed in three storage chambers where the following storing conditions were applied: (1) variable temperature from -14°C to -22°C, changes initiated every 48 h, (2) constant temperature of -18°C, and (3) constant temperature of -30°C.

**Analytical methods.** The aim was to specify physical and chemical changes in vanilla ice-cream stored for nine months in a variable temperature from  $-14^{\circ}\text{C}$  to  $-22^{\circ}\text{C}$ , a constant temperature of  $-18^{\circ}\text{C}$  and a constant temperature of  $-30^{\circ}\text{C}$ . Evaluation of changes in the ice-cream quality during storage was conducted based on the following commodity tests:

(1) *flakiness indication* – according to the method specified by Polish Norm [PN 67/A-86430]. A cylinder-shaped mould was inserted into the ice-cream so that it would fill up with ice-cream completely. The ice-cream was transferred from the mould to a 200 mL measuring flask and after adding 2 mL of diethyl ether, the flask was refilled with distilled water, measured with a burette, up to the scale mark. Flakiness was represented by a percentage proportion of the melted ice-cream volume:

$$x = \frac{a - [d - (b + c)]}{d - (b + c)} \cdot 100\%$$

where: a – mould capacity in mL, b – volume of water added in mL, c – volume of diethyl ether added in mL, d – measurement flask capacity in mL;

(2) *potential acidity indication* – according to the method specified by Polish Norm [PN-A-86431]. Distilled water (50 mL) was added to 50 g of melted ice-cream; then it was titrated against pH-meter, with a 0.25 N sodium hydroxide, until pH equal to 7.0 was obtained. The acidity of ice-cream was calculated in Soxhlet-Henkel's degrees according to the formula:

$$X = a \cdot 2$$

where: a – the volume of 0.25 N solution of sodium hydroxide used to obtain pH equal to 7.0;

TABLE 1. Physical and chemical characteristics of the ice-cream tested.

Characteristics	Ice-cream manufacturer X	Ice-cream manufacturer Y
Flakiness (%)	148.3	140.2
Potential acidity ( $^{\circ}\text{SH}$ )	1.80	1.85
Active acidity (pH)	6.38	6.50
Volume of dry substance (%)	33.98	35.19
Melting (mL)	2.50	3.50

(3) *active acidity indication* – according to the method specified by Polish Norm [PN-A-86431], performed with the HANNA Instruments PH-meter, type H 211;

(4) *dry substance indication* – sand drying method at a temperature of  $102^{\circ}\text{C}$ , according to the method specified by Polish Norm [PN-A-86431];

(5) *melting indication* (resistance to melting) – according to the method developed by the Central Refrigeration Laboratory in Łódź [Bergamn-Szczepanik & Kałuziak, 1988]. This method consists in measuring the volume of melted ice-cream within a time scale of 60 min, in a constant temperature of  $20^{\circ}\text{C}$ . The ice-cream used was the ice-cream which had been cut out with a special cylinder-shaped mould so that it would fill up with ice-cream completely. The results were given in mL.

Storage tests were conducted every 30 days.

## RESULTS AND DISCUSSION

Before conducting storage tests ice-cream from both manufacturers was tested physically and chemically in order to prepare its characteristics. The results are shown in Table 1. The ice-cream structure and texture were smooth and homogenous; the shape and appearance corresponded to the moulds used in the production process and did not show de-

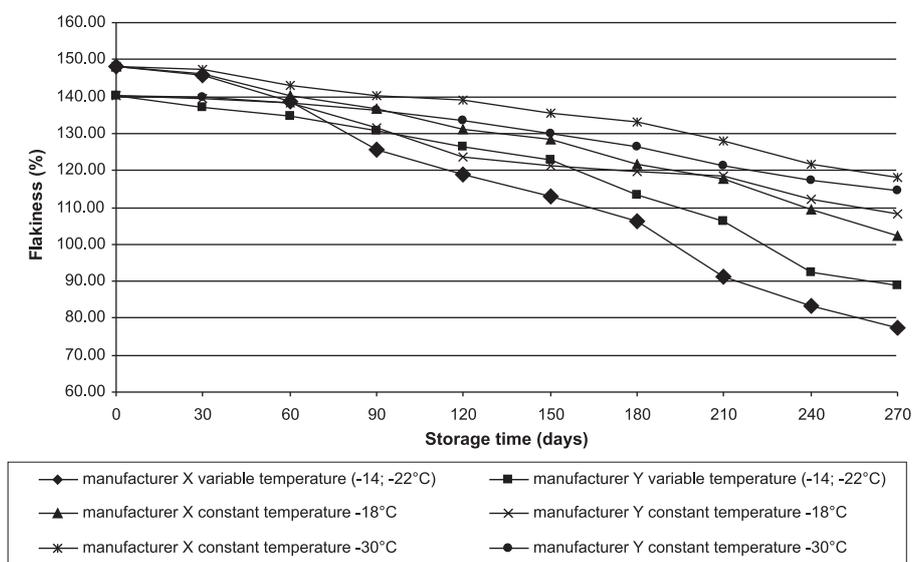


FIGURE 1. Changes in vanilla ice-cream flakiness during storage.

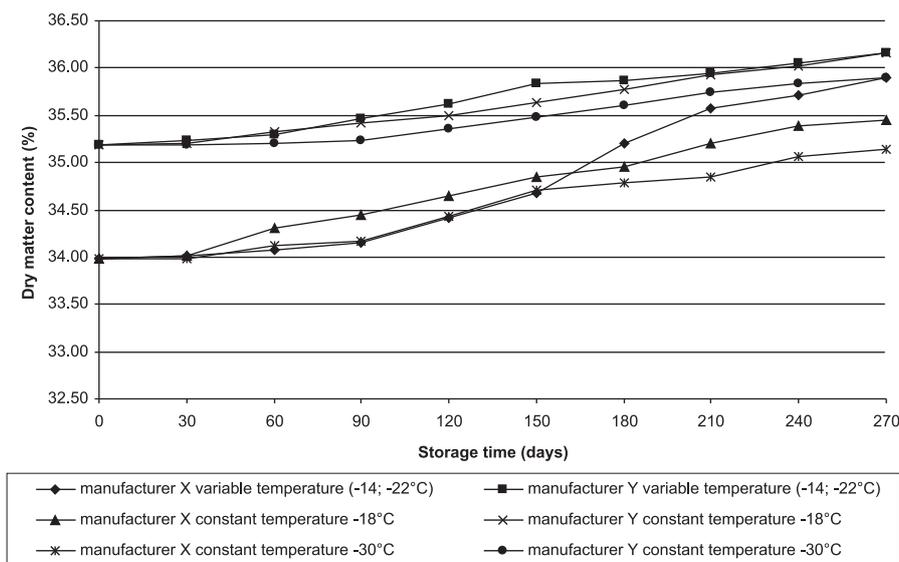


FIGURE 2. Changes in the content of dry matter in vanilla ice-cream during storage.

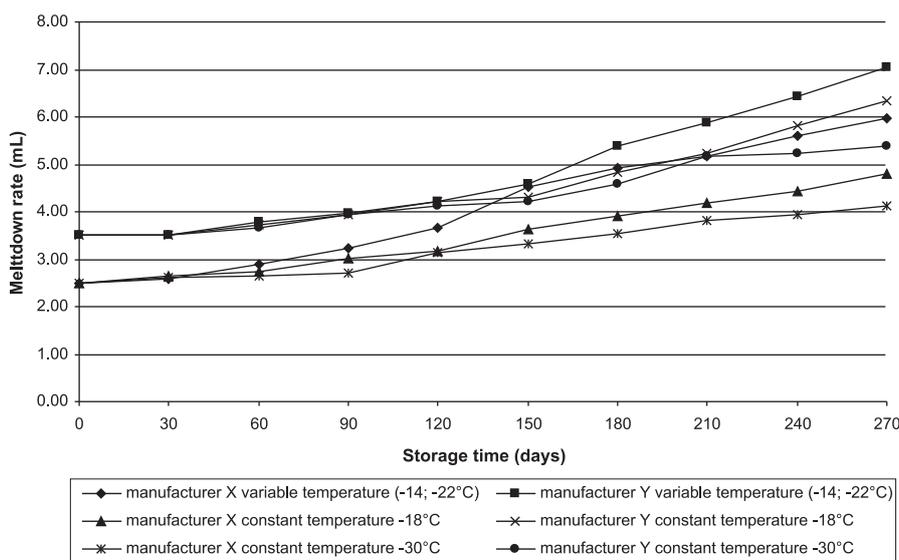


FIGURE 3. Changes in vanilla ice-cream meltdown rate during storage.

formation. The colour of the ice-cream was characteristic; the taste and flavour were characteristic to the additives used, the colour was homogenous throughout the whole bulk.

Flakiness is one of the most important ice-cream qualities. In the conducted experiment, flakiness demonstrated a downward tendency from the initial value between 148.3% and 77.3% for manufacturer X (under variable temperature conditions); 102.3% at -18°C; and 118.1% at -30°C, whereas for manufacturer Y, from 140.2% to the value of 88.9% after nine months of storing (under variable temperature conditions); 108.3% at -18°C; and 114.5% at -30°C (Figure 1). Certain ingredients significantly influence the ice-cream flakiness: eggs, sugar content, sodium citrate, disodium phosphate.

The proportions of individual ingredients, mainly fat and dry substance, as well as the addition of a proper quantity of stabilisers, have a great influence on the ice-cream air content. [Pluta, 1999; Polak & Kałuziak, 2000]

The initial value of the ice-cream potential acidity was 1.80°SH for manufacturer X, and 1.85°SH for manufacturer Y. During the entire storage period and in all the experiment variants, the potential acidity value decreased slightly – for manufacturer X by 0.33°SH (in variable temperature conditions), 0.27°SH at -18°C, and 0.33°SH at -30°C; for manufacturer Y by 0.55°SH (under variable temperature conditions), and 0.52°SH at -18°C and -30°C. The active acidity of ice-cream changed the most in variable temperature con-

ditions. However, the changes were relatively small because the pH increased from 6.58 to 6.74 for ice-cream made by manufacturer X; and from 6.57 to 6.73 for ice-cream made by manufacturer Y.

For manufacturer X, the dry substance content before storage was 33.98%; after nine month storage it increased to 35.89% (under variable temperature conditions), 35.45% at  $-18^{\circ}\text{C}$  and 35.14% at  $-30^{\circ}\text{C}$ . For manufacturer Y, the content increased from the initial level of 35.19% to 36.15% (under variable temperature conditions), 36.16% at  $-18^{\circ}\text{C}$ , and 35.90% at  $-30^{\circ}\text{C}$  (Figure 2).

During the entire storage period, the meltdown rate of the tested ice-cream demonstrated a downward tendency, and the dynamics of observed changes depended on the storage temperature. The highest dynamics of the meltdown rate reduction was demonstrated by the ice-cream stored under variable temperature conditions. The ice-cream made by manufacturer Y had the highest meltdown rate. Before the storage, the meltdown rate of ice-cream made by manufacturer X was 2.5 mL, and for the ice-cream by manufacturer Y it was 3.5 mL. After the storage ended, the meltdown rate was respectively 5.9 mL and 7.0 mL (under variable temperature conditions); 4.80 mL and 6.33 mL at  $-18^{\circ}\text{C}$ , and 4.10 mL and 5.12 mL at  $-30^{\circ}\text{C}$  (Figure 3).

## CONCLUSIONS

The physical and chemical changes in ice-cream depended on the type of ice-cream and storage temperature.

The highest dynamics of change was demonstrated by the ice-cream stored under variable temperature conditions ( $-14^{\circ}\text{C}$ ;  $-22^{\circ}\text{C}$ ). Among the tested qualities, the most significant changes were observed with regard to flakiness. The evaluation of physical and chemical properties showed that the ice-cream made by manufacturer Y changed most dynamically. The temperature of  $-30^{\circ}\text{C}$  was reported to be the most advisable out of all the temperature conditions applied in the experiment.

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## WPŁYW WARUNKÓW PRZECHOWYWANIA NA ZMIANY JAKOŚCI LODÓW FAMILIJNYCH

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Celem pracy było określenie zmian fizykochemicznych lodów waniliowych dwóch producentów w czasie przechowywania przez dziewięć miesięcy w temperaturze zmiennej ( $-14^{\circ}\text{C}$ ;  $-22^{\circ}\text{C}$ , zmiany inicjowano co 48 godzin), stałej  $-18^{\circ}\text{C}$  i stałej  $-30^{\circ}\text{C}$ . Ocenę zmian jakości lodów w czasie przechowywania prowadzono w oparciu o następujące badania towaroznawcze: oznaczanie puszystości, kwasowości potencjalnej, kwasowości czynnej, zawartości suchej masy, oraz topliwości. Zmiany fizykochemiczne lodów uzależnione były od rodzaju lodów i temperatury przechowywania, największą dynamiką zmian charakteryzowały się lody przechowywane w zmiennej temperaturze ( $-14^{\circ}\text{C}$ ;  $-22^{\circ}\text{C}$ ). Spośród badanych cech największe zmiany stwierdzono w przypadku puszystości. Ocena właściwości fizykochemicznych wykazała większą dynamikę zmian dla lodów producenta Y. Spośród zaproponowanych w doświadczeniu warunków przechowywania najbardziej korzystna dla jakości lodów była temperatura  $-30^{\circ}\text{C}$ .