Unit for food's temperature control during their refrigeration

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ABSTRACT

Introduction. Temperature control of foods during cooling & freezing is important for the development of refrigeration processing modes. Cryoscopic temperature determination is a one of main tasks during ice-cream production. There is no data about new ice-cream mixes. Standard method for determining cryoscopic temperature has some weaknesses.

Materials and methods. New ice-cream mixes and distilled water were studied with our experimental unit. Main parts of it were T-type thermocouples, controllers ICP I-7014, signal converter ICP I-7520 and PC with special software NDCONUTILv3 for temperature registration.

Results. Curve freezing for 20 new ice-cream mixes on a different bases are built. Cryoscopic temperature for this mixes were determined from this curves. Using of distilled water during all time of measurements allowed increasing accuracy. Simultaneously measurements for 4-5 mixes with 2-3 thermocouples in each mix allowed to increase accuracy of measurements and reduced time for it. A method for determining cryoscopic temperature using thermocouples is developed. Laboratory unit for measurements of cryoscopic temperature is designed and erected.

Introduction

Temperature control of foods during cooling & freezing is important for the development of refrigeration processing modes, because:

- It is important to know cryoscopic temperature for setting minimal temperature of cooling or supercooling, and to calculate the water share frozen off the product;
- The rate of temperature dropping during freezing impact on the course of crystallization of cellular juice in product and determines the extent of damage to its cellular structure.
- Lowering the temperature in freezer will reduce the duration of freezing, improve product quality, but will increase the power consumption.

The structure of ice cream formed during freezing determined by the shape and size of ice crystals. Higher quality ice cream can be produced if small ice crystals are more evenly distributed in the product volume. A significant content of bound water and small molecules significantly affect the nature of the process of water crystallization in the mixture.

Ice crystals in the ice-cream mixtures begin to form at cryoscopic temperature. Temperature of the mixture is decreasing during crystallization.

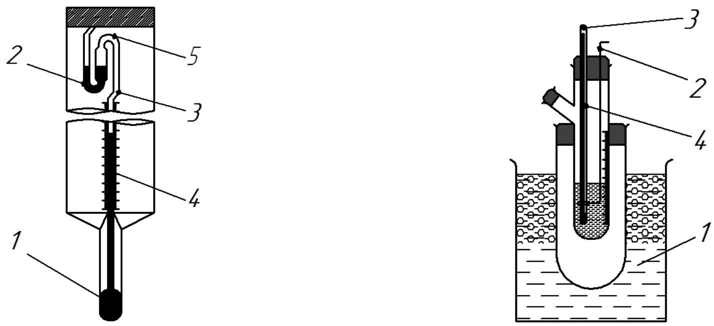
According to the known cryoscopic temperature we have an opportunity (Raoult's law) to establish the water share frozen off the mixture (ω) during freezing, storage and transportation of hardened ice cream:

$$\omega = 1 - t_{cr} / t$$

t_{cr} – cryoscopic temperature, ºC; t – current temperature, ºC.

Objective of our research was defining cryoscopic temperature for existing standard mixes and new mixtures for the production of ice cream (milk-based and fruit or vegetable-based).

Standard method for determining cryoscopic temperature. Cryoscopic temperature is determining with Metastatic Beckmann thermometer (fig.1, a). Test-tube with measured product is placed in the ice-salt mix reservoir with temperature approximately –40 ºC (Fig.1, b). Calibrated Beckmann thermometer is placing into product.



a *b*

Fig. 1:

a – Metastatic Beckmann thermometer (1 - lower mercury reservoir; 2 - upper mercury reservoir; 3 – capillary; 4 – scale; 5 – the place of the capillary to the upper reservoir);

b – Standard unit for measurement of cryoscopic temperature (1 – ice-salt mix reservoir; 2 – Metastatic Beckmann thermometer; 3 – mixer; 4 –product under study).

Operator fixes indications every 10 sec during freezing. Result of measurements is a freezing curve – dependence product temperature (°C) from time (sec). Cryoscopic temperature is determining from this curve. Example of freezing curve (for distilled water) shown at the fig. 2. Cryoscopic temperature of distilled water is 0 °C.

Standard method is good because:

- has accuracy to 0,01 °C
- has lower cost
- no additional equipment is required.

But its users have some problems:

- risk of damage to a mercury thermometer
- countdown temperatures make no more than once every 10 seconds
- subjective uncertainty
- no automatic fixation of the results

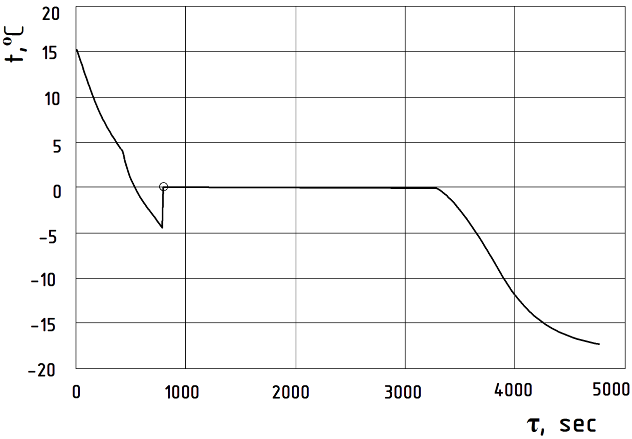


Fig. 2. Curve freezing of distilled water – dependence temperature (°C) from time (sec)
Cryoscopic temperature 0 °C

Materials and methods

For this experiments was modernized unit, which was developed at the Thermal Engineering Department of National University of food technologies [1]. Experimental unit is shown at the Figure 3. Main part of this unit is refrigerator with temperature –25ºC (1). Metallic bottles with mixes (3) and control bottle with distilled water (4) are placed into refrigerator. Thermocouples (2) are in the bottles. Signals from thermocouples collect in controllers (5), convert in signal converter (6) and register in PC (7) with software NDCONUTILv3.

Advantages of proposed method are:

- The absence of toxic substances in the unit
- The possibility of simultaneous measurements of several mixes
- Compliance with current knowledge and experience
- The possibility of measuring with a 1-second intervals and less if necessary
- Automatic results registration

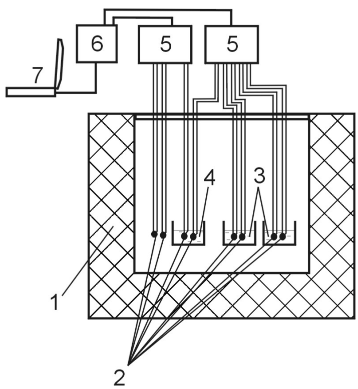


Fig 3. Experimental unit:
1 – refrigerator; 2 – thermocouples type T; 3 – bottles with mixes; 4 – control bottle with distilled water; 5 – controllers I-7014; 6 – signal converter I-7520; 7 – PC

We used controllers ICPcon I-7014 with automatic zero-compensation. Problem of these controllers is a less accuracy. Working controllers can make error from wrong zero-compensation, so its accuracy is 0,5…2 ºC. For increasing it we measured of distilled water freezing temperature permanently. Thermocouples data were recalculated according data from thermocouple with distilled water freezing temperature. We had accuracy up to 0,05…0,1 ºC.

Results

With this unit we built curve freezing of different ice-cream mixes and determined its cryoscopic temperatures (Tables 1)

Table 1. Cryoscopic temperatures for ice-cream mixes

№	Mix	Cryoscopic temperature, ˚C
	Milk-based mixes	
1	Milky	-2,71
2	Creamy	-2,94
3	Plombières	-3,08
4	Milky without stabilizator	-2,16
5	Milky with wheat flour (2%)	-2,38
6	Milky with wheat flour (3%)	-2,4
7	Milky with oat flour (3%)	-2,3
8	Milky-wheat with wheat germs	-2,38
9	Milky-pumpkin	-2,75
10	Milky-carrot	-2,36
11	Milky-apple	-2,66
	Fruit & vegetables-based mixes	
1	Pumpkin	-2,82
2	Apple without gelatin	-2,66
3	Apple with gelatin	-2,9
4	Apple-eggs	-3,38
5	Apple-protein	-3,54
6	Apple-oat	-3,35
7	Flavor with extract of Hibiscus	-2,20
8	Flavor with pumpkin & extract of Hibiscus	-2,86
9	Flavor mint	-2,17

Conclusion

1. A method for determining cryoscopic temperature using thermocouples is developed. Using of distilled water as an sample object allowed to increase accuracy.

• Laboratory unit for measurements of cryoscopic temperature is designed and erected. Simultaneously measurements for 4-5 mixes with 2-3 thermocouples in each mix allowed to increase accuracy of measurements and reduced time for it.

- Cryoscopic temperature of 11 milk-based mixes for ice cream and **9** fruit and vegetable-based mixes were defined.

The project has been improved by Thermal engineering and cooling equipment Department and Milk and milk products Technology Department of the National university of food technologies.

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