Thermophysical characteristics of frozen semi-finished products for restaurant technology

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Keywords:

Cryoscopic
Freezing
Fruit
Dessert
Blend

Article history:

Received
16.05.2020
Received in revised form 14.09.2020
Accepted
25.12.2020

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DOI:
10.24263/2310-1008-2020-8-2-6

Abstract

Introduction. The aim of the study is to determine the influence of thermophysical characteristics of frozen semi-finished products on the quality of desserts.

Materials and methods. To determine the quality of frozen semi-finished products in the technology of the desserts the raw materials Raw materials were used: glucose-fruit syrup, maltodextrin, apple puree, kiwi, banana, pumpkin; semi-finished products in the form of blended pairs: apple – kiwi; apple – banana; apple – pumpkin. As control sample it was used traditional apple sambuk .The study of sensory quality indicators was carried out on a 10-point scale. Determination of physicochemical parameters of the samples was carried out by mass fraction of dry matter; active acidity; water activity; enthalpy; moisture content.

Results and discussion. The use of cryoprotectant (glucose – fructose syrup) equalizes the osmotic pressure of concidered food system, as in the syrup glucose and fructose are contained, which reduces the cryotemperature of the samples and inhibits the formation of intracellular ice, which allows preserving the quality of the blended semi-finished product on the content of biologically active substances.

Differences in the freezing parameters of fruit puree semi-finished products with cryobiotics, namely glucose-fructose syrup and maltodextrin, were established. Monosaccharides, glucose and fructose, have been found to have lower cryoscopic temperatures than sucrose, due to the nature of the crystallization and the size of the crystals formed in the system. With the same chemical formula and molecular weight of sugars, the value of cryoscopic temperature depends on the hydration of sugars.

Based on the identified quality indicators and weighting factors, a comprehensive quality indicator of ready-made desserts (using developed blended semi-finished products) made by the developed technology was calculated, and a quality model was built.

The rating of the dishes showed that the studied samples of sambuca with blended pairs have a high rating of 92.9 points^2 and 96.9 points^2, compared to the control sample – 91.2 points^2. The apple-pumpkin sambuk has a little below 88.8 points^2. The decrease in the rating of sambuk «apple – pumpkin» is due to the specific aroma of the blended pair «apple – pumpkin».

Conclusion. Cryoscopic temperatures of fruit purees, semi-finished products and ready-made desserts with the introduction of cryoprotectants were determined. Studies on sensory and physicochemical parameters give grounds to create desserts with predicted high quality indicators.

Introduction

The problem area in the development of desserts is the preservation of vitamins [1], microelements [2, 3], biologically active substances [4] and their use for enrichment of the dessert, using fruit and berry raw materials.

To reduce the technological and physiological losses of vitamins and organic acids, the most effective way is to use low-temperature technologies [4]. The advantages of using shock freezing of foods are bacteriological purity, significant reduction in weight loss of foods, increased shelf life, and significantly higher quality of frozen products compared to the traditional method [4, 5].

However, the method of rapid freezing does not guarantee the high quality of the products, especially after their defrosting [4, 5]. The sensitivity of cells and tissues of different fruits and berries is different to the effects of low temperatures (and related physical and mechanical processes), and the quality and consumer characteristics are determined by the successful choice of cryoprotectant, its concentration, duration of contact with frozen materials, which necessitates the study of indicated factors.

Scientists around the world proved [4, 5], that the use of artificial cold provided minimal change in the nutritional and biological value of ready meals, products and semi-finished products, but also influenced their sensory characteristics. However, freezing of the range of fruit and berry semi-finished products has advantages over other methods of heat treatment, namely drying, pasteurization, sterilization, and canning.

Hydrocolloid Stabilizers. A wide variety of hydrocolloid chemistry studies have examined the physical and chemical properties and behavior of typically larger molecules or particles dispersed within or residing at the interface of an aqueous continuous phase [4]. The chemical and physical actions of the hydrocolloids involve mechanisms based on various factors, including the presence of charged moieties, hydrophobic regions, and high water-holding capacities of such ingredients [6]. Advances in this realm have led to the inclusion of a vast array of stabilizers derived from a variety of sources [7, 8] that affect the rheological, stability, and sensory properties. In general, these stabilizers impede the outgrowth of ice crystals and the sublimation of water [9] while increasing the viscosity of the mix, sensory smoothness, and foam stability [10].

Characteristics of fruit raw materials for restaurant technology. *Kiwifruits* exhibit antioxidative, antiproliferative, antiinflammatory, antimicrobial, antihypertensive, antihypercholesterolemic, neuroprotective, antiobese properties and promote gut health [11-15]. Contents of total dietary fiber and free phenolics and in vitro antioxidant capacities of kiwifruit flour were significantly higher than those of potato, maize and wheat flours [12, 13]. Pasting, gel texture and dynamic oscillatory analysis showed that the starchy kiwifruit flours had some similar characteristics to traditional flours with differences. The viscosity and gelation were little developed in the flours of eating-ripe kiwifruit. The flour properties were much determined by starch content and properties. The starchy kiwifruit flour may be used for "novel" and "healthy" food formulations [12]. The amounts of PPs and vitamin C were encouragingly high. Health beneficial compounds, dimethyl-caffeic acid hexoside, caffeic acid derivatives, protocatechuic acid, syringic acid, salicylic acid/o-coumaric acid, lutein and beta-carotene, were detected in the final products [14].

Bananas are a worldwide crop for food and traditional medicine [15]. Banana fruit has high nutritional value and is consumed worldwide [16]. Bananas contain phenols, flavonoids and antioxidants [17–20]. The highest total antioxidants capacity and total phenols concentration were found in the ripe banana fruit. 2,2-Diphenyl-1-picrylhydrazyl radical scavenging activity remained constant and the highest total flavonoids concentration was found in the mature green fruit [18]. Banana peel was found to contain phenolic compounds ranging from 0.90 to 3.0 g/100 g dry weight [19].

Pumpkin flesh contains a variety of phenolic compounds, flavonoids, vitamins, as well as minerals. It also has low calorie content (17 kcal/100 g flesh) [21]. One of the major carotenoids in pumpkin fruit (>80%) is β-carotene, which contributes to the high nutritional value of pumpkins [22]. Traditionally pumpkin is cooked in variety of dishes or used to make desserts and beverages. However, pumpkin contains a high level of insulin-dependent sugars, which is problematic for diabetic patients [23]. Therefore, in this study, fermentation is utilized in the development of pumpkin based beverage in which the microorganisms could utilize the sugar during fermentation [24]. This reduces the insulin-dependent sugars so that this beverage is more suitable for the consumption of diabetic patients. Moreover, fermentation of vegetables and fruits such as pumpkin may not only improve the food safety levels and prolong the shelf life, but may also enhance the availability of certain nutrients [25].

Apples. The results showed great quantitative differences in the composition of the apple cultivars, particularly in their phenolic contents. Fructose was the most dominant sugar in the different apple cultivars, followed by glucose and sucrose, while malic acid was the principal organic acid. Asparagine and serine were the principal amino acids. Chlorogenic acid and protocatechuic acid were the dominating phenolic compounds [26]. The fruit of apple possessed five quercetin glycosides, namely hyperin, isoquercitrin, reynoutrin, avicularin and quercitrin, as the major flavonol components. Total flavonol levels were in the range 26.4 to 73.9µg/g fresh wt (expressed as aglycone) with hyperin the dominant form, where quercitrin predominated, and the cider apples, where avicularin predominated. The proportion of flavonol in the peel ranged from 63.0 to 97.1% for the dessert and cooking apples and was not dependent on fruit size. Juice produced from the three varieties of cider apple contained 9.9 to 12.7% of the flavonols with the remainder retained in the pomace [27].

Taking into account the aforementioned, the *aim* of this work is to determine the cryoscopic temperatures and the intensity of ice formation in blended semi-finished products, made on the basis of fruit and vegetable raw materials. Attention is paid to the formation of recommendations on the use and dosage of blended semi-finished products while developing new types of desserts.

Indicated aim can be achieved through a number of *tasks*, namely:

- determination of influence of the cryoprotectants use on technological process and changes in structures of bioobjects;
- study of the changes in product quality during the use of rapid freezing;
- analysis of the influence of selected freezing conditions on the sensory characteristics of prepared desserts;
- formation of recommendations on the use and dosage of blended semi-finished products while developing new types of desserts.

Materials and methods

Materials

Raw materials were used: glucose-fruit syrup, maltodextrin, apple puree, kiwi, banana, pumpkin; semi-finished products in the form of blended pairs: apple – kiwi; apple – banana; apple – pumpkin.

Apple puree was prepared with subsequent adding of 10% of sugar, 10% of glucose-fructose syrup, and 1% of maltodextrin. The study of blended semi-finished products was performed using a cryoprotectant – 10% of glucose-fructose syrup.

As control sample it was used traditional apple sambuk – a jelly dessert based on whipped egg whites [29].

Methods

Determination the quality criteria of desserts [28–30]

To effectively assess the sensory properties of infusions, a list of descriptors was formed. The most acceptable is the method of visualization of sensory parameters of products in the form of profilograms, which can be used to assess the intensity, originality, coherence, expression of taste, aroma and color of alcohol semi-finished products. The obtained values of sensory parameters were used to determine the quality criterion of the profile [28].

The method of determining the quality criterion of products by quantitative indicators includes the definition of specific indicators and descriptors that characterize the product, the conversion of units into dimensionless units (if necessary), drawing up a mathematical model and the calculation of the criterion of product quality. The quality criterion is constructed on the area principle, that is the value of the complex criterion corresponds to the area of the polygon in which the distance from its center to the vertices is equal to the normalized values of the individual quality indicators $f_j,\ j=\overline{1,N}$, where N – the number of individual quality scores [29]:

$$S=\sum_{j=1}^{N}\left(\frac{1}{2}\cdot f_j\cdot f_{j+1}\cdot sin\frac{2\pi}{N}\right)=\frac{1}{2}sin\frac{2\pi}{N}\cdot\sum_{j=1}^{N}\left(f_j\cdot f_{j+1}\right),\qquad f_{N+1}=f_1$$

For each sample with a set of values of individual indicators $(f_1, f_2,...,f_N)$, it is possible to calculate the value of the complex criterion *S*.

The qualitative area (*S*) of polygon is equal to the total sum of the areas of the triangles, formed by corresponding lines of the individual (partial) quality indicators. Instead of the function *S*, it is advisable to use another function *F*, which differs from *S* only by a constant multiplier, which doesn`t affect the choice of the largest value. To choose the most successful option with the largest value of the complex criterion, it is enough to use the criterion formula [30]:

$$F = f_1 f_2 + f_2 f_3 + ... f_{N-1} f_N + f_N f_1,\ \text{points}^2.$$

The problem of finding the optimal value and effect of a new ingredient (in our case – the blended pair) on the food system was solved as a problem of finding the extremum of the target multicriteria quality function of quality of nonlinear product with a system of restrictions on individual quality indicators.

Determination of cryoscopic temperatures of fruit and berry raw materials [31]

Measurements of the cryoscopic temperature of the model samples were performed by the method of thermal analysis based on the construction of curves of temperature change over time. The temperature was recorded and recorded using a measuring complex [31].

The complex includes a device for temperature control with a set of copper-constantan thermoelectric transducers type T with a measurement error of not more than 0.05 °C, a primary transducer and a signal converter brand i7520. Temperature values were recorded using a personal computer through the program NDCONUTILv3xx [31].

The thermocouple junction was placed in the center of the sample (weight 7.5 g) and transferred to a SAMSUNG freezer with refrigerant freon R134a and a working chamber temperature of minus 25 °C. With continuous stirring of the mixture performed automatic recording of temperature change at equal intervals (10 s) in experimental and control samples [31]. Frozen (in portions) blended semi-finished products were added into the egg white, and started whipping after 8–10 minutes at the room temperature. Other ingredients were added to the whipped mass and whipping was continued.

Results and discussions

Physico-chemical parameters of fruit blended semi-finished products

The results of the research presented in Table 1 allow obtaining several patterns that require scientific explanation. Firstly, the obtained data show that the chemical composition of plant raw materials has an effect on presented indicators and retains different contents of bound and free moisture (it is supposed to be an affect of the esterification degree of plant pectin), which positively or negatively affects cryoscopic temperatures.

Table 1

Physico-chemical parameters of fruit blended semi-finished products

Sample description	Mass fraction of dry matter, %	pH	Water activity, Aw	Enthalpy, J/g	Moisture content, U %
Apple (control sample)	10.10±1.54	6.4	0.986	63.36	19.560±1.530
Apple-sugar	11.30±0.85	7.3	0.986	60.74	18.064±1.100
Apple-glucose-fructose syrup	12.15±1.10	6.9	0.970	61.22	18.259±1.200
Apple-maltodextrin	10.10±1.14	7.5	0.986	62.10	18.920±1.240
Blended pairs					
Apple-kiwi	15.00±0.70	7.5	0.990	63,90	17.647±1.100
Apple-banana	14.00±1.20	7.3	0.986	62.77	16.279±1.160
Apple-pumpkin	14.00±0.90	6.5	0.986	62.86	16.279±1.120

As a result of the conducted researches, optimum limits of pH values for blending pairs, making 6.5–7.5, were established. Also the purposefulness of glucose-fructose syrup and maltodextrin use as cryoprotercopes was proved.

Determination of cryoscopic temperature in fruit purees

According to the cryoscopic temperatures of studied blended pairs, the content of frozen water in samples at negative temperatures in the range of values from -5 to -10 ºC was calculated (Figure 1).

Such calculations are very important, because in blended purees during storage of the blended semi-finished product the ratio between frozen and unfrozen water is constantly changing, which significantly affects the formation of physicochemical parameters of the finished product [29].

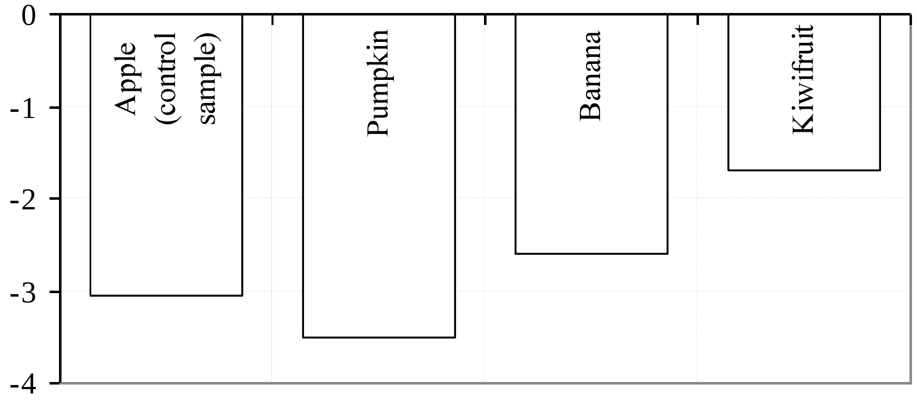

Figure 1. Determination of cryoscopic temperature in fruit purees

Determination of cryoscopic temperature in blended semi-finished products

Analysis of the content of frozen water in blended semi-finished products (Figure 2), in comparison with native apple puree, has an improved chemical composition and allows identifying samples with the biggest risk of appearing of defects appropriate for frozen fruits and berries of long-term storage, namely blend delamination and formation of iced structure.

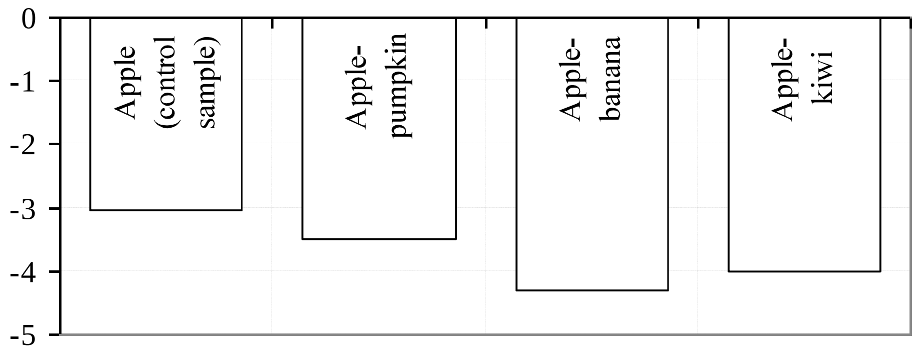

Figure 2. Determination of cryoscopic temperature in blended semi-finished products

Cryoscopic temperature of fruit and berry blends is one of the main physical characteristics that determine the technological modes of the storage process of the semi-finished product and after defrosting of the finished product [7, 29].

Further experiments were performed to determine the quality of ready-made cold desserts using blended pairs.

Cryoscopic temperature of desserts model systems

The obtained cryotemperatures in samples of desserts with different blending pairs are presented in Figure 3.

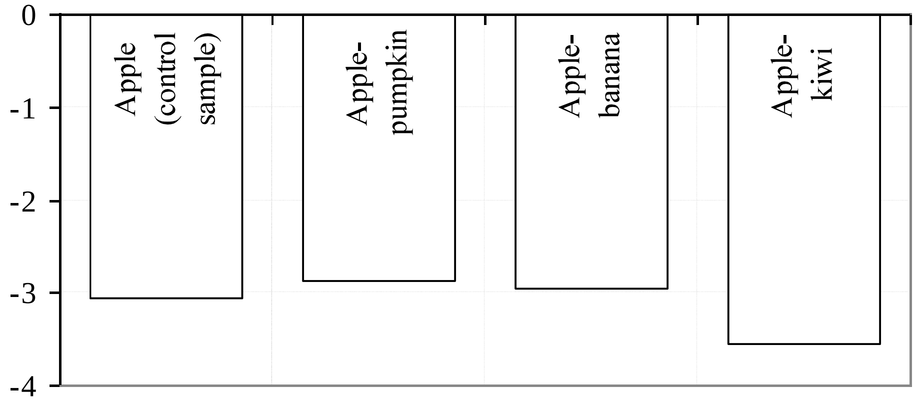

Figure 3. Cryoscopic temperature of desserts model systems

The obtained results show that the use of cryoprotectant (glucose – fructose syrup) equalizes the osmotic pressure of considered food system, as in the syrup glucose and fructose are contained, which reduces the cryotemperature of the samples and inhibits the formation of intracellular ice, which allows preserving the quality of the blended semi-finished product on the content of biologically active substances.

In the calculated blending mixtures, water is frozen in the form of ice crystals, due to which the concentration of sucrose, fructose and mineral salts in the rest of the water increases significantly. This concentration of low molecular weight substances in the water phase of the mixtures and their saturation with air during subsequent whipping of the dessert allows getting a soft and light dessert with excellent quality indicators.

During the blended semi-finished products storage, at the high content of the frozen water, slow defrosting and, especially, at violation of storage regimes, processes of recrystallization of the water phase can occur in a product, which essentially reduce its consumer properties.

Determining of desserts rating

The results of model samples studies are shown in Table 2.

Table 2

Determining of desserts rating

Sensory characteristics, points	Weight ratio	Dessert with blended pair apple-kiwi, points[2]	Dessert with blended pair apple-pumpkin, points[2]	Dessert with blended pair apple-banana, points[2]	Control sample (with apple puree) traditional apple sambuk, points[2]
Appearence	3.0	28.4	25.8	29.4	27.6
Colour	2.0	18.5	17.7	19.3	18.1
Taste	2.0	18.8	18.3	19.4	18.5
Smell	1.5	13.7	13.5	14.6	13.6
Consistency	1.5	13.5	13.5	14.2	13.4
Rating:		92.9	88.8	96.9	91.2

Based on the identified quality indicators and weighting ratios, a complex quality indicator of desserts (prepared using developed blended semi-finished products) was calculated, and a quality model was built. Analysis of the rating of new dishes showed that the studied samples of sambuk prepared with blended pairs have a high rating of 92.9 and 96.9 points^2, compared with the control sample (91.2 points^2). The apple-pumpkin sambuk has a little less rating (88.8 points^2). This fact can be explained by the presence of a specific aroma in «Apple-pumpkin» sambuk.

Conclusions

The cryoscopic temperatures and the intensity of ice formation in blended semi-finished products, made on the basis of fruit and vegetable raw materials, were determined. The recommendations on the use and dosage of blended semi-finished products while developing new types of desserts were formed.

Based on the results of comprehensive research, the next conclusions were made:

1. The use of cryoprotectants made allows significantly reducing the technological process, preventing cryodamage of cells and structures of bioobjects, resulting in the formation of fine crystalline ice in cells and intercellular space, which prevents the destraction of plant cells. Therefore, their structure changes a little and even after defrosting blends almost do not change the mass fraction of dry matter, while maintaining the quality and taste properties, which is the main requirement of consumers.
2. The advantages of foods shock freezing are bacteriological purity, a significant reduction in weight loss, increased shelf life, the possibility of rapid use and significantly sufficient quality of frozen semi-finished products compared to the traditional method.
3. Analysis of the chemical composition of the developed desserts with the use of traditional apple puree and with the use of blended fruit semi-finished products showed that developed desserts have reduced caloric content.
4. When developing new types of desserts, recommendations for the composition, use and dosage of blended pairs of fruit semi-finished products were given: the recommended defrosting time is up to 25 minutes, with rapid defrosting temperature (as an example when whipping dessert), which eliminates the loss of biologically active substances.

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