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THE SWEET ICES FOR PREGNANT WOMEN

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Abstract. Daily food consumption norms of an average woman and a pregnant woman have been analysed. It has been established that in a pregnant woman's diet, it is necessary to increase the content of proteins, fibre, vitamins C, E, D, PP, and B, and reduce fats, carbohydrates (easily digestible), vitamins B5 and H, sodium, magnesium, salts, and water. Taking into account the above-mentioned requirements, eight recipe compositions of sweet ices based on plant raw materials have been suggested. The recipes were selected by linear programming using MS Excel. The products have a low calorific content (26–137 kcal per 80 g), and an increased nutritional value (due to vitamin C, carotene, etc.). For the first time, cereals, various types of seeds, nuts, have been put into the recipe of sweet ices, as well as raw materials, which eliminate physiological complications during pregnancy. The products developed differ in their composition and are made without sugar. However, some recipes include small quantities of honey as it is highly palatable. The chemical composition of the new sweet products has been studied and analysed in details and sugar/acid indices have been calculated. The developed ices have a slightly acidic taste or no acidity at all, which corresponds to the values of sugar/acid indices 13.4–26.6, while the sample from the store, selected for comparison, contains a large amount of sugars, as evidenced by the cloying taste and high sugar/acid index (more than 30). The source of fatty acids in sweet ice for pregnant women *Joy* is almond nuts. The results of the chromatographic study have shown that this product as for the quantitative fatty acid composition, meets the current requirements. We recommend introducing the sweet ice manufacture technology on the equipment already in use in canneries. The products are formed (poured into moulds where wooden sticks are then inserted) in a *Hassia* machine. One of the main operations, freezing, is done in a quick freezer *GyroFreze*. We also recommend manufacturing sweet ices using existing restaurant equipment.

Key words: pregnant women's nutrition, sweet ice, sweet products, fatty acid composition, sugar/acid index.

СОЛОДКІ ЛЬОДИ ДЛЯ ВАГІТНИХ

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Анотація. Проведено порівняльний аналіз добових норм споживання харчових речовин середньостатистичної та вагітної жінки. Встановлено, що у раціоні харчування вагітної жінки необхідно підвищувати вміст білків, клітковини, вітамінів С, Е, Д, РР та групи В, водночас знижувати вміст жирів, вуглеводів (за рахунок легкозасвоюваних), вітамінів B_5 та Н, натрію, магнію, а також солі та води. З огляду на вищеперераховані вимоги, запропоновано вісім рецептурних композицій солодких льодів на основі рослинної сировини. Рецептури підібрано методом лінійного програмування з використанням редактора MS Excel; продукти мають невисоку калорійність (26–137 ккал на порцію 80 г), підвищену харчову цінність (за рахунок вітаміну С, каротину тощо); вперше для солодких льодів у рецептуру введено зернові, різні види насіння, горіхи, а також сировину, яка нівелює фізіологічні ускладнення у період вагітності. Розроблена продукція має різний компонентний склад, та виготовляється без використання цукру, однак, з огляду на гарне органолептичне сприйняття, у деякі рецептури було введено мед у незначних кількостях. Докладно вивчено та проаналізовано хімічний склад нової солодкої продукції та розраховано цукровокислотні індекси. Розроблені льоди мають слабокислий смак або зовсім кислотність не відчувається, що відповідає значенням цукрокислотних індексів у межах 13,4–26, 6, тоді як зразок з магазину, обраний для порівняння, містить велику кількість цукрів про що свідчить приторно-солодкий смак і високий показник «цукрокислотного індексу» (більше, ніж 30). Джерелом жирних кислот у солодкому льоді для вагітних «Радість» є горіх мигдалю. Результати хроматографічного дослідження показали, що дана продукція за кількісним складом жирних кислот відповідає діючим вимогам. Впроваджувати технологію виробництва солодких льодів рекомендовано на існуючому обладнанні консервних заводів. Формування продукції (заливання у форми та вставляння дерев'яної палички) відбувається на апараті «Хассія» Однією з головних операцій є заморожування, яке відбувається у морозильному апараті GyroFreze. Також виробляти солодкий лід рекомендовано на існуючому обладнанні у закладах ресторанного господарства.

Ключові слова: харчування вагітних, солодкий лід, солодка продукція, жирокислотний склад, цукрокислотний індекс.

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Introduction. Formulation of the problem

New trends in the market of sweet products require using natural raw materials, excluding preservatives and flavour enhancers from the recipe, reducing the maximum of sugar and, accordingly, lowering the calorific content of such products. One of these sweet products is ice cream based not on milk, but on fruit ice. This is how it is defined by State Standard of Ukraine 4734: 2007 "Aromatic fruit and berry ice cream, sherbet, ice. General specifications, " "Sweet ice (frozen juice) is ice cream, whipped or not whipped, made using fruits, berries, vegetables, products of their processing, or solutions (tea, coffee, cocoa, herbs, etc.), or flavourings, natural and nature-identical, colourants, compounds and ingredients necessary for its production." Fruit and sweet ices on a natural basis can be considered "new-style" sweet eco-products with low sugar and, accordingly, low calorific content. Now considerable attention is paid to the nutrition of various social groups. So, the emphasis is laid on the fact that human nutrition should be of full value and varied. Of course, this applies to "special" periods of life, such as, for example, pregnancy. During this period, it is necessary to focus even more on the consumption of natural and useful products [1-3]. One of the options for sweet products on a natural basis is sweet ices for pregnant women, the production technology of which is discussed below.

Analysis of recent research and publications

Carrying a child is a special period in every woman's life. You need to pay more attention to yourself and stick to a proper diet. In this situation, many products are forbidden or have partial contraindications. The pregnancy period becomes a test for the woman's whole body. There are a lot of changes: taste preferences change, toxicosis appears, the mood changes dramatically, the body needs more vitamins and other useful elements than before [4-6]. And it is such a nuisance having your favorite sweets partially forbidden, too. In order for a mother to be healthy and be able to give a birth to a healthy baby, she should be careful about what she eats [7-8]. So, unlike the usual diet, the diet during pregnancy should be include a larger number of useful vitamins and minerals. Table 1 shows the daily food consumption norms of an average and a pregnant woman [9-10].

Table 1 – The daily food consumption norms of an average and a pregnant woman

Food component	An average woman	A pregnant woman (gestation period)	
		First half	Second half
Proteins, g	8–100	110	120
Fats, g	90–110	75	85
Carbohydrates, g	350–500	350	400
Dietary fibre, g	25	25–30	25–.30
Calorific content, Kcal	2100	2400–2700	2800–3000
Water, l	1.5–2	1–1.2	до 1
Vitamins, mg			
Beta carotene	5	6	6
A	1	1.3	1.3
B1	2.2	3–5	3–5
B2	1.3–2.4	3	3
B5	6–8	4–7	4–7
B6	1.7–2.2	2.5	2.5
B12	3 mcg	3–4 mcg	4 mcg
C	70–100	100–200	100–200
H	150–300 mcg	30–100 mcg	30–100 mcg
E	8–10	15–20	15–20
D	4–5 mcg	15–30 mcg	15–30 мкг
PP	15	16–19	16–19
Folic acid	300 mcg	400 mcg	400 mcg
Minerals, g			
Sodium	5	up to 3	up to 3
Calcium	0.6–2	up to 1.5	up to 1.5
Phosphorus		1.3–1.5	1.3–1.5
Magnesium	0.4	300–350 mkg	300–350 мг
Potassium	2.5	3–5	3–5
Iron	10–30 mcg	30–60 mcg	30–60 mcg
Zinc	0.005–0.02	15–20 mcg	15–20 mcg
Salt, g	up to 15	10-12	up to 8

During pregnancy, 25% more of protein is required than in the normal period, because it is the material for all the muscle tissues of the child's body. Fats and carbohydrates should be limited so as not to increase greatly the body weight of the mother and the foetus. Besides, pregnant women often badly perceive fatty foods, so it is recommended to eat lighter and more digestible fats. It is recommended to reduce carbohydrates except for the easily digestible ones. Since oedema is common during pregnancy, it is necessary to reduce significantly the consumption of water and salt. For vitamins, it is recommended to increase the amount of vitamins C, D, E, PP, and almost all of the B group. The microelements, such as calcium, iron, phosphorus, zinc, are especially important, that is why their consumption should be increased. Also, it is necessary to reduce the consumption of vitamins B5 and H, as well as the minerals sodium and magnesium [10-12].

Compared with milk-based ice cream, sweet ices have lower calorific content. They do not contain as many proteins and fats as other types of sweets do. They perfectly refresh and enrich the body with vitamins from fruits. Besides being palatable, sweet

ices allow you to relax, improve your mood, and relieve insomnia. Sweet ice is sometimes compared with an antidepressant, but it is almost harmless to pregnant women compared to drugs; it calms the nervous system, which is so unstable during this period of a woman's life.

Proper nutrition of a pregnant woman is a prerequisite for ensuring the health of the unborn child, the stability of his body against the infections effects, the ability to learn during all ages and other adverse factors. Regular inclusion to the diet of food enriched with essential macro-and microelements creates conditions for the normal course of pregnancy and the birth of a healthy and strong baby [13,14]. During pregnancy, it is necessary to monitor the daily intakes of easily digestible carbohydrates and at the same time provide a varied set of foods and dishes. Due to the body's increased energy consumption, sweet products for pregnant women are in high demand [4]. If there is a lot of sugar in the product, it can provoke a significant increase in weight [1]. Excessive fat in the stomach and thighs worsens the state of the expectant mother. That is why pregnant women cannot eat a lot of sweets. So, providing pregnant women with more low calorific sweet products is a topical issue. One of the sweet products' types is fruit sweet ice. Today in shops, you can find quite a large assortment of fruit ices. But the problem is that this ice cream is made of water, sugar, stabilizers, food acids, aromatic and colouring agents and is not beneficial for the human body, but, on the contrary, is harmful for health.

The literature analysis and the range of existing sweet products have shown that the problems still unsolved are: lack of special food products (for different social groups), imbalance of their nutrient composition, presence of artificial substances in recipes, excessive sweetness characterized by a high sugar/acid index.

So, **the purpose** of this article is to develop recipe compositions and technology of sweet ice for pregnant women based on natural raw materials. To achieve this goal, it is necessary to solve the following **tasks**:

– to analyse the daily nutritional needs of an average and a pregnant woman; to determine the minor components (vitamins and minerals), the content of which must be increased in the diet;

– to select raw materials for the recipes of sweet ices, taking into account the daily nutritional needs of a pregnant woman;

– to analyse the chemical composition of the developed sweet ices (namely the main macronutrients and calorific content)

– to carry out chromatographic analysis of the fatty acid composition of the sweet ice sample with the largest mass fraction of fat;

– to calculate the sugar/acid index of the sweet ices and compare it with the samples of products industrially manufactured nowadays;

– to develop recommendations on the manufacturing features and the shelf life of sweet ices for pregnant women; to give the sensory assessment of the sweet ices developed.

Research materials and methods

To determine the fatty acid composition of the sweet ice *Joy*, chromatographic studies were carried out on the basis of the Odesastandartmetrology laboratory. Chromatographic tests, processing of the results, and bringing the fatty acids content into accordance compliancewith the requirements, were carried out according to State Standard of Ukraine ISO 5508-2001 "Animal and vegetable fats and oils. Gas chromatography analysis of fatty acid methyl esters" and State Standard 30623-98 "Vegetable oils and margarine products. The method of detecting counterfeit products."

Sensory assessment of the samples was carried out according to State Standard 8756.1-79 "Concentrated food products. Methods for determining the sensory indicators, net weight, or volume, and mass fractions of the components" Sensory assessment of the sweet ices quality was carried out by a closed procedure (by agreement with the panel members). The assessment results were filled in the tasting sheet by each panel member, and then, the general tasting sheet was filled in. The ice cream quality (including that of sweet ices) was evaluated on a 10-point scale: taste and aroma – 6 points; structure and consistency – 3 points; colour – 1 point.

Results of the research and their discussion

While selecting the raw materials for the sweet ices, we stuck to the following requirements:

1. The components must be exclusively natural, without any artificial substances in the product;

2. The product must have a low calorific content, but an increased nutritional value and, accordingly, contain components that provide a disease-preventive effect;

3. The recipe should not include sugar;

4. The product components must form a good combination;

5. It is advisable to add cereals, various types of seeds, nuts (for example, flax seeds, sesame, almonds, oatmeal) as a source of additional biologically active substances (besides the fruit and vegetable components);

6. It is necessary to add to the recipe the raw materials that will eliminate the physiological complications during pregnancy (low immunity, toxicosis).

The recipes were selected by linear programming with the MS Excel editor for various objective functions. The suggested recipe compositions of sweet ices for pregnant women are given in Table 2.

The chemical compositions of sweet ices are given in Table 3 [15]. In the presented range of sweet ices for pregnant women, the smallest calorific content is that of the sweet ice "Vitamins." This is due to the fact that its formulation includes raw materials with low carbohydrate content. This sweet ice provides 1% of the calories that pregnant women require daily. The highest calorific content is that of "Cranberries" due to the honey in the recipe. The content of macronutrients in sweet ices is

insignificant. Thus, the greatest amount of proteins is in "Smile" due to the presence of oat flakes in the recipe. This product provides 2.7% of the calories that pregnant women require daily. The highest carbohydrates content is in "Cranberries" because of the honey content. The total carbohydrates in this sweet ice by 8% meets pregnant women's daily requirements of carbohydrates.

Table 2 – The recipe compositions of sweet ices for pregnant women

"Smile"	
Raw material	Formulation quantity, g
Carrot	44.0
Black currant	13.2
Oat-flakes	17.6
Mint	0.5
Honey	4.4
Total	80

"Dream"	
Raw material	Formulation quantity, g
Pumpkin	30
Apple	17
Kiwi	24
Ginger root	0.5
Honey	8.8
Total	80

"Sweet midnight"	
Raw material	Formulation quantity, g
Pumpkin	30
Banana purée	30
Prunes	11.2
Mint	0.5
Flax seeds	0.5
Orange juice	7.5
Total	80

"Freshness"	
Raw material	Formulation quantity, g
Apple	60.4
Kiwi	14.0
Lettuce	0.5
Mint	0.5
Honey	4.65
Total	80

"Joy"	
Raw material	Formulation quantity, g
Black currants	19
Apple	19
Carrot	30
Almond	7.6
Honey	3.8
Total	80

"Vitamins"	
Raw material	Formulation quantity, g
Black currants	13.2
Pumpkin	44.0
Peach purée	13.2
Mint	0.5
Orange juice	9.0
Total	80

"Cranberries"	
Raw material	Formulation quantity, g
Cranberries	35
Ginger root	0.5
Mint	0.5
Oat-flakes	16.2
Orange juice	8.3
Honey	20.1
Total	80

"Ice mix"	
Raw material	Formulation quantity, g
Black currants	8.5
Banana purée	53.5
Spinach purée	2.0
Sesame	0.5
Honey	9.0
Orange juice	6.0
Total	80

Table 3 – The chemical compositions of 80 g portions of sweet ices for pregnant women

No	**Name of the product**	**Water, g**	**Protein, g**	**Fat, g**	**Carbohydrates, g**		**Dietary fibre, g**	**Ash, g**	**Calorific content kcal**
					Total	**Mono- and disaccharides**			
1	"Freshness"	66.0	0.4	0.01	11.0	6.4	1.7	0.2	51.7
2	"Vitamins"	71.7	0.6	0.1	5.1	3.6	1.5	0.5	26.2
3	"Dream"	64.7	0.7	0.1	15	4.8	3.1	0.4	56.4
4	"Sweet midnight"	53.4	1.2	0.6	14.2	13.2	2.5	0.7	69.6
5	"Ice mix"	53.6	1.2	0.8	19.8	11.4	1.3	0.7	93.2
6	"Joy"	60.3	2.2	4.7	10.1	5.0	2.7	0.8	90.0
7	"Cranberries"	44.8	2.5	1.1	28.7	2.5	2.3	0.5	137.7
8	"Smile"	53.6	3.0	1.2	18.1	3.9	2.8	0.5	97.2

The highest fat content is in "Cranberries" and "Smile." They, respectively, by 1.5% and 1.6% meet pregnant women's daily requirement for fat. Omega-3 fatty acids play a special role in nutrition during pregnancy. They increase the mental development of the child. Besides, omega-3 fatty acids are necessary for

premature birth prevention and the miscarriage of the foetus, and they reduce the risk of late toxicosis developing, pregnant women's depression, prevent the development of blood clots and heart rhythm disorders. That is why, a high content of these substances in a pregnant woman's diet is vital for the proper formation and development of the foetus [11,13]. The source of fatty acids in sweet ices for pregnant women "Joy" is almond nuts. A chromatogram of the fatty acid composition of this product has been made. The chromatographic results are given in Table 4. According to the experimental results, "Joy" in its quantitative composition of fatty acids meets the requirements of State Standard 30623-98.

Table 4 – Fatty acid composition of the sweet ice "Joy"

	Parameter, units	Value of the parameter		Regulatory documents and research methods
		The standard	The measured value	
I	Fatty acid composition, %	№ 2003.1	№ 2003.1	
1	Myristic acid (C_{14})	≤ 1.5	< 0.2*	DSTU ISO 5508-2001
2	Palmitic acid (C_{16})	3.0 – 9.8	6.8	DSTU ISO 5508-2001
3	Stearic acid (C_{18})	2.1 – 4.0	2.1	DSTU ISO 5508-2001
4	Oleic acid ($C_{18:1}$)	43.8 – 84.0	70.5	DSTU ISO 5508-2001
5	Linoleic acid ($C_{18:2}$)	13.4 – 44.3	19.1	DSTU ISO 5508-2001

* less than the definition limit

Due to the different recipe compositions of the sweet ices, their different varieties represent different sources of certain micronutrients. The sweet ice "Smile" contains carrots in its recipe composition, which is a source of beta carotene. This range of ices by 88 % meets pregnant women's daily requirements of carotene. The greatest vitamin C amount is in the fruit ice "Dream" because there are apples and kiwi in its recipe. This ice by 29% satisfies pregnant women's daily need for this vitamin. The sweet ice "Sweet midnight" contains potassium due to banana purée and pumpkin in its recipe. This type of product meets 7% of daily requirements of potassium. The ice "Freshness" contains iron because of the content of apples and supplies 4% of the amount of this mineral that pregnant women require daily. The product' harmonious taste depends on the mass fraction of organic acids [16]. For the quantitative assessment of the taste, the sugar/acid index is used; it is expressed as a dimensionless quantity and represents the quotient of the sugar mass fraction divided by the acid mass fraction. The sugar/acid index of sweet ices for pregnant women and that of a sample from the shop have been calculated (Table 5). New ices have a slightly acidic taste or no acidity at all, and the sample from the shop contains a lot of sugars, as evidenced by the cloying taste and a high sugar/acid index.

Table 5 –The sugar/acid indices of sweet ices for pregnant women and of the sample from the shop

Name of the product	The sugar/acid index	The acidic taste
«Cranberries»	15.2	Slightly acidic
«Dream»	13.4	Slightly acidic
«Ice mix»	25.7	No acidity felt
«Freshness»	16.7	Slightly acidic
«Joy»	26.3	No acidity felt
«Vitamins»	17.0	Slightly acidic
«Sweet midnight»	18.8	Slightly acidic
«Smile»	26.1	No acidity felt
The sample*	more than 30	Extremely sweet

*"The Sample" means sweet ices that were bought in a retail shop (for ethical reasons, the sweet ices manufacturing firm is not mentioned).

It is possible to introduce the sweet ices manufacture technology on the existing equipment of cannery plants, as well as in restaurants. The project of a pregnant women-oriented sweet ice manufacturing department is based on the equipment of a canning department and contains four technological lines: for processing carrots, pumpkins, apples, and berries. To manufacture sweet ices, standard technological schemes are used, which are as low-waste as possible and ensure a continuous technological process. To process raw materials, lines, with the maximum level of mechanization, are to be assembled from the existing equipment and installed. Preference is given to continuous operations, because during this cycle, the line capacity increases, the machines do not have to be stopped, the process is healthier, and the production loss is minimum. Raw materials are processed on each line in view of the latest achievements in the preservation of biologically active components of raw materials. In the recipe of some sweet ices, there is honey to improve the organoleptic perception. Honey is added at the last technological stage to avoid mixture heating. The products moulding (pouring into the moulds and inserting wooden sticks) takes place in the Hassia machine. One of the main operations is freezing, it is performed in the GyroFreze machine. It has a number of advantages, among them: ease of exploitation, maximum hygiene, intensive cooling, and minor shrinkage [17]. In restaurants, sweet ices are manufactured on the equipment already in use in hot and cold departments. It is necessary to store sweet ices at the temperature (-20 ± 2)°C for not more than 12 months.

A comprehensive sensory assessment has been performed by a group of 9 people. All samples of the developed products have received high marks. Out of

the maximum ten points, the developed products have received the following ratings: "Cranberries" – 9.7; "Freshness" – 9.6; "Sweet midnight" and "Joy" have the same score – 9.5, all other sweet ices – 9.4. The manufactured sweet ices for pregnant women are shown in Fig. 1.

Fig. 1. The sweet ices for pregnant women

Conclusion

The daily consumption norms of an average woman and a pregnant woman have been analysed. A list of nutrients that need to be increased and of those that need to be reduced in the diet during pregnancy has been made. It has been emphasized that besides changing the nutrient composition, a pregnant woman's diet should be varied. Sweet products are of particular interest, as in the diet, it is necessary to reduce the content of easy digestible carbohydrates while ensuring diet variety. In the light of the above requirements, eight recipe compositions of sweet ices based on vegetable raw materials have been suggested. The developed products have different compositions, and are made without adding sugar; however, taking into account the good organoleptic perception, some recipes do include honey in small quantities. The scientific novelty of the work consists in clarifying, correcting the existing data, and spreading the results already known on a new class of objects and systems. So, the recipe of sweet ices for pregnant women has been created by the linear programming method using the MS Excel editor; the products have a low calorific content (26–137 kcal per 80 g), increased nutritional value (due to vitamin C, carotene, etc.); the sugar/acid index is regulated by varying the composition of the raw materials. For the first time, cereals, various types of seeds, nuts (for example, flax seeds, sesame, almonds, etc.) have been included into the sweet ice recipes; kiwi, mint, ginger root have also been added to the product recipes as they eliminate the physiological complications during pregnancy. It is possible to introduce the sweet ice production technology on the equipment already in use at canneries and in restaurant industry.

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