Iodine and iron fortified muffin technology

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Abstract. Flour confectionery is considered as one of the most popular food products. They can’t be included in the food ration of people leading a healthy lifestyle due to their chemical structure and nutritional value. The recent trend is to expand a range of flour confectionery products by imparting functional properties to them. The development of muffins with a reduced sugar and fat content is relevant taking into account the worldwide increase in the level of nutritional diseases (cardiovascular and oncological diseases, obesity, anemia, etc.). Improving the technology of confectionery products by introducing persimmon and feijoa into the formulation of processed products will make it possible to deal scientifically with the issue of the lack of confectionery products with the increased nutritional value and reduced calorie content. So it can improve their assortment and ensure widespread consumption in everyday life. The paper presents the research results concerning the development of technology for muffins enriched with iodine and iron. The paper also states the substantiation of the reduction in the prescription amount of sugar and substitution of margarine with a smaller amount of sunflower oil, as well as the introduction of persimmon puree and pieces of feijoa fruit into the recipe. The presented muffin is characterized by a high content of iodine, iron, calcium, magnesium, potassium and dietary fiber, as well as reduced by a third the content of added sugar and fat.

1. Introduction
A balanced diet is well-known to be a basis of human health [1-7]. Failure to comply with the recommended food ration leads to some diseases called alimentary (food) [8-14]. They include such deseases as diabetes mellitus, diseases of the cardiovascular system, obesity, hypertension, atherosclerosis, neoplasms. Largely, the development of these diseases is facilitated by disruption of the endocrine system.

The thyroid gland is one of the most important components of the endocrine system. It is responsible for the metabolism and production of hormones that affect all systems of the human body, as well as it is involved in the regulation of growth, mental and physical development. A malfunction of the thyroid gland can be caused by a constant stress state, an unfavorable environmental situation, problems of the gastrointestinal tract, a lack of vitamins and minerals in nutrition. Diabetes and pregnancy are also included into risk factors.

Iodine and amino acid tyrosine are necessary for the synthesis of thyroid hormones, i.e., triiodothyronine (T3) and tetraiodothyronine (thyroxine T4). A lack of iodine disrupts the synthesis of these hormones; they in turn affect the state of the body as a whole.

The problem of iodine deficiency is extremely urgent. About 50-60% of Europeans and about 35% of the world's population as a whole have a constant lack of iodine [15, 16]. According to the World
Health Organization, diseases associated with iodine deficiency are one of the most important modern problems.

The greatest danger of iodine deficiency is in pregnancy period and in childhood. It increases a risk of complications of pregnancy and childbirth. It increases the incidence of miscarriages and stillbirths, contributes to congenital abnormalities and high infant mortality. One of the most significant consequences of iodine deficiency at an early age is disorders of the development of the central nervous system, and in severe iodine deficiency, cretinism. Changes caused at the stage of intrauterine development and at an early age are already irreversible and in the future are practically not amenable to treatment.

Thus, it is extremely important to prevent a state of iodine deficiency even in pregnancy period [17]. The need for iodine of pregnant women increases by 20% and it amounts to 180 mg per day [18].

The situation of natural iodine deficiency is complicated by an increase in the relative deficit associated with a low level of consumption of iodine-containing products (fish and seafood, meat products), especially among the population with low incomes. The most typical field of the iodine deficiency diseases prevention is the fortification of food products, mainly for mass consumption [19].

Iron is a vital trace element. Three quarters of iron is a part of the hemoglobin of the blood. During pregnancy, the need for iron more than doubles, is 38 mg per day [18] and it is especially necessary in the second and third trimesters, when an increase in blood mass occurs. Factors contributing to the development of iron deficiency anemia include malnutrition, multiple, early or age-related pregnancies, and some chronic diseases. Deficiencies of vitamin B12, folic acid and protein also contribute to the development of anemia in pregnancy period [20].

Iron deficiency anemia is one of the most typical complications during pregnancy. According to the WHO, the frequency of iron deficiency anemia can reach from 21 to 80% of cases. Iron deficiency of pregnant women increases the risk of complications at childbirth. If iron deficiency is severe in a pregnant woman, the fetus may also be deficient. The prevention of diseases associated with iron deficiency includes the adherence to a rational balanced diet.

The development of the technology of flour confectionery products with a high content of nutrients necessary for pregnant women and a low sugar content will not only expand the range of specialized nutrition products, but it also diversify the assortment. All these will solve the problem of the lack of flour confectionery products for pregnant women scientifically [21-24].

Flour confectionery is one of the preferred snacks, including for pregnant women. The excessive consumption of simple carbohydrates is a frequent violation of the rational diet of a modern person. It can lead to metabolic disorders, obesity, diabetes, and diseases of the cardiovascular system. In this regard, the tendency to reduce the added sugar in the formulations of food products, including confectionery products, is gaining more and more popularity [23-31].

Gestational diabetes mellitus (diabetes of pregnant women) occurs in about 7% of pregnant women. It significantly increases a risk of complications during pregnancy, both for the woman and the fetus, as well as the risk of perinatal mortality.

The aim of the research was to develop cupcakes with increased nutritional value and reduced sugar and fat content for the nutrition of pregnant women.

2. Materials and methods
The objects of research were samples of cupcakes with persimmon and feijoa fruits, intended for inclusion in the food ration of pregnant women, as well as persons who follow to a healthy lifestyle.

The sample preparation of cupcakes was carried out in the laboratory conditions of the department "Technologies of grain processing, bakery, pasta and confectionery industries" of the Federal State Budgetary Educational Institution of Higher Education Moscow State University of Technology and Management named after K.G. Razumovsky (PKU).

The composition of the sample recipe included such raw materials as wheat flour of the highest grade (GOST 26574), sugar (GOST 33222), sunflower oil (GOST 1129), margarine (GOST 32188), melange (GOST 30363), fresh feijoa (GOST 34217), persimmon fresh (GOST R 51074), powdered milk (GOST
33629), sodium bicarbonate (GOST 2156), food salt (GOST R 51574). The requirements for raw materials and the content of harmful substances and impurities are standardized for all types of raw materials in accordance with the relevant standards and sanitary and epidemiological rules, and the regulations "Hygienic requirements for the safety and nutritional value of food products. SanPiN 2.3.2.1078-01”.

A control sample was a cupcake "Yantarny". It did not contain additional prescription components, prepared as follows. Initially, whip melange for 5-7 minutes, then add sugar and continue whipping for 4-5 minutes more, then add margarine to the resulting mixture, continue whipping for 2-3 minutes more. After that add baking salt, drinking soda, milk powder, whip till homogeneous soft paste within 2-3 minutes. Then add wheat flour and the knead dough for 1-2 minutes. The dough is formed into metal molds, treated with a special coating, or lined with paper or paper capsules. Cupcakes are baked at the temperature of 180-200°C for 25-50 minutes, depending on the weight. After baking, the cupcakes are chilled in the mold for about 2-3 hours. Then they are removed from the molds and packaged. The quality of the ready products was assessed by organoleptic and physicochemical indicators in accordance with generally accepted methods.

3. Results and discussion

The analysis of the scientific information showed the possibility of using persimmon and feijoa fruit processing products in the technology of cupcakes. Feijoa and persimmon are the leaders in iodine content among fruits and berries. Their use will expand the range of confectionery products fortified with iodine, including products intended for feeding pregnant women.

Persimmon fruits are distinguished by a high content of iodine, iron, manganese, potassium, vitamins of group B and E. Persimmon from fruit crops is the second only to feijoa in the accumulation of iodine. Persimmon is characterized by high antioxidant activity compared to other fruits. Persimmon helps to strengthen the heart muscle, it improves the functioning of the cardiovascular and nervous system, increases immunity, normalizes metabolic processes. It is a good prevention of iodine deficiency and iron deficiency anemia.

The iodine content in feijoa is close to seafood. Also, feijoa fruits are rich in pectin, B and C vitamins, including folic acid, potassium, phosphorus, iron and manganese. Feijoa fruits have a mild allergenicity. They are characterized by high antioxidant activity; it helps to strengthen the immune system, prevent the development of anemia and strengthen the nervous system.

Taking into account the information on such a frequent side effect of thyroid diseases as obesity, which limits the possibility of consuming confectionery, the high risk of developing diabetes mellitus during pregnancy, as well as the general trend in the development of confectionery products with low sugar content and calorie content, characterized by increased nutritional value, on the first At this stage, studies were carried out on the possibility of reducing the sugar content in the recipe.

For this, the sugar content according to the recipe was reduced by 20, 35 and 50% (test samples 1-3, respectively) in the recipe of the control sample of the cupcake "Yantarny". The results are shown in table 1.

**Table 1.** Effect of reducing the sugar content in the recipe on the quality indicators of cupcakes

| Indicator name | Control sample | Experimental sample 1 | Experimental sample 2 | Experimental sample 3 |
|----------------|----------------|-----------------------|-----------------------|-----------------------|
| **Organoleptic quality indicators** | Correct, with small crannies typical for cupcakes | Correct, less convex top crust, with small crannies typical for cupcakes | Flat top crust, not typical for cupcakes | |
| **Surface colour** | Light brown | Light brown | Brown | |
| **Shape and surface** | | | | |
The research results presented in table 1 showed that with a decrease in the amount of sugar in the recipe, the volume of the finished product decreased. At the same time, experimental samples 1 and 2 differed slightly from the control sample and met the requirements of GOST 15052-2014. Experimental sample 3 was characterized by reduced organoleptic and physicochemical quality indicators that did not meet the requirements of GOST. Sample 2 with 35% reduced sugar content according to the recipe was selected for further research following the task (reducing the sugar content).

Then, the optimal fat reduction in the formulation was determined. For this, in the recipe of the control sample of the cake (prototype 2 according to previous research results with a decrease in sugar by 35%), the margarine was replaced with sunflower oil and its content according to the recipe was reduced by 20, 35 and 50% (experimental samples 4-6, respectively).

The results are presented in table 2.

Table 2. Effect of reducing the fat content in the recipe on the quality indicators of cupcakes.

| Indicator name                  | Control sample | Experimental sample 4 | Experimental sample 5 | Experimental sample 6 |
|---------------------------------|----------------|-----------------------|-----------------------|-----------------------|
|                                  |                |                       |                       |                       |
| Organooleptic quality indicators|                |                       |                       |                       |
| Shape and surface               | Correct, less convex top crust, with small crannies typical for cupcakes | Flat top crust, not typical for cupcakes |                       |                       |
| Surface colour                  | Light brown   |                       |                       |                       |
| Taste and smell                 | Less sweet and pronounced, but typical for cupcakes |                       |                       |                       |
| Fracture appearance             | Soft, less cohesive and aerated, typical for cupcakes |                       |                       |                       |
| Wetness, %                      | 18.8          | 18.7                  | 18.5                  | 18.3                  |
| Density, g/cm³                  | 0.57          | 0.57                  | 0.58                  | 0.62                  |
| Height to diameter ratio, H/D    | 1.41          | 1.41                  | 1.39                  | 1.2                   |

The analysis of the information presented in table 2 showed that with a decrease in the amount of vegetable oil in the formulation, the volume of the finished product decreased, the crumb became denser and less aerated. At the same time, experimental samples 4 and 5 differed slightly from the control sample. Experimental sample 6 was characterized by reduced organoleptic and physicochemical quality indicators. Sample 5 with 35% reduced vegetable oil content according to the recipe was selected for further research following the task of reducing the fat content in the product.

Cupcakes and muffins belong to the group of flour confectionery products and have a similar appearance, but different historical origins and some distinctive features from each other. Muffin, in contrast to cupcake, is characterized by a denser texture, less volume, and contains less sugar. Vegetable
oil is more often used as a fatty product. Muffin is characterized by higher wetness content compared to muffin. Therefore, in the future, in relation to the product being developed, a term "muffin" was applied.

For the optimal dosage of additional raw materials determination, a method of selection of the percentage of introduced ingredients was also applied. As a source of iodine, mashed persimmon and pieces of feijoa fruit were added to the muffin recipe.

Persimmon puree of 30, 45 and 60% were added to the mass of flour into the experimental samples (samples 7-9, respectively). Feijoa pieces were added to all test samples as filler in an amount of 50% by weight of flour. The dosages were determined on the basis of preliminary calculations to cover the needs of pregnant women with iodine. The experimental samples were characterized by a regular shape with a slightly convex outer crust, a more yellow crumb color (with an increase in the dosage of persimmon puree, the color became more saturated). The taste and smell of persimmon and feijoa appeared. The structure of the crumb is soft, cohesive aerated, porous, without voids and seals, however, with an increase in the dosage of persimmon puree, it became slightly denser and less aerated. With a large dosage of persimmon puree (sample 9), the organoleptic quality of the product did not meet the requirements of regulatory documents, since it had a flat outer crust, an overly dense structure and a moist crumb.

According to the results of laboratory baking tests, the best experimental sample was sample 8. It was characterized by optimal organoleptic and physicochemical quality indicators.

Thus, a recipe for the "Winter Vitamin" muffins, enriched with iodine and iron, was developed on the basis of the conducted research.

Figure 1. Appearance of muffins "Winter Vitamin".

The nutritional value of the proposed product was determined by calculation in comparison with a control sample (a cupcake Yantarny).

A the satisfaction degree of pregnant women’ daily need is given in %:
• in proteins (control sample 8.11, experimental sample 8.4),
• in fats (control sample 31.3, experimental sample 22.7),
• in carbohydrates (control sample 18.5, experimental sample 17.6),
• in dietary fiber (control sample 0.1, test sample 3.0).

The satisfaction degree of the daily food ration for pregnant women for certain minerals and vitamins is in%:
• in iodine (control sample 0.1, experimental sample 29.0),
• in magnesium (control sample 3.2, test sample 4.1),
• in potassium (control sample 5.7, experimental sample 7.8),
• in iron (control sample 3.1, prototype 32.3),
in vitamin B1 (control sample 4.4, experimental sample 11.6),
• in vitamin B2 (control sample 11.6, experimental sample 23.2).

According to the results of the nutritional value calculation, the proposed muffin, in comparison with the control sample, was characterized by an increased degree of satisfaction of the daily food ration for a pregnant woman for protein (by 0.3%), dietary fiber (by 2.9%), calcium (by 0.3%), magnesium (by 0.9%), and potassium by 1.3%. in vitamin B1 (by 7.2%) and B2 (by 11.6%). Consumption of 100 g of "Winter Vitamin" muffin covers the need for a pregnant woman for iodine (by 29%) and iron for (by 32.3%). At the same time, the content of the added sugar and fat was reduced by one third, and the energy value of the developed product was 88 kcal lower compared to the control sample.

4. Conclusions
It can be concluded that according to the presented results cupcakes with persimmon puree and feijoa pieces is characterized by an increased content of minerals and vitamins, including iodine and iron, and a reduced sugar and fat content. So, the proposed cupcake can be recommended for the food ration of pregnant women and persons at risk of developing iodine deficiency diseases, iron deficiency anemia, as well as for expanding the range of flour confectionery.

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