Enrichment of choux pastry semi-finished products by local plant raw material

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Abstract. Bakery products are widespread among Russian population. With their enrichment with natural ingredients used in balanced diets new healthy food products can be obtained. The paper presents the results of development of choux pastry semi-finished products with craquelin dough, which are enriched by infrared-dried spinach powder. Infrared drying of spinach allows preserving its beneficial features and using obtained powder as an enriching ingredient. The technological process of bakery products preparing is developed and the flowchart of the process is presented. The control and experimental samples were evaluated on sensory and physico-chemical (dry matters and ash content) characteristics. It is established that increasing of infrared-dried spinach powder makes the samples’ color more intensive, the dry matters content increases by 1.8…7.5%, and the ash content increases by 0.84…1.53%. Therefore, the spinach powder in amount of 7.0% and 2.5% from flour weight in choux pastry dough and craquelin dough accordingly is advisable. The developed choux pastry semi-finished products are recommended for practical implementation and further research in this direction.

1. Introduction

According to the information from Institute of Nutrition of Russian Academy of Sciences, one of the most common problems of Russian population nutrition is insufficient consuming of vitamins and minerals. This problem leads to health deterioration among adults and children [1]. It is determined that poor nutrition plays important role in growth of such diseases, as cardiovascular, oncology and type 2 diabetes. For reducing the risk of occurrence and progression of these diseases it is necessary to improve diets by their supplementation with enriched and functional food products [2, 3]. The suitable food products for enrichment can be bakery products, including choux pastry products.

Bakery products are presented on Russian consumer market in a wide range. Their popularity is stable because of their high consumer properties. The expansion of bakery products range by their enrichment with vitamins, minerals and dietary fibers can be carried out by using natural plant ingredients [3–6].

Among traditional plant raw materials for enriching bakery products, the non-traditional raw materials can be used too. Besides enrichment of food products with necessary supplements, they can also improve their sensory characteristics. One of the most suitable plant raw materials for bakery
products enrichment can be garden spinach. For now, spinach is not specific for Russian consumers, but its beneficial features allow one to use it in formulations of different food products, including bakery products.

The purpose of the research is the development of formulations and technology process of choux pastry semi-finished products with craquelin dough enriched by infrared-dried spinach powder.

2. The formulation of the problem

Garden spinach (Spinacea oleracea L.) is widely known cultivated leafy plant vegetable. It is regarded as a rich source of vitamins, minerals, flavonoids, antioxidants, proteins and β-carotene. The vegetable is commonly used in diets for people with nerve system diseases, diabetes, gastritis, urinary, renal and gallstone diseases. Thus, its use as a bakery product supplement can be promising, because it can enrich bakery products with above mentioned nutrients and improve their sensory characteristics [7, 8].

It is known that 100 g of leafy (digestible) part of spinach contain 2.9 g of protein, 0.3 g of fats and 2.0 g of carbohydrates. The total calorie of spinach is 23 kCal, which allows one to consider it as low-calorie product [7]. Besides, 100 g of raw spinach contain vitamins, macro- and microelements, which exceed 15.0% from daily norm for adults according to “The norms of physiological requirements in energy and nutrients for different population groups in Russian Federation” (2009). Therefore, it may be considered as a functional ingredient. The content in 100 g of β-carotene is 4.5 g (90.0% from daily norm), vitamin B9 (folates) – 80 mcg (20.0% from daily norm), magnesium – 82 mg (20.5% from daily norm), potassium – 774 mg (31.0% from daily norm), manganese – 897 mcg (44.9% from daily norm). Some substances in spinach exceed daily norm: vitamin E (tocopherol equivalent) – 55 mg (2.2 times), vitamin K – 482.9 mcg (4 times), calcium – 106 mg (1.1 times), iron – 13.51 g (1.4 times) [7, 8]. Most of these substances are preserved after heat treatment and can be used with spinach without major losses. However, 100 g of spinach hold a large amount, so it is advisable to introduce it into the bakery dough in concentrated (dried and powdered) state. It is also known that spinach contains fat-soluble substances, so its use in choux pastry products is advisable too, because these products contain enough fat components [9].

Drying is a complex heat and mass transfer process. It is the one of well-known preservation methods, which allows to save production obtained from animal and plant raw material. The advantages of drying are the possibility of long-term shelf-life and transportation of production without cooling, small weight of dried products (3…5 times smaller than in raw material) and accessible package material for dried products. After drying, water-soluble substances in the products become more concentrated and the osmotic pressure increases. This makes impossible the nutrition of microorganisms contained in the product. Their cells lose the possibility of normal using of nutritional substances, so they are not further evolved [9].

The infrared drying is based on the properties of heat (infrared) rays to penetrate deep into the product and affect selectively on water molecules. This kind of drying allows one to obtain dried product, which keeps all biologically valuable substances contained in fresh vegetables. The infrared-dried products almost completely retain the color of raw material and have got strongly marked taste and sense [10, 11]. In the İnönü University (Malatya, Turkey), there were carried out the researches of spinach leaves infrared drying. The obtained results showed that drying speed directly depends on the increase in power of infrared heat lamps (the power outputs of lamps varied from 300 to 500 W) and back on quantity of spinach leaves (from 15 to 60 g). Depending on varying of these indices, the drying time reduced from 3.5 to 16.5 min, which is less than time of hot air drying (1.5 h and more) [12].

Therefore, infrared-dried spinach powder can enrich wide range of bakery products, including choux pastry products, with additional nutrients. The peculiarity of choux pastry products is that they have large cavities inside. Since the water vapor inside the heated dough cannot go outside during baking process, the cavities inside are formed [13]. The structure of choux pastry semi-finished products is used for filling them with various stuffing and thus the new food products’ formulations can be developed.

Besides that, for the improving of choux pastry products appearance the craquelin dough can be used. The craquelin dough is a kind of shortbread dough used mainly for decoration of bakery products. After
baking process, it’s got cracked-like structure, which improves bakery products appearance. For improving its sensory characteristics, the craquelin dough can be also enriched with spinach powder.

Food products enriched with infrared-dried spinach powder have natural green color without using chemical food colors. This property can also be helpful for healthy food products formulations and technologies.

3. Materials and methods

3.1. The organization of the experiment

The experimental research was carried out at the Technology and Organization of Food Industries Department of Novosibirsk State Technical University. There were developed formulations and technologies of choux pastry semi-finished products with craquelin dough, which were enriched with infrared-dried spinach powder. The high-grade wheat flour used in formulations was replaced with 2.5%, 5.0% and 7.0% of spinach powder from its weight both in choux pastry dough and craquelin dough. After preliminary experiments, the spinach powder was used in craquelin dough formulation in amount of 2.5%.

The high-grade flour was obtained on “Avangard Flour Mill Plant” in Novosibirsk, Russian Federation. The other raw materials (sugar, salt, butter, eggs, spinach) were purchased from local retail network in Novosibirsk.

For obtaining of infrared-dried spinach powder, the primary processed spinach was cut into pieces and dried in the electrical infrared compact dryer (Russian patent № 2265169) at 50…60 °C during 2.5…3 h in pulse mode. After that, the dried spinach leaves were cooled at 20…25 °C and mechanically grinded into fine powder.

The flowchart showing the preparing process of choux pastry semi-finished product with craquelin dough with using of infrared-dried spinach powder is presented in figure 1.

The choux pastry dough preparing process consisted of following technological operations. In the cookware the softened butter, milk, water, salt and sugar were mixed. Then the mixture was heated to boiling temperature of 100 °C. After that, the high-grade wheat flour was added gradually into the mixture. The dough was brewed until thickening and transforming into plastic mass.

Further the dough was cooled during 3…4 min and placed into the bowl of the TAUR022-2V spiral dough kneader. At the middle mixing speed, the egg mass and spinach powder were added.

The choux pastry dough was dropped from pastry bag onto the baking tray, the craquelin dough was placed on the top of the formed choux pastry dough pieces. After that, the pieces were frozen in the Indesit SFR 167 NF freezer at –15…–18 °C. The frozen dough pieces were placed into the Electrolux A0S061EAA1 combi oven (Sweden) at 160…180 °C and were prepared during 20…25 min at the convection mode.

Thus, the following control and experimental samples of choux pastry semi-finished products were obtained:

- choux pastry semi-finished product with craquelin – control sample;
- choux pastry semi-finished product with craquelin and infrared-dried spinach powder (2.5% from flour weight) – experimental sample № 1;
- choux pastry semi-finished product with craquelin and infrared-dried spinach powder (5.0% from flour weight) – experimental sample № 2;
- choux pastry semi-finished product with craquelin and infrared-dried spinach powder (7.0% from flour weight) – experimental sample № 3.

The semi-finished products were cooled to 20…25 °C and evaluated on their sensory and physico-chemical characteristics (dry matters and ash content).
Figure 1. Preparing of choux pastry semi-finished product with craquelin dough enriched by infrared-dried spinach powder
3.2. Sensory evaluation
Sensory evaluation of obtained semi-finished product samples was carried out according to Russian national standard GOST 31986-2012 “Public catering service. Method of sensory evaluation of catering products” for the following characteristics:

• appearance;
• scent;
• taste;
• color;
• consistency.

Every sensory characteristic was evaluated on the 5-point scale (5 indicates the best and 1 implies the worst) by 4 semi-trained panelists. As a result of the evaluation, the average points for each characteristic were obtained. During evaluation it was considered that experimental samples had got green color.

3.3. Physico-chemical characteristics

Dry matters content. The dry matters content was evaluated according to GOST 21094-75 “Bread and bakery products. Method for the determination of moisture”. The drying of prepared and weighted samples to constant weight at (130±2) °C was carried out in the ShS-80-01 SPU drying cabinet (Russia). The samples before and after drying were compared by their weights and dry matters content \( D (\%) \) was determined using following equation:

\[
D = 100 \left(1 - \frac{m_1 - m_2}{m}\right),
\]

where \( m_1 \) (g) is weight of cup with sample before drying, \( m_2 \) (g) is weight of cup with sample after drying, \( m \) (g) is weight of sample before drying. In this study, \( m \) is 5 g.

Ash content. The ash content was evaluated according to GOST 27494-87 “Flour and bran. Methods for determination of ash content”. The sample weights were ignited in crucibles at the hotplate at 400…500 °C with following incinerating at the PM-10M 732 muffle furnace (Russia) at 350…400 °C during 1.5…2 days to constant weight. After incineration, the ash content \( A, \% \) was determined using following equation:

\[
A = m_1 \cdot \frac{100}{m_0} \cdot \frac{100}{100 - H},
\]

where \( m_0 \) (g) is weight of sample before incineration, \( m_1 \) (g) is weight of sample after incineration, \( H \) (\%) is humidity of sample before drying. In this study, \( m_1 \) is 5 g.

Humidity. The humidity of samples was obtained from their dry matters content according to equation (1) and using following equation:

\[
H = 100 - D.
\]

4. Results and discussion
The results of choux pastry semi-finished products sensory evaluation are presented in figure 2.

The spinach powder can be kept in choux pastry dough in amount of 5.0% and 7.0%, because these powder concentrations didn’t have negative effect on sensory characteristics of experimental samples № 2 and № 3. Therefore, in further researches the craquelin dough with 2.5% spinach powder content was used in the experimental samples.

The sensory evaluation also showed the specific spinach taste presence in all experimental samples. However, the taste is pleasant and doesn’t cause rejection.
The increasing of spinach powder concentration in semi-finished choux pastry products had influence on their color. The higher the concentration, the more intensive is the color, which is regular for food products enriched with spinach powder.

![Figure 2. Sensory evaluation of choux pastry semi-finished product with craquelin dough and infrared-dried spinach powder](image)

The results of dry matter content evaluation in control and experimental samples are presented in figure 3.

![Figure 3. Dry matters content evaluation of choux pastry semi-finished product with craquelin dough and infrared-dried spinach powder](image)

According to obtained results, with increasing of infrared-dried spinach powder amount the dry matter content also increases. In experimental sample № 1 the dry matters content is higher than in the control sample by 1.8%, in the experimental sample № 2 – by 2.4%, in the experimental sample № 3 – by 7.5%. This can be explained that spinach powder is a concentrated product and contains more dry matters than wheat flour.

The results of ash content evaluation in control and experimental samples are presented in figure 4.
According to obtained results, there is also increasing of ash content among with increasing of infrared-dried spinach powder amount in formulations. In experimental sample № 1 the ash content is higher than in control sample by 0.84%, in experimental sample № 2 – by 1.4%, in experimental sample № 3 – by 1.53%.

Thus, there can be made the conclusion that experimental samples contain more minerals than control sample, so the enriched food product is obtained.

The sensory and physico-chemical evaluation of choux pastry semi-finished products samples allowed to determine their optimal formulation with amount of infrared-dried spinach powder of 7.0% from flour weight with craquelin with amount of infrared-dried spinach powder of 2.5% from flour weight. Introducing of spinach powder into choux pastry products formulations allowed them to obtain pleasant taste, sense and nice green color and did not have negative effect on products’ appearance and consistency.

5. Conclusion
The theoretical and experimental researches on enriching choux pastry semi-finished products with craquelin dough by infrared-dried spinach powder in amount of 7.0% and 2.5% from flour weight into choux pastry dough and craquelin dough accordingly is advisable. The enriched product has high sensory characteristics without any negative effects. The dry matter and ash content in the product are 37.32% and 1.59% accordingly, which is higher than in control sample by 7.5% and 1.53% accordingly. The further research is directed to evaluation of nutritional value and functional properties of semi-finished choux pastry products. If needed, the optimization of semi-finished product can be carried out. The obtained semi-finished products can be the base ingredients for formulations of bakery products with different stuffing, which may be produced and realized on public catering and retail enterprises.

References
[1] Baranovsky A Y 2008 Dietology (Saint-Petersburg: Piter)
[2] Kasabova E R and Samokhvalova O V 2013 The influence of food fibers additives on bread-making properties of wheat flour Scientific bulletins of the Belgorod State University. Series: Natural Sciences 24 (25) 111–6
[3] Alert A A and Alshevskaya M N 2017 Scientific substantiation of using vegetable masses of beetroot, carrot, parsley in bakery products technology KSTU News 45 125–35
[4] Kolomnikova Y P, Derkanosova A A, Manukovskaya M V and Litvinova E V 2015 Effect of non-traditional vegetable raw materials on the properties and biotechnological structure pastry Proceedings of VSUET 3 157–60
[5] Lobanov V G, Slepokurova Y I, Zharkova I M, Koleva T N, Roslyakov Y F and Krasteva A P 2018 Economic effect of innovative flour-based functional foods production Foods and Raw Materials 6 (2) 474–82

[6] Potapova A A and Perfilova O V 2014 Pastry, enriched with essential micronutrients vegetable raw Technologies for the food and processing industry of AIC – healthy food 4 50–4

[7] Limareva N S and Donchenko L V 2016 Functional beverages containing pectin based on spinach Sovremennaa nauka i innovacii 4 (16) 99–104

[8] Jiraungkoorskul W 2016 Review of neuro-nutrition used as anti-Alzheimer plant, spinach, Spinacia oleracea Pharmacognosy Review 10 (20) 105–8

[9] Xi Y, Xiaojuan L, McClements D J, Yong C and Hang X 2018 Enhancement of phytochemical bioaccessibility from plant-based foods using excipient emulsions: impact of lipid type on carotenoid solubilization from spinach Food & Function 9 (8) 4352–65

[10] Perfilova O V 2019 The using of microwave, infrared heating in technology of carrot powder from refuse Proceedings of VSUET 81 (1) 144–8

[11] Zavaliy A A and Rutenko V S 2015 Energy saving devices of agricultural production infrared drying Bulletin of Orenburg State Agrarian University 5 (55) 79–82

[12] Sarimiseli A and Yuceer M 2015 Investigation of infrared drying behavior of spinach leaves using ANN methodology and dried product quality Chemical and Process Engineering 36 (4) 425–36

[13] Bychkova E S, Sapozhnikov A N, Matseychik I V, Ashirova N N, Korpacheva S M and Svarovskaya E I 2017 Technology of bakery, bread and pastry production on public catering enterprises (Novosibirsk : Novosibirsk State Technical University)