Development of formulation and technology of pancakes with beetroot powder of infrared drying

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Abstract. Development of new formulations of bakery products with the use of vegetable ingredients is a promising direction for agriculture and food processing industry contributing their sustainable development. Thus, the development of new formulations and production technology of bakery products on the example of pancakes with addition of infrared-dried beetroot powder is of interest. The use of beetroot powder allowed to improve nutritional value of the product by increasing its vitamins and mineral substances content, especially with potassium, iron and vitamin C. At the same time, sensory characteristics of pancakes with beetroot powder remained at the same level or increased. Quality of pancakes also increased because of preliminary treatment of wheat flour with infrared radiation. Based on an analysis of sensory characteristics and nutritional value of products, the optimal amount of beet powder is 6% from wheat flour weight. The results obtained can be used in food processing and public catering enterprises.

1 Introduction

Bakery products are widespread in many countries of the world. Their advantages are high availability, low cost of incoming ingredients and simple production technology. They are also highly attractive to consumers. At the same time, traditional bakery products have high energy value and low content of vitamins, mineral substances and dietary fibers. So, their regular consumption can lead to various health problems. The improvement of nutritional value of bakery products can be reached by using vegetable ingredients in their formulations [1]. Besides, the introduction of vegetables into production process of bakery products can also reduce their losses during storage, distribution and consumption. The loss reduction of vegetable raw materials is included into the goals of sustainable development for agriculture and food processing industries.

The taproot of a beet plant *Beta vulgaris* L., known as beetroot, can be used as a vegetable ingredient in bakery product formulations. The beet plant is cultivated almost everywhere and can be consumed in both natural and processed state. It is known that beetroot contents large amounts of beneficial nutrients. Due to their presence, beetroot has high antioxidant

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and anti-inflammatory properties. It can be used in prevention and treatment of diabetes, cancer, cardiovascular and other chronic diseases [2–4].

Beetroot processing is a very important issue because it allows to save native useful properties of fresh vegetable for a long time. Processed beetroot can also be valuable for use as an ingredient in bakery products. It can be used as a form of freeze-dried powder [5–7] or juice [8]. Beet fibers in powder form mixed with buckwheat hull and flax fiber powders were used in formulation of bread from rye and wheat [9]. Biscuits from wheat flour were prepared using beetroot extract [10] and powders obtained by different drying methods [11–14]. Beetroot powder was also used in formulation of cupcakes [15]. The use of processed beetroot in all above-mentioned experimental samples of bakery products allowed to improve both their sensory characteristics and nutritional value. Therefore, the use of beetroot powder obtained by infrared (IR) drying in pancakes formulations is of interest. Pancakes are world-famous bakery product originally founded in North American countries. The beetroot powder can improve their characteristics and thus expand their range.

2 Materials and Methods

2.1 Ingredients

The main and additional ingredients for pancakes were high-grade wheat flour, fresh beetroot, dry yeast, sugar, salt, pasteurized milk 2.5% fat, unsalted butter 72.5% fat, refined sunflower oil, vanilla sugar and chicken eggs. All products were purchased from a retail chain in Novosibirsk.

2.2 Obtaining of beetroot powder and flour treatment with IR-radiation

For powder obtaining, the beetroots were washed, peeled, ground and dried using laboratory IR-dryer. The source of IR-radiation was quartz halogen lamps KGT-220-1000 (Saransk, Russia) which are located by the sides of drying chamber. These lamps have form of a tube and work in pulsed mode. The pulsed mode means that the lamps turn off at maximum set temperature in dryer chamber and turn on when the temperature is lowered [16]. The drying process lasted for 3.5–4 h. After the process had finished, the dried beetroot was cooled down at 20–25 °C within 1–1.5 h, finely ground and sieved.

For gluten strengthening, wheat flour was sieved and treated by IR-radiation in the dryer within 20–25 min in pulsed mode. Maximal temperature of treatment process was 60 °C (Russian patent № 2322084). After the end of the process, the treated flour was cooled down at 20–25 °C within 20–30 min [17].

2.3 Pancakes samples preparation

In the beginning of preparation process, all dry products were sieved and mixed, the milk was filtered, the eggs were sanitized. Then the egg contents were separated from the shell, mixed with milk until smooth, and filtered. The egg and milk mixture were stirred vigorously with dry products mixture until a homogeneous dough structure was formed. After that, the sunflower oil was added to the dough and stirred vigorously again until the oil was evenly distributed throughout the dough mass.

The dough portions were poured onto a grill pan at 160–180 °C and fried within 3–4 min until golden brown on the bottom. Then the dough was turned over and fried until done within 1–1.5 min. The pancake samples were cooled down at 20–25 °C within 15–20 min and studied on their sensory characteristics and nutritional value.

A total of 4 pancake samples were prepared: № 1, № 2, № 3 and № 4. Sample № 1 was control sample prepared according to basic formulation. The other pancake samples were experimental, with addition into formulations of 4%, 6% and 8% of beetroot powder of IR-drying from wheat flour weight accordingly.

2.4 Research methods

Sensory evaluation of pancake samples was carried out according to Russian national standard GOST 31986-2012 by 10 semi-trained panelists. The samples were evaluated by the following indicators: appearance, surface condition, homogeneity, color, consistency, smell and taste. Each indicator was scored in the range from 1 to 5 points, where the lowest score was 1, the highest was 5.

For taste and smell indicators as the most important criteria for choosing bakery products by consumers, a descriptor-profile method was used. This method contributes to obtaining an objective evaluation of individual properties of samples and can improve formulations and production technologies of food products further [18]. For each characteristic of the indicator, a score of 0 to 5 points was taken, where 5 points meant the most pronounced characteristic of taste and smell, 0 points meant the absence of a corresponding characteristic of taste and smell.

Chemical composition of pancake samples, which determines their nutritional value, was evaluated using methods from the following Russian national standards. For moisture content determination GOST 21094-75 was used, for protein content determination – GOST 26889-86, for fats content determination – GOST 5668-68, for carbohydrates content determination – GOST 5672-68, for dietary fibers content determination – GOST R 54014-2010, for β-carotene and vitamins content determination – GOST 13496.17-2019, GOST 32042-2012 and GOST 34151-2017, for mineral substances content determination – MUK 4.1.3606-20, GOST 30615-99 and GOST 32343-2013 (ISO 6869:2000).

Energy value of samples was calculated based on the obtained values of proteins, fats and total carbohydrates content and specific Atwater factors: 4 for proteins and carbohydrates, 9 for fats [19].

3 Results and Discussion

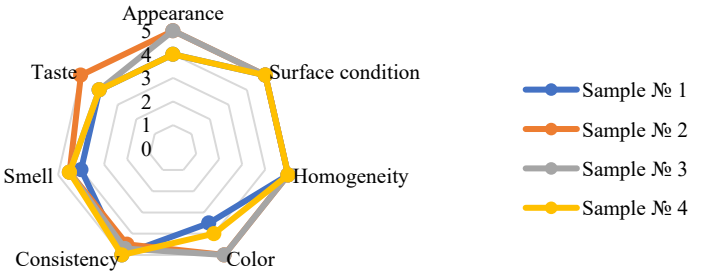
3.1 Sensory characteristics

The results of sensory evaluation of pancake samples are presented on the Fig. 1 in profilogram form.

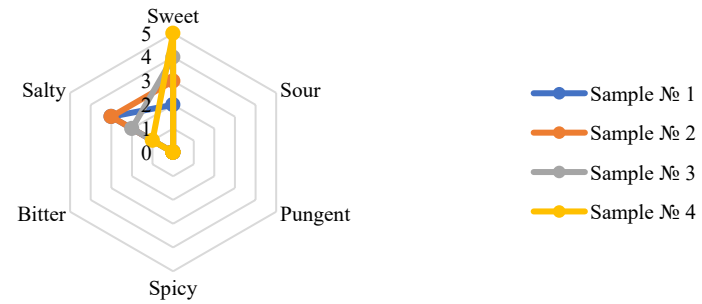
The first profilogram shows that the addition of beetroot powder in the amount of 4% and 6% improved the appearance of samples № 2 and № 3 up to maximum level compared to sample № 1. The appearance of sample № 1 remained at the same level.

In all cases, the addition of the powder into pancake samples kept their surface condition and homogeneity at the same level and improved their smell. The color of experimental samples № 2 and № 3 was more pleasant than the color of sample № 4 because of its intensity. The consistency of samples № 2 and № 3 slightly decreased. At the same time, the consistency of sample № 4 remained at maximum level as for sample № 1. The taste improved only for sample № 2, for other experimental samples it remained at the same level.

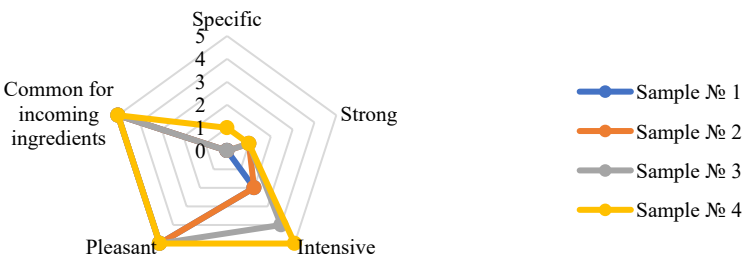
The results of descriptive-profile analysis of the samples showed that with the increase of beetroot powder amount, the taste becomes more sweet and less salty. This can be explained by presence of sugars in beetroot powder. At the same time, salty tinge is masked by the powder, because salt amount does not change.



(*a*)



(*b*)



(*c*)

Fig. 1. Sensory evaluation of pancakes samples: *a* – general sensory evaluation; *b* – descriptive-profile sensory evaluation of taste; *c* – descriptive-profile sensory evaluation of smell

The smell remains pleasant and common for incoming ingredients, while with the increase of beetroot powder amount it becomes more intensive and a little bit stronger. The smell becomes specific with 8% of beetroot powder amount.

3.2 Nutritional and energy value

The nutritional and energy value indicators are shown in Table 1.

Table 1. Nutritional and energy value of pancake samples.

Indicators	Sample № 1		Sample № 2		Sample № 3		Sample № 4	
	Value	Daily norm percentage	Value	Daily norm percentage	Value	Daily norm percentage	Value	Daily norm percentage %
Moisture, %	23.0±1.15	-	22.9±1.2	-	22.9±1.1	-	22.9±1.1	-
Proteins, %	11.2±0.6	13.1	11.3±0.6	13.2	11.3±0.6	13.3	11.3±0.6	13.3
Fats, %	17.9±0.9	19.9	17.9±0.9	19.8	17.9±0.9	19.8	17.9±0.9	19.8
Carbohydrates (total), %	63.2±3.2	16.6	63.6±3.2	16.7	63.8±3.2	16.8	64.0±3.2	16.8
Dietary fibers, %	2.1±0.1	10.5	2.6±0.1	13.1	2.9±0.1	14.4	3.1±0.2	15.7
Mineral substances								
Sodium, mg%	135.1±6.8	10.4	146.1±7.3	11.2	151.5±7.6	11.7	157±7.9	12.1
Potassium, мг%	334.3±16.7	9.6	400.5±20.1	11.4	433.6±21.7	12.4	466.7±23.3	13.3
Calcium, mg%	123±6.2	12.3	130.4±6.5	13.0	134.2±6.7	13.4	137.9±6.9	13.8
Magnesium, mg%	28.9±1.5	6.9	33.2±1.7	7.9	35.3±1.8	8.4	37.5±1.9	8.9
Phosphorus, mg%	191.7±9.6	27.4	198.9±9.9	28.4	202.5±10.1	28.9	206.1±10.3	29.4
Iron, mg%	1.3±0.07	9.5	1.6±0.1	11.4	1.7±0.1	12.4	1.9±0.1	13.3
Vitamins								
A (β-carotene), mg%	0.1±0.01	1.8	0.1±0.01	1.9	0.1±0.01	1.9	0.1±0.01	1.9
B_1, mg%	0.2±0.01	12.2	0.2±0.01	12.2	0.2±0.01	12.2	0.2±0.01	12.3
B_2, mg%	0.3±0.01	14.3	0.3±0.01	14.7	0.3±0.01	14.9	0.3±0.01	15.1
PP, mg%	2.4±0.12	11.8	2.4±0.12	12.0	2.4±0.12	12.2	2.5±0.12	12.3
C, mg%	0.5±0.03	0.6	1.5±0.07	1.6	2.0±0.1	2.2	2.4±0.12	2.7
Energy value, kcal	458	17.1	459	17.2	460	17.2	461	17.3

With the introduction of beetroot powder of IR-drying into pancake formulation, moisture, protein, fats, carbohydrates content and energy value of experimental samples remained almost at the same level. At the same time, dietary fibers content increased by 2.6–5.2%. Due to vitamins and mineral substances contained in beetroot, their content in experimental pancake samples increased by 0.7–3.8% for mineral substances and by 0.3–2.1 for vitamins with the increase of amount of introduced powder. The maximum increase of mineral content was 3.8% for potassium and iron and 2.1% for vitamin C while 8% of powder was added.

4 Conclusion

The results of study showed the advisability of using beetroot powder of IR-drying in formulation of pancakes. It was found that pancake samples with powders keep or improve their sensory characteristics compared with control sample. At the same time, the taste of the product becomes sweeter and less salty, and the smell becomes more intense.

The use of beetroot powder of IR-drying increases content of dietary fibers, vitamins and mineral substances. The most increase is for potassium, iron and vitamin C. Proteins, fats, carbohydrates content and energy value remain at the same level. Preliminary treatment of wheat flour by IR-radiation within 20–25 min also improves quality of pancakes.

Based on data analysis, the optimal amount of beetroot powder of IR-drying for pancake formulations is determined as 6% from wheat flour weight. The results obtained can be practically implemented on food industry and public catering enterprises.

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