Research on possibilities of non-traditional flour types use in baking industry

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Abstract. The article considers the possibility of using non-traditional raw material - tiger-nut flour (chufa-nut) – in the production of flour confectionery biscuit cake mix. During the research, experimental baking of biscuits was carried out with a different dosage of tiger-nut flour and wheat flour. Samples of biscuits with a different combination of tiger-nut flour and wheat high-grade flour were studied in ratios of 5:95; 10:90; 15:85%. The research was carried out in the laboratory of the department "Technology of agricultural raw materials storage and processing and catering" at the Volgograd state agrarian university. During the experiment, the authors studied the following: the flour confectionery products production at the present stage; growth geography, tiger-nut yield and quality; tiger-nut and flour obtained from it chemical composition; the tiger-nut influence on human health and well-being; organoleptic quality indicators of experimental biscuit cake mix products samples with tiger-nut flour adding; physical and chemical quality indicators. As the result of the research, it was possible to produce biscuit cake mix products with tiger-nut flour use, and the optimal dosage of tiger-nut flour and high-grade wheat flour was established, which allows obtaining biscuit cake mix with high organoleptic and physicochemical parameters. According to the carried out research results, it is recommended to use tiger-nut flour (chufa-nut) in the amount of 5:95 and 10:90% by the wheat flour weight.

1. Introduction

Nowadays, humanity has achieved a lot, both in the spiritual and in the material world. Many products of centuries-old human activity are amazing, universal, and without them, we cannot imagine our life. But, unfortunately, with civilization development and the advent of innovations, global problems for the whole society simultaneously entered our lives. And one of the most important is the problem of human health. When analyzing factors that have a significant influence on human health, we can confidently confirm that proper nutrition and a healthy lifestyle are in the first place, ahead of the influence of ecology, medicine and heredity combined.

The human body receives almost all the necessary substances through food and water. The composition of food products and their properties directly affect health, physical development, ability to work, emotional state and, in general, the quality and duration of a person’s life. It is difficult to find another factor that would have such a severe effect on the human body. Only when the food is not only healthy but also tasty, from which a person experiences joy, will the hormonal and endocrine system be strengthened. And it, in turn, is responsible for our youth, health, beauty and active
longevity. Today there are many delicious products. However, the most interesting are flour confectionery. These goodies are designed to give joy with their external appearance, taste, flavour, and satiate the body with their composition. But these products, unfortunately, have significant shortcomings, such as high-calorie content, a small amount of protein, dietary fibre, macro- and micronutrients. In this regard, there is a need to increase the nutritional value of confectionery products by introducing new types of raw materials in the formula that can improve both the taste and nutritional properties of products.

One of these products can be tiger-nut flour or as it is also called "chufa-nut".

Tiger-nut, chufa-nut, yellow nutgrass, or earth almonds (lat. Cyperus esculentus) is a perennial herbaceous plant of the sedge family, whose tubers are consumable. The homeland of the chufa-nut is considered to be the Mediterranean and North Africa. Tiger-nut (chufa-nut) is one of the first plants cultivated by man: vessels with walnut nodules - "food supply for the road" - archaeologists discovered them in the tombs of Egyptian pharaohs dated to 2-3 millennium BC. Tiger-nut is grown in Brazil, Spain, Portugal, Africa. Today, this crop can be found everywhere, in almost every country [3, 4].

Nodules are consumed fresh, boiled, fried, made butter, coffee, sweets, halva, ice-cream and processed into flour. Tiger-nut flour is actively used for making cereals, granola and cookies. However, the flour sweet-nutty taste can be well suited for the production of flour confectionery. This product natural sweetness allows reducing or completely removing the amount of sugar in the formulae of bakery products and thereby improving the dietary properties of products. Tiger-nut flour is coarser in its properties than traditional wheat flour, and for this reason, it contributes to the production of bakery products with a rougher texture. In its turn, the tiger-nut flour (chufa-nut) existing roughness is associated with a large amount of fibre, which helps to lower cholesterol in the human body, as well as improve the motility of the gastrointestinal tract. It is worth noting that tiger-nut flour (chufa-nut) is rich in essential healthful lipids, amino acids, vitamins A, B, C, calcium, iron, phosphorus, magnesium, potassium, zinc, copper, selenium, iodine. In terms of nutritional value, tiger-nut flour is superior to flour from peanuts by more than 3 times [4, 5, 10]. Due to the valuable chemical composition, tiger-nut is recommended for children of school age, adults and the elderly, as well as for people with diabetes. The results of the composition of the tiger-nut tubers chemical analysis are given in Table 1 and show its perspective for use as a functional ingredient.

| Component                  | Content in 100 g of chufa-nut tubers | Component | Content in 100 g of chufa-nut tubers |
|----------------------------|-------------------------------------|-----------|-------------------------------------|
| Water, g                   | 9.79                                | Minerals: |                                     |
| Proteins, g                | 6.78                                | K, mg     | 733                                 |
| Fats, g                    | 23.22                               | Ca, mg    | 121                                 |
| Carbohydrates:             |                                     | Mg, mg    | 92                                  |
| mono- and disaccharides, g | 19.8                                | P, mg     | 239                                 |
| starch, g                  | 26.5                                | Vitamins: |                                     |
| fiber, g                   | 12.36                               | E, mg     | 21.6                                |
| Fructose, % on dry matter  | 0.05                                | B1, mg    | 6.9                                 |
| Glucose, % on dry matter   | 0.14                                | B2, mg    | 5.4                                 |
| Sucrose, % on dry matter   | 19.4                                | C, mg     | 2.5                                 |
| Ash, g                     | 4                                   | Energy value, kJ | 1804 |

The amount of water-soluble substances exhibiting antioxidant activity in tiger-nut tubers is 30% more than in high-grade wheat flour. Tiger-nut tubers are gluten-free (can be used in the production of gluten-free products), and the high content of K, Ca, P, polyunsaturated fatty acids (12.5% of total lipids) and vitamin E makes them a promising raw material for creating products that help to lower cholesterol in the blood, in the prevention of cardiovascular diseases [4, 5, 7].
In Russia, tiger-nut has been known since the end of the 18th century under the name of meadow saffron Colchicum or yellow nutgrass. Tiger-nut is not whimsical to growing conditions: it grows in almost all soil and climatic zones of the Russian Federation. However, a particularly good harvest can be obtained only on moderately moist soil, without excess or lack of moisture. In the 30s of the XX century, 413 hectares were occupied under the cultivation of earth almonds in the former USSR. But today - this is a rare and undeservedly forgotten culture in Russia that can yield a dry nodule crop of 6.5 to 9.5 t / ha [1, 8, 10].

According to the given the above material, the research aim was to study the possibility of tiger-nut flour use in the production of flour confectionery (biscuit).

For achieving this goal, the following tasks were set:
- the study of the tiger-nut flour influence on the organoleptic characteristics of experimental products;
- the study of the tiger-nut flour influence on physical and chemical quality indicators of experimental products;
- to determine the optimal dosage of tiger-nut flour in the production of biscuits.

2. Research materials and methods

Experimental samples were prepared from one batch of raw materials. Sampling and preparation of samples for laboratory research was carried out according to a unified method for studying the properties of finished products according to All-Union State Standard 5904 "Confectionery. Acceptance rules, methods of sampling and sample preparation," the sampling method, according to All-Union State Standard 26669 "Food and flavouring products. Sample preparation for microbiological analysis."

The finished products analysis was carried out after their cooling. The baked biscuit cake mix was evaluated by porosity, moisture, structural and mechanical properties of the crumb, organoleptic characteristics.

Biscuit dough is a highly concentrated dispersion of air in the environment from egg products, sugar and flour. Therefore it refers to foams.

Wheat flour of weak or medium quality gluten (28 – 34%) is used for preparing a biscuit cake mix. When using strong wheat flour, the biscuit cake mix crumbles, which decreases the quality of the biscuit.

3. Research results

For the manufacture of flour confectionery (biscuits) experimental samples, the formula was selected according to All-Union State Standard (fresh eggs (190 kg), granulated sugar (100 kg), wheat high-grade flour (100 kg)

In the developed biscuit formulae, high-grade wheat flour was replaced with tiger-nut flour (chufa-nut) in the amount of 5, 10 and 15% of the total amount of flour (Table 2).

| Ingredient                  | Sample № 1 | Sample № 2 | Sample № 3 |
|-----------------------------|------------|------------|------------|
| Eggs                        | 190        | 190        | 190        |
| Granulated sugar            | 100        | 100        | 100        |
| Wheat high-grade flour      | 95         | 90         | 85         |
| Tiger-nut flour             | 5          | 10         | 15         |

From the data given in Table 2, we can conclude that in the experimental samples formula, only the ratio of high-grade wheat flour and tiger-nut flour was changed. In laboratory conditions, tiger-nut flour and wheat high-grade flour experimental samples were studied in the ratios of 95:5, 90:10, 85:15.
Baked biscuit samples were investigated according to organoleptic and physical and chemical parameters. The organoleptic characteristics given in Table 3 were evaluated on a 5-point scale, where the highest score is 5 points.

| Indices            | Ratio: flour from tiger-nut, % | wheat flour, % |
|--------------------|--------------------------------|----------------|
|                    | 5-95                           | 10-90          | 85-15          |
| Flavour            | 5                              | 5              | 4.4            |
| Taste              | 5                              | 5              | 4.4            |
| Elasticity         | 4.8                            | 5              | 4.6            |
| Porosity           | 4.4                            | 4.4            | 4.4            |
| Shape              | 4.4                            | 4.8            | 4.6            |
| Crust condition    | 4.8                            | 4.6            | 4.4            |
| Total points       | 28.4                           | 28.8           | 26.8           |

From the data given in Table 3, it follows that with the tiger-nut flour amount increase, the organoleptic characteristics changed as follows. The experimental sample, with the addition of 10% tiger-nut flour (Figure 1) got a maximum amount of points. On this variant, the tasters noted the optimal combination of taste and flavour, as well as the correct form with the score of 4.8 points. Porosity, in its turn, was not sufficiently developed and received the score of 4.4 points.

![Figure 1](image1.png)

(a) (b)

**Figure 1.** Biscuits external appearance with the addition of 10% tiger-nut flour: (a) top view; (b) biscuit cut view

The second place with a minimum gap of 0.4 points was given to the sample with the content of tiger-nut flour and wheat flour in a ratio of 5-95%. On this variant, the tasters noted a slight decrease in the products’ elasticity and shape (Figure 2).

![Figure 2](image2.png)

(a) (b)

**Figure 2.** Biscuits external appearance with the addition of 5% tiger-nut flour: (a) top view; (b) biscuit cut view
According to the tasting analysis results, the third place was given to the sample with a combination of tiger-nut flour and wheat flour in the ratio of 15-85%. On this variant, there was a deterioration in taste and flavour for which tasters put 4.4 points. Also, a slight deterioration was observed in other indicators (Figure 3).

![Figure 3. Biscuits external appearance with the addition of 15% tiger-nut flour: (a) top view; (b) biscuit cut view](image)

Analyzing the dynamics depending on the studied samples and quality indicators, it can be noted that with the increase in the tiger-nut flour proportion, the products acquired a more pronounced almond flavour.

The taste with the tiger-nut amount proportion increase became more sweet. With an increase in the tiger-nut flour (chufa-nut) proportion compared to wheat flour, a decrease was observed in the assessment of such an indicator as “crust condition” from 4.8 in the variant 5-95% to 4.6 and 4.4% in the variants 10-90% and 15: 85% respectively.

Making a conclusion, when assessing the biscuit samples organoleptic characteristics, we can note that all the samples were of rather high quality, however, the samples with the addition of 5-95% and 10-90% mixture of tiger-nut flour (chufa-nut) and wheat flour had the best nutty taste and aroma.

An increase in the amount of introduced tiger-nut flour shows the following. The organoleptic characteristics and the physical and chemical properties of this product type changed. Physical and chemical properties of biscuit with the addition of tiger-nut flour are presented in Table 4.

| Indices             | Ratio: flour  | from tiger-nut, % | - wheat flour, % |
|---------------------|---------------|-------------------|------------------|
| Moisture content, % | 5.95          | 15-85             | 10-90            | 23.8 | 24.6 |
| Porosity, %         | 69.6          | 67.6              | 67.6             | 68.8 | 67.6 |
| Alkalinity, degrees | 0.3           | 0.3               |                  | 0.3  |

According to the data given in Table 4, we can conclude that the moisture content increases from 23.8% in the variant with the addition of 5% tiger-nut flour to 24.4% and 24.6% in the variant with the addition of 10 and 15% tiger-nut flour to wheat flour. The innovative products’ moisture increase can be explained by the increase in the proportion of dietary fibre added with tiger-nut flour [7, 10], which have a water-holding ability. The increase in the proportion of tiger-nut flour contributes to a slight decrease in the porosity of the product, so with the addition of 5% tiger-nut flour (chufa-nut), this indicator was 68.6%, with a further increase to 10 and further to 15%, this indicator decreased to 68.8 and 67.6%, respectively. When analyzing this indicator, it should be noted that the porosity of all products with the addition of tiger-nut flour was 5% lower than that of products manufactured according to the standard recipe. Alkalinity, in turn, did not undergo any changes and amounted to 0.3 degrees on all variants of the experiment.
4. The results discussion

In general, all flour confectionery (biscuits) produced experimental samples with tiger-nut flour (chufa-nut) use in combination with wheat flour meet the requirements of regulatory documents. However, based on the organoleptic evaluation data, it is possible to recommend the production of variants with the addition of 5 and 10% of tiger-nut flour in combination with wheat flour.

5. Conclusion

During the experiment it was established that the application of tiger-nut flour (chufa-nut) together with wheat flour in the ratio of 5:95% and 10:90% has a positive influence on the biscuit products taste and aroma, they acquire a nutty flavour.

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