Development of a semi-finished biscuit recipe for vegans

Elvira Pyanikova[1*], *Anna* Kovaleva[1], *Oxana* Evdokimova[2],and *Anastasia* Ryazantseva[1]

[1]Southwest State University, 94, 50 Let Oktyabrya st., Kursk, 305040, Russia
[2]Orel State Agrarian University named after N V Parakhin, 69, Generala Rodina st., Orel, 302019, Russia

Abstract. This study explores the introduction of alternative components into the formulation of a semi-finished biscuit product to adjust the production technology. The experiment involved preparing a thick mass from aquafaba of green peas, a two-stage baking process at different temperature conditions, and cooling the finished product in both an oven and workshop conditions. Three formulations of a vegan semi-finished biscuit were developed with varying ratios of oatmeal and almond flour: 8:13, 15:7, and 13:8. The optimal ratio was found to be 13:8. The resulting semi-finished biscuit product exhibited a pleasant, balanced flavor profile, a golden uniform color, and a soft, elastic, and non-crumbling consistency. The use of alternative raw materials reduced the energy value, increased protein and fat content, decreased carbohydrate content, and improved the fiber, vitamin, and mineral composition of the product.

1 Introduction

Poor nutrition due to a number of factors, one of which is the lack of access to food of acceptable quality, can be harmful to human health. The development of sustainable food distribution systems and the creation of sustainable diets play a key role in promoting public health. The issue of providing the population with different dietary preferences with high-quality products that make it possible to fill the need for essential nutrients is urgent.

Biscuits are popular flour confectionery products, the demand for which is constantly growing on the world market [1]. The vegan lifestyle is becoming increasingly popular, and therefore it is necessary to expand the range of products, including confectionery, for this category of the population. In this regard, research is being conducted aimed at developing products that do not contain ingredients of animal origin, such as eggs, or in which traditional raw materials are replaced with more useful vegetable ones (for example, wheat flour, other types of flour, sugar - with a sweetener, etc.) [2, 3].

Egg is one of the most important ingredients in the biscuit recipe, which is considered a multifunctional element. Egg yolk proteins contain livetin, phosphitin and lipoproteins,

* Corresponding author: pyanikovaelvira@yandex.ru

which act as emulsifiers, reduce the interfacial tension at the oil–water interface and simplify the breakdown of fat particles. They also contribute to the color, aroma and gel formation [4]. On the other hand, egg white proteins are responsible for the formation and stabilisation of foam. The globulin fraction is a foaming agent, whereas ovomucin is a foam stabiliser [5].

Although eggs are multifunctional and are one of the most important ingredients in the production of biscuits [6, 7], the need to replace eggs in food products is due to several reasons: health (to reduce cholesterol in the yolk, the risk of causing allergies, hives and rashes), dietary preferences (vegans and vegetarians) and economic factors (high cost of eggs in the consumer market).

Eggs can be replaced with an aquafaba made from legumes. The most preferred substitute is aquafaba, obtained from green peas. This viscous liquid, taken from canned peas, forms a stable foam when whipping, the same as when whipping egg whites. It can be used as a vegan rheological supplement that does not contain gluten and cholesterol [8].

Pea protein has emulsifying and gel-forming properties, so it can be used in formulations of semi-finished biscuit products without eggs [9].

The recipe also replaces wheat flour with almond flour. Almond flour has both functional properties and better solubility, emulsifying, oil-absorbing and foaming ability.

The aim of the study was to study the effect of non-traditional raw materials in semi-finished biscuit products for vegans on the quality of the finished product

2 Materials and methods

When developing a semi-finished biscuit for vegans, ingredients were replaced in the classic biscuit recipe. Wheat flour was replaced with a selected mixture of oatmeal and almond flour, eggs with green pea aquafaba powder, sugar with Erythritol sweetener. To improve the whipping of the aquafaba, salt was added to the dough, and baking powder was added to improve the properties of the dough.

Oatmeal is superior to wheat flour in terms of protein, fat, dietary fiber, potassium, calcium, magnesium, phosphorus, iron, vitamins B1, B2, E and PP and is considered an important functional ingredient [10, 11]. According to the amino acid composition, oat protein is easily absorbed by the body, is more balanced and differs from wheat protein in an increased content of amino acids (choline and tyrosine). Oatmeal also contains calcium and phosphoric mineral salts, enzymes, essential oil and easily digestible carbohydrates.

Almond flour is a carefully ground almond, so its composition is dominated by fats (50%), with a fairly high content of proteins (20%) and carbohydrates (20%), as well as vitamins [12]. All the active substances that are present in almond seeds are preserved after grinding. Therefore, in most cases, the chemical composition of almond flour is identical to the nuts from which it is produced.

Almond flour is rich in vitamins and minerals such as: vitamin B2 - 52.2%, vitamin B9 - 13.3%, vitamin E - 161.4%, vitamin PP - 15.8%, potassium - 29.9%, calcium - 34.7%, magnesium - 69.8%, phosphorus - 63.5%, iron - 19.4%, manganese - 106.6%, copper - 93.4%, zinc - 27.4% [13].

The caloric content per 100 g of the product is about 500-600 kcal, which is almost 2 times more than that of premium wheat flour.

The glycemic index of almond flour, compared with that of wheat flour - 85 units, is quite low and amounts to 25 units.

Since nuts naturally do not contain gluten and cholesterol, almond flour does not contain gluten (therefore, almonds are safe for the heart and blood vessels, despite the high fat content).

Almond seed protein is a protein with an ideal balance of amino acids that is easily digested and absorbed by the human body. Baking from almond flour turns out sweet, crumbly and delicate and has a nutty flavor.

To replace egg whites in order to create a lush foam, aquafaba powder from peas was used in the recipe of the biscuit semi-finished product. Nutritional value per 100 g: proteins - 6.1 g, fats - 0 g, carbohydrates - 14 g. The energy value of aquafaba powder is 351 kJ/84 kcal.

The composition of aquafaba includes proteins [14], polysaccharides, sucrose, saponins, mycose, myo-inositol and up to 20 other organic substances dissolved in water (organic acids, alcohols, etc.).

Aquafaba in combination with other ingredients can improve the textural properties of biscuits, improving air distribution and interfacial tension [15]. The presence of proteins, carbohydrates and saponins gives emulsifying, gelling and foaming properties [16] to aquafaba, which can be used in the production of plant-based products.

The key factor is the absence of fats in the composition of aquafabs, which usually reduce the amount and stability of foam. On average, the protein content in aquafab is 10 times less than in egg white. But due to the presence of saponins and polysaccharides, egg white can be replaced with 1:1 aquafaba.

As a control sample, a recipe from the collection of recipes for cakes, pastries, muffins, rolls, cookies, gingerbread, gingerbread and pastry products was used. Antonova A.P. The recipe included three ingredients: wheat flour (160 g), sugar (160 g) and chicken egg (280 g). Based on the chemical analysis of the raw material composition of the recipes of the biscuit semi-finished product for vegans, the ingredients in the recipe of the classic biscuit (control sample) were replaced with alternative ones. The resulting formulations are presented in Table 1.

Table 1. The recipe of a semi-finished biscuit for vegans.

Name of raw materials	Quantity of raw materials, g		
	Sample 1	Sample 2	Sample 3
Aquafaba	100	100	100
Sweetener "Erythritol"	40	30	40
Oat flour	40	75	65
Almond flour	65	35	40
Food salt	0.5	0.5	0.5
Baking powder	2	2	2

The preparation of a semi-finished biscuit for vegans begins with the preparation of raw materials: oatmeal and almond flour are sifted through a sieve with 1.6 mm cells. Sifting is carried out in order to clean the flour from foreign impurities, as well as for its loosening and aeration (oxygen saturation). Baking powder is added to the sifted flour and stirred for 3-5 minutes. Prepare a solution of aquafaba powder from peas and drinking water. Aquafaba powder is dissolved in boiled water at a temperature of 40-60 ° C, stirred and allowed to infuse for 2-3 minutes until the powder is completely dissolved and a cloudy viscous solution is formed. The resulting solution is cooled to +4°C and whipped to obtain a thick mass from the aquafaba. To prevent rapid settling of the mass and its stabilisation, food salt is added and beaten until soft peaks appear .This takes between 5-7 minutes at a rotation speed of the mixer of 300 rpm. "Soft peaks" or "round peaks" are the second stage of whipping proteins. At this stage, the whipped mass becomes like foam. It turns white, looks more stable, but still remains very soft, "moist", it still does not hold its shape firmly. Then the Erythritol sweetener is added to the mass and whipped to stable peaks for 5 minutes at a rotation speed of the mixer of 300 rpm. A dry mixture of flour and baking powder is added to the beaten mass and thoroughly mixed for 5 minutes at a rotation speed of 100 rpm. The dough is

deposited into molds and baked in two stages. At the first stage, baking is carried out for 30 minutes at a temperature of 150-160 ° C. At the same time, the processes occur evenly (during baking, gases expand, components of the Erythritol sweetener interact, protein particles come together and stick together, due to which their size increases, the biscuit becomes stable and the possibility of its settling is eliminated), the biscuit does not rise "slide" and surface tears do not form. At the second stage, baking is carried out at a temperature of 180 ° C for 10 minutes to brown the semi-finished biscuit product. The baked semi-finished biscuit product is cooled in the oven for 1 hour to prevent moisture accumulation at the bottom of the semi-finished biscuit product. They are wrapped in a film and continue cooling in the workshop for 6-8 hours to evenly distribute moisture over the entire mass of the semi-finished biscuit product.

3 Results and discussion

The assessment of the quality of samples of semi-finished biscuit products for vegans according to organoleptic indicators was carried out in accordance with the requirements of regulatory documents for the following indicators: appearance, sectional view, consistency, surface, taste and smell. For the organoleptic assessment, a scale of the biscuit quality score was developed, in which the maximum number of points was assigned to each indicator - 5, the total amount of points was 30 points.

The assessment of the qualitative indicators of baked biscuit samples was carried out using expert and organoleptic methods. The expert method is based on the fact that each of the 5 experts participating in the survey assigns a certain score to each of the criteria. The tasters, using their senses, assessed the quality of the organoleptic parameters of the developed biscuit samples [17]. The average values of the organoleptic quality indicators of biscuit samples are shown in Fig. 1.

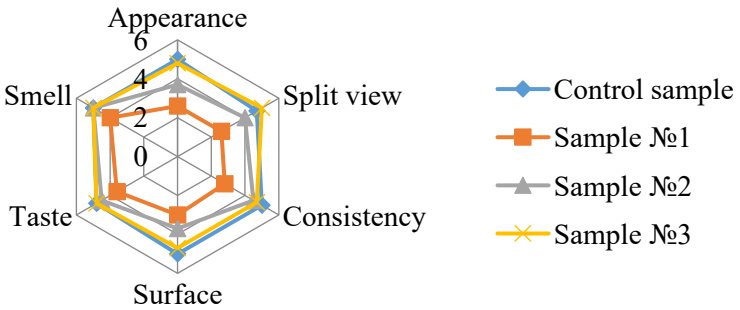

Fig. 1. Assessment of organoleptic quality indicators of biscuit samples.

In the course of the study, it was revealed that the best biscuit sample was No. 3, which received 29 points out of 30 possible.

The control sample had an intensely pronounced pleasant wheat taste, not a pronounced egg flavour, characteristic of a biscuit baked using traditional technology.

The biscuit sample No. 1 had a shape corresponding to the container in which it was baked. The upper surface of the product is concave, without cracks and explosions. The side sections are burnt. The porosity is undeveloped. The colour of the upper surface is uneven. The colour is uniform in the section. The biscuit is noticeably compacted, slightly elastic,

moist to the touch, clumps when cut. Sample No. 1 has a pronounced nutty taste, a pleasant oatmeal flavor, and a barely perceptible pea flavor. The smell peculiar to biscuits, none of the ingredients are released in the finished product.

Sample No. 2 had a shape corresponding to the container in which it was baked. The upper surface of the product is convex, with pronounced breaks. The colour of the surface is uniform, without burn marks. In the section, the colour of the biscuit is golden, non-crumbling mass, well-baked, with a sufficiently uniform porosity, without traces of non-kneading. In sample No. 2, there is an intense taste of oatmeal, as it prevails in the recipe, a pleasant almond flavor, subtle notes of a pea flavor. The smell peculiar to biscuits is pleasant and balanced.

According to the results of all organoleptic studies, No. 3 turned out to be the best sample. Since oatmeal and almond flour were used in the recipe, intensely pronounced oatmeal and pronounced nutty flavors were noted in the biscuit. The amount of ingredients was optimally selected so that the taste was balanced (oatmeal and almond flour in a ratio of 13:8). Since the pea aquafaba itself does not have a pronounced taste and smell, the pea taste in the sample was barely perceptible. The biscuit semi-finished product had a soft, elastic, moderately moist consistency, not crumbling and not clumping when cut. The smell of sample No. 3 was fragrant, characteristic of the smell of the introduced ingredients, which did not stand out from the general aromatic range.

Since sample No. 3 turned out to be the best in terms of organoleptic parameters, further studies on physico-chemical parameters and chemical composition were carried out with it in comparison with the control sample.

A study of the physico-chemical parameters of the developed sample of a semi-finished biscuit for vegans and a control sample showed that the mass fraction of fat in sample No. 3 was 12.77% (due to the introduction of almond flour), and in the control – 9.1%; humidity: in sample No. 3 - 15.6%, in the control – 32%. The lower humidity of the developed sample in comparison with the control one is due to the fact that its formulation includes oat flour rich in fiber, which has a high water absorption capacity. The mass fraction of total sugar in sample No. 3 was 8.35%, in the control sample – 42.8%. The decrease in sugar in the sample of a semi-finished biscuit for vegans is due to the replacement of this ingredient with the sweetener erythritol, the degree of sweetness of which is 0.6 units of sugar. The mass fraction of ash in the developed sample was 0.09% and the control sample was 0.1%. The data obtained are within the limits allowed by the current regulatory documentation.

A study of the nutritional value (Table 2) of the developed sample of a semi-finished biscuit for vegans and a control sample allowed us to establish that the energy value of the control sample is higher than that of the developed one by 8.3 kcal. Calorie reduction occurs due to the introduction of a sweetener into the formulation, the replacement of high-calorie foods (fat, egg products) with products with a lower calorie content (Erythritol sweetener, pea aquafaba powder).

Table 2. Nutritional value of the developed sample of a semi-finished biscuit for vegans and a control sample, per 100 g of product.

Nutrients	Control sample	Sample No. 3
Energy value, kcal	265.8	257.5
Proteins, g	8.6	13.6
Fats, g	5	12.7
Carbohydrates, g	45.5	24.1
Dietary fiber, g	0.6	3
Vitamin B1, mg	0.069	0.113
Vitamin B2, mg	0.241	0.033
Vitamin B4, mg	145.8	8.4
Vitamin B5, mg	0.81	0.055

Vitamin B6, mg	0.092	0.03
Vitamin B9, mcg	30.846	9.697
Vitamin E, mg	0.524	0.616
Vitamin PP, mg	0.3437	1.2376
Potassium, mg	106.21	185.23
Calcium, mg	33.18	81.92
Magnesium, mg	12.26	42.48
Sulfur, mg	0	18.95
Phosphorus, mg	123.9	146.9
Iron, mg	1.253	1.634
Molybdenum, mg	0	0.222

Due to the introduction of aquafaba from green peas and almond flour into the formulation, the protein content in the developed sample of a semi-finished biscuit for vegans increases by 1.6 times, compared with the control sample. An increase in the amount of fats in the developed sample by 2.5 times is associated with the use of almond flour rich in unsaturated fatty acids in the formulation, but at the same time the amount of carbohydrates decreases by 1.9 times in comparison with the control sample.

Due to the replacement of wheat flour in the formulation with a mixture of almond and oatmeal, the content of dietary fibers, which provide daily needs, increases by 10% (3g / 100g).

Compared with the control sample, the content of vitamin B1 in the biscuit semi-finished product for vegans increases by 39%, which is 10% of the daily requirement.

The vitamin E content increases by 15% compared to the control sample, which is 5% of the daily requirement. The content of vitamin PP increases 3.6 times, which is 10% of the daily requirement.

Also, the developed semi–finished biscuit for vegans contains: potassium – 1.7 times more, calcium – 2.5 times more, magnesium – 3.5 times more, phosphorus – 1.2 times more and iron - 1.3 times more when compared with the control sample.

By replacing wheat flour with almond and oatmeal, nutrients such as molybdenum and selenium appear in the developed sample.

4 Conclusion

In the course of the conducted research on the influence of non-traditional raw materials in semi-finished biscuit products for vegans on the quality indicators of the finished product, the following conclusions were made:

- due to the replacement of traditional semi-finished biscuit products for vegans with alternative ones, there have been changes in the technology of making semi-finished biscuit products: an operation has been introduced to prepare a thick mass of green pea aquafaba, consisting of whipping in 2 stages (first aquafaba with salt, and then with the addition of the sweetener Erythritol and whipped to stable peaks for 5 minutes); also, baking was carried out in 2 stages (at the first stage, baking is carried out for 30 minutes at a temperature of 150-160 ° C; at the second - at a temperature of 180 ° C for 10 minutes); the finished semi-finished product was cooled first in the oven for 1 hour, and then for 6-8 hours in the workshop;
- the use of oatmeal and almond flour, aquafaba from green peas in the formulation has a beneficial effect on the organoleptic characteristics of the finished product: the product acquires a golden uniform color, pleasant balanced flavour properties

inherent in the introduced ingredients, soft, elastic, non-crumbling and non-clumping consistency when cut;

- a study of the physico-chemical parameters of the developed semi-finished biscuit product sample showed that they are within the limits allowed by the current regulatory document: the mass fraction of fat was 12.77%, humidity was 15.6%, the mass fraction of total sugar was 8.35% and the mass fraction of ash was 0.09%;
- the developed semi-finished biscuit product for vegans has a fairly high nutritional value in comparison with the control sample: the protein content increases by 1.6 and fat by 2.5 times, while the amount of carbohydrates decreases by 1.9 times; the content of dietary fiber, vitamin B1 increases by 39%, vitamin E b by 15%, vitamin PP by 3.6 potassium – 1.7 times, calcium – 2.5 times, magnesium – 3.5 times, phosphorus – 1.2 times and iron – 1.3 times; nutrients such as molybdenum and selenium appear;
- the energy value in the developed sample decreases, in comparison with the control sample, by 8.3 kcal.

Based on the results obtained during the study, the developed sample of a semi-finished biscuit can be recommended to people who adhere to a vegan diet and lead a healthy lifestyle.

References

1. M. Lin, S.H. Tay, H. Yang, B. Yang, H. Li, F. Hydrocolloids **69**, 440 (2017)
2. M.K. Movahhed, M. Mohebbi, A. Koocheki et al., J. Food Sci. **85**, 1479 (2020)
3. E.A. Pyanikova, A.E. Kovaleva, E.V. Ovchinnikova, O.S. Taratorina, M. Kolchanov, Achievements of Science and technology **8(36)**, 58 (2022)
4. S. Hedayati, S.M. Jafari, S. Babajafari, M. Niakousari, S.M. Mazloomi, F. Hydrocolloids **128**, 107611 (2022)
5. Y. Zhu, S.K. Vanga, J. Wang, V. Raghavan, Trends in Food Science & Technology **78**, 188 (2018)
6. T. Godefroidt, N. Ooms, B. Pareyt, K. Brijs, J.A. Delcour, A review Comprehensive Reviews in Food Science and Food Safety **18(5)**, 1550 (2019)
7. L. Slade, M. Kweon, H. Levine, Critical Reviews in Food Science and Nutrition **61(2)**, 283 (2021)
8. Y. He, V. Meda, M. J.T. Reaney, R. Mustafa, Trends in Food Science & Technology **111**, 27 (2021)
9. S. Hedayati, S.M. Jafari, S. Babajafari, M. Niakousari, S.M. Mazloomi, F. Hydrocolloids **128**, 107611 (2022)
10. S.S. Sergeeva, V.S. Popov, V.N. Krasilnikov et al., Int. Scientific Research J. **11,** 65 (2017)
11. A.E. Kovaleva, E.A. Pyanikova, Bulletin of the Voronezh State University of Engineering Technologies **1(79)**, 256 (2019)
12. E.A. Skorbina, I.A. Trubina, O.V. Sycheva, S.M. Laptev, Technologies of the food and processing industry of the agro-industrial complex - healthy food products **3**, 193 (2022)
13. A.N. Yildirim, F. Yildirim, B. Şan, M. Polat, Y. Sesli, J. Appl. Bot. Food Qual. **89** 163 (2016)

14. M.A. Zaikina, G.V. Plushev, E.T. Greshilov et al., Technologies of the food and processing industry of the agroindustrial complex – healthy food products **3**, 84 (2022)
15. R. Mustafa, Y. He, Y.Y. Shim, M.J.T. Reaney, I. J. of Food Science and Technology **53(10)**, 2247 (2018)
16. D. Tufaro, C. Cappa, F. Hydrocolloids **136** 108231 (2023)
17. E.A. Pyanikova, A.E. Kovaleva, M.A. Zaikina, IOP Conf. Ser.: Earth Environ. **839** 022044 (2021)