potravinárstvo®
OPEN ACCESS
Received: 10.5.2024
Revised: 23.7.2024
Accepted: 24.7.2024
Published: 28.8.2024

Slovak Journal of Food Sciences

Potravinarstvo Slovak Journal of Food Sciences
vol. 18, 2024, p. 776-791
https://doi.org/10.5219/1985
ISSN: 1337-0960 online
www.potravinarstvo.com

The technology of cooking falafel with high biological value for vegans

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ABSTRACT

The article presents the results of scientific research on the possibility of increasing the biological value of falafel dishes for vegans through the use of flax seeds and blueberry extract. Vegan nutrition analysis in Ukraine shows that dishes for this population group are mostly deficient in biologically active substances. One way to solve this problem is to develop dishes for vegans using raw plant materials with a high content of biologically active substances. The chemical composition of flax seeds and blueberry extract is analysed in terms of using these products for vegan cuisine. The feasibility of using flax seeds and blueberry extract to increase the biological value of the falafel vegan dish was proven. The feasibility of replacing vegetable oil and a fraction of wheat flour to optimise the vitamin-mineral composition of falafel was determined. Based on the organoleptic evaluation of the control and test samples, the optimal ratio of falafel ingredients was established: 2.5% dry blueberry extract and 7.5% flax seeds per 100 g of the dish. The falafel chemical composition with the addition of flax seeds and blueberry extract was studied compared to the control sample. According to the research results, the technology of cooking falafel for vegans with an increased content of biologically active substances was developed. Based on the data obtained, it can be concluded that the developed dish will enrich vegan nutrition with deficient biologically active substances. The social effectiveness of the developed technology of cooking falafel is to expand the range of vegan dishes. The developed dish can be recommended for the nutrition of fasting people. It is advisable to use the technology developed to cook falafel in restaurants.

Keywords: falafel, vegan nutrition, biological value, organoleptic properties, restaurant technologies

INTRODUCTION

Human nutrition is essential in ensuring a high level of health, increasing life expectancy, and preserving working capacity **[1]**, **[2]**.

It is known that human food products should contain about 600 substances or nutrients necessary for the normal functioning of the body **[3]**. These substances are important in biochemical processes' complex, harmonious mechanisms. For 96% of organic and inorganic compounds obtained with food products, one or another biological property is inherent. Therefore, human health depends on the amount and ratio of these substances in the diet **[4]**.

Today, various forms of vegetarianism are becoming increasingly popular in the world's developed countries **[5]**. One of them is veganism – a form of strict vegetarianism accompanied by the rejection of fish, eggs, milk, honey and, of course, meat, that is, the rejection of absolutely all products of animal origin. Studies by scientists **[6]** prove that veganism positively affects the gastrointestinal tract and cardiovascular system. Adherence to a strict form of vegetarianism is one of the ways to prevent atherosclerosis, hypertension, some forms of cancer, and diabetes. However, the complete rejection of any animal products has several disadvantages: people are deficient in protein, iron, calcium, zinc, phosphorus, and copper, as well as fat-soluble vitamins A and E and omega-3 fatty acids. According to the World Health Organization, a vegan diet without additional intake of

vitamin B_{12} can cause anemia **[7]**. Therefore, the urgent task is to develop new technologies for vegan dishes with the optimal macro- and micronutrients necessary for the human body and improved organoleptic indices.

Vegetarianism has been a part of human culture since ancient times. Adherents of plant-based diets existed in ancient Greece and Asia **[8]**. Pythagoras, Zarathustra, Aristotle, and Plato did not eat meat. In the 1700s, Christians in Europe and North America promoted the concept of vegetarianism as part of a religious lifestyle that also included pacifism, abolition of slavery, and abstinence from alcohol. Until the 19th century, moral and metaphysical arguments justified the refusal to eat animals. However, in the early 1800s, an increased pursuit of better health in combination with increased authority of science helped to shape the physiological arguments for vegetarianism. As food science has developed since the mid-twentieth century, vegetarianism has gained general acceptance as a healthy dietary alternative. But since this alternative is still often chosen for moral or religious reasons, familiarisation of future vegetarians with possible negative health consequences remains an important activity. Today, vegetarianism is the most widespread system of non-traditional nutrition. Eating food is a significant part of social culture and identity, as is the appearance of vegetarianism and veganism, which are associated with a new culture of nature management and humanism.

It has been determined **[9]** that vegetarianism is a diet that refuses to consume meat and meat products, including meat of cattle, poultry, fish, and flesh of any other animal. This diet is gradually gaining great popularity around the world. Thus, one of the largest vegetarian communities lives in India, and many people who adhere to this diet live in European countries, such as Italy, Great Britain, Germany, and the Netherlands. At the same time, veganism is a more stringent diet that involves a complete rejection of food products associated with animals, including milk, eggs, and other products for the manufacture of which animals are involved in one way or another. According to various estimates**[10]**, vegans today comprise 0.25 to 2.5% of the UK population and 0.2 to 1.3% of the US population. Many vegans live in Holland, Sweden, Denmark, and other European countries.

A recent study **[11]** shows a rapid tendency to increase the number of vegans in Ukraine. The reasons for adhering to vegetarianism are various, from ethical reasons, religious beliefs, and features of the closest environment to improvement in health. The results of many scientific studies **[12]**, **[13]** on the positive effects of vegetarian diets on human health are known. Thus, vegetarianism as a type of diet can be attributed to healthy nutrition.

However, new vegan cafes, restaurants, catering establishments, bakeries, and enterprises that produce food products and various vegan products exist and are constantly opening abroad. Many online stores specialise in vegan products on the Internet **[14]**. The works of many scientists are devoted to the issue of rationing the nutrient composition of health-improving food products to a person's physiological needs in nutrients: P.O. Karpenko, M.I. Peresichnyi, L.V. Bal-Prylypko, V.N. Korzuna, A.M. Dorokhovych, H.O. Simakhina, N. M. Zubar, O.I. Cherevka, M.R. Shpahat, H. Godfray, V. Bezsheiko, NSRizzo et al. **[15]**, **[16]**. Based on the analysis of literature sources, it can be concluded that developing new technologies for cooking dishes with increased biological value for vegan cuisine is a timely and promising task for scientists.

Scientific Hypothesis

Given the rapid trend of increasing the number of vegans in Ukraine, an analysis of the range and composition of vegan nutrition dishes has been conducted. It has been determined that there is a need for more biologically active substances in vegan dishes. The development of technologies for cooking dishes for vegan nutrition using plant raw materials, which have a high content of biologically active substances, is an urgent task. Given this, using flax seeds and blueberry extract in vegan cuisine will purposefully improve falafel's functional and organoleptic indices. Accordingly, the developed technology of cooking falafel dishes will make it possible to enrich the diet of vegans with deficient biologically active substances and expand the range of menus for restaurant industry facilities.

MATERIAL AND METHODOLOGY

Samples

The study was performed in a laboratory of healthy nutrition and restaurant technologies of the Faculty of Food Technology and Product Quality Management of the Agro-Industrial Complex of the NULES of Ukraine.

Chemicals

Water (chemical formula H_2O) was used to soak different flax seed varieties during extraction. Water corresponds to the national standard DSTU ISO 7887:2003 **[25]**. A salt solution (1% NaCl) extracted polysaccharides from flax seeds.

Animals, Plants and Biological Materials

The following was used for the study:

- dry blueberry extract – manufacturer: Frutta (Ukraine) (Figure 1-a);
- highest quality flax seeds (humidity 7.8%, purity – 97.9% (VIOLA brand (Ukraine) (Figure 1-b);
- chickpeas with a humidity of 10.6%, protein content – of 21%, and fibre of 17.1% (Kyshentsi LLC, Cherkasy region, Ukraine) (Figure 1-c);
- vegetable oil **[17]**: sunflower oil, refined, first pressing (Oleina™, Ukraine)
- wheat flour **[18]**: of the highest quality (Kyivmlyn LLC, Ukraine)
- spring onion, garlic, parsley leaves.

a b c

Figure 1 Main ingredients for cooking falafel: a – dry blueberry extract, b – flax seeds, c – chickpeas.

Instruments

Laboratory scales AXIS AD 510 (Poland) with a permissible weighing error of ±0.01 g.
Laboratory mill OlisLab 2100 manufactured by Olis LLC (Ukraine).
Blender BOSCH MSM2620B (Germany).
Convection oven XF 023 9 Brand: Unox (Italy).
Glass beaker with a volume of 500 cm^3 according to DSTU ISO 4787:2009.
Porcelain tableware, according to DSTU 2084-92.
Laboratory thermometer (TLS-200, manufactured by Inter-Syntez LLC, Ukraine).

Laboratory Methods

The methods of research are organoleptic, experiment planning, and mathematical processing of experimental data based on computer technologies. The organoleptic quality assessment was carried out using a five-point scale. For each organoleptic indicator, a weighting factor was determined: appearance: 0.3, consistency: 0.2, colour: 0.1, odour: 0.2, and flavour: 0.2 **[19]**.

Description of the Experiment

Sample preparation: To develop the technology of cooking the falafel dish, 300 g of chickpeas were weighed, washed with running water, and transferred to a glass beaker. Then, the chickpeas in the beaker were poured with water and left to soak for 4 hours. After soaking, the chickpeas were boiled for 2 hours, cooled, and crushed in a laboratory mill to a homogeneous consistency.

While the chickpeas were cooked, other components of the dish were prepared for each sample: one control sample and three experimental samples.

Onion, garlic, and parsley were peeled, washed, and crushed, and the estimated amount for each study option was weighed. The flour was sifted and weighed separately for the control variant, 15 g, and the experimental variant, 10 g.

Flax seeds and dry blueberry extract were used only for experimental variants. Flax seeds were crushed in a laboratory mill and weighed according to the experimental variant: Experiment No. 1 – 7.5 g; Experiment No. 2 – 5 g; Experiment No. 3 – 2.5 g. The dry blueberry extract was weighed according to the experimental variant: Experiment No. 1 – 2.5 g; Experiment No. 2 – 5 g; Experiment No. 3 – 7.5 g.

For each variant, 60 g of crushed chickpeas were weighed, and an appropriate number of prepared components were added. All elements of the control variant and the three experimental variants were separately mixed to a homogeneous consistency using a blender. The falafel balls were formed and baked in a convection oven at 180ºC for 5 min.

Number of samples analyzed: during the experimental studies, four samples were taken, namely, three experimental samples and one control sample.

Several repeated analyses: The experiments were repeated five times; thus, the methods of mathematical statistics of experimental data processing were used.

Number of experiment replications: Each experiment was conducted five times, and the number of samples – three- led to repeated analyses.

Design of the experiment: Cooking the falafel dish was carried out according to the expected technological scheme, which consists of the following operations: acceptance and mechanical culinary processing (MCP) of raw materials; soaking of chickpeas for 4 hours; boiling of chickpeas for 2 hours; grinding of flax seeds; weighing of components; dosing of components by experimental options; mixing of components; forming of falafels; baking of samples at a temperature of 180 °C; cooling and preparation for organoleptic evaluation.

The experimental design accounted for variations in sample composition and preparation processes to ensure the reliability and reproducibility of results. Using several samples and repeated experiments minimised the influence of random errors and ensured the statistical significance of the obtained data. Various options for components and their ratio allowed us to assess the influence of each element on the final quality of falafel, which contributed to the development of optimal cooking technology.

Statistical Analysis

Statistical processing was performed using Microsoft Excel 2016 in combination with XLSTAT. The accuracy of the experimental data obtained was determined according to Student's t-criterion with a confidence probability of ≤0.05 for several replicate measurements – minimum 5. Linear programming problems were solved using the settings of MS Excel "Finding a solution" (ExcelSolver) **[19]**.

RESULTS AND DISCUSSION

Vegetarian cuisine in general, and vegan cuisine in particular, combines original traditional dishes of different world peoples with their adapted versions—so-called ‘veganized’ **[20]**. Recipes can be 'veganized' by replacing animal products with plant-based ones. The development of technology for cooking food products for vegan nutrition is based on the knowledge of the norms of each nutrient content in the finished product to meet human needs optimally **[21]**.

In Ukraine, where supporters of vegetarianism and veganism represent a fairly large proportion of the population, more specialised restaurant industry facilities and a narrow range of products offered on the menus of the facilities mentioned above need to be observed **[22]**.

It has been determined **[23]** that in vegetarian and vegan nutrition with the refusal of consumption of meat and meat products, dairy products, that is, products that are sources of animal protein, protein deficiency is replaced due to the widespread use of legumes, namely soybeans, peas, beans, chickpeas.

Chickpeas (*Cicer arietinum*) – one of the most consumed legumes in the world (more than 2.3 million tons come on the world market annually) **[24]**. Studies have shown that chickpeas, one of the most consumed legumes in the world, are an essential source of proteins, carbohydrates, vitamins, minerals, and dietary fibre. Due to this, chickpea seeds are used for vegetarian nutrition **[25]**.

To increase the biological value of the falafel dish, research was conducted on various types of plant raw materials grown in Ukraine and characterised by a high content of biologically active substances **[26]**.

A vegan diet requires special attention to nutrients such as protein, iron, calcium, vitamin B12, vitamin D, and omega-3 fatty acids with long chains to prevent deficiencies and ensure overall health and well-being **[27]**.

Different raw materials from plants with a high biologically active content are used for desserts and beverages **[28]**. The functional and technological features of ice cream for vegetarians have also been researched **[29]**. A promising direction is to use raw materials from medicinal plants to create food products that improve health **[30]**.

Blueberries were selected after analysing the use of wild raw materials to provide food products with biologically active substances **[31]**. Blueberries were traditionally used in Ukrainian cuisine for making beverages, filling for pies, and dumplings **[32]**.

Today, the technology of low-temperature extraction of raw plant materials, namely blueberries and elderberries, which makes it possible to preserve all valuable components, has become widely used. For extraction, environmentally friendly raw materials are used, which undergo several stages of processing: grinding, extraction, moisture removal, and lyophilic drying. As a result, a finely dispersed, highly hygroscopic powder is obtained, with an insoluble substance content of not more than 5% **[33]**. Dry blueberry extract produces such technology, allowing it to preserve vitamins, microelements, and other biologically active substances **[34]**.

The composition of dry blueberry extract includes **[35]** anthocyanins (up to 25%); oligo-elements: potassium, calcium, magnesium, and iron; vitamins: C, B_1, B_2. The extract also contains organic fruit acids: lemon, apple,

milk, oxalic, amber, quinic, tanning substances, tannins, epimirtin, quercetin, hyperoside, and isoquercitrin. The chemical composition of the dry blueberry extract is given in Table 1.

Table 1 Chemical composition of dry blueberry extract.

Name of indicator	Value, mg % per 100g
Ascorbic acid, C	10
Thiamine, B1	1.4
Riboflavin, B2	0.8
Pantothenic acid, B3	2.1
Carotenes	0.75-1.6
Flavonoids: ***hyperin, astragalin, quercitrin, isoquercitrin, rutin***	460-600
Anthocyanins: ***delphinidine, malvidine, petunidine, idain, myrtiline***	650-780
Phenolic acids: ***coffee, quinic, chlorogenic***	28-35
Phenols and their derivatives: ***hydroquinone, monotropeoside, asperuloside***	30
Tanning substances	120
K (potassium)	870-1,200
Ca (calcium)	98-1,120
Cl (chlorine)	76-435
P (phosphorus)	125-286
S (sulfur)	123-232
Zn (zinc)	10.4-31.4
Fe (iron)	729-3,120
Cu (copper)	570 -3,230

Dry blueberry extract has astringent, rot-preventing, and antimicrobial properties **[36]**. Blueberry carotenoids improve night vision and visual apparatus function. Dry blueberry extract is of particular value for vegans due to many anthocyanins, which reduce the aggregation ability of red blood cells in vitro and have a hematopoietic function **[37]**.

Flax seed is also a traditional raw material for enriching food products **[38]**, and it is used mainly in bakery products. However, it has a unique chemical composition and pharmacological properties. The content of essential substances in mature flax seeds, protein substances 18-33%, mucus 5-12%, carbohydrates 12-26%, nitrogen-free extractive substances 22%, fatty oils 30-50%, fatty acid triglycerides: linolenic 30-45%, linoleic 25-59%, oleic 18-20%, stearic glyceride 8-9%, palmitic, arachidonic, myristic, and α-tocopherol **[39]**. The uniqueness of flax seed is due to its very high content of polyunsaturated a-linolenic fatty acid, which is essential for the human diet. Like certain hormones, it contributes to the performance of important biochemical functions in the human body – it is part of cell membranes, participates in the regeneration of the cardiovascular system, in brain growth and development, has vasodilating properties, and exhibits anti-stress and antiarrhythmic effects. Seeds contain phytosterols, enzymes, and vitamins C, A, and F. High molecular weight compounds that release lino-caffeine and linocinamarine during hydrolysis have been found in the flaxseed shell. Flaxseed contains oil consisting of glycerides of linoleic and linolenic acids; organic acids and carotene; macronutrients: potassium, calcium, magnesium, iron; micronutrients: manganese, copper, zinc, selenium, and boron. Flaxseed also has anti-inflammatory, analgesic, anti-sclerotic, and mildly laxative effects. Attractive appearance and the ability of flax shell substances (lignan compounds – antioxidants) to prevent hormone-dependent cancer, namely, prostate and mammary gland cancer, to stabilise blood sugar levels, determine the use of flax raw materials in whole grains.

The results **[40]** of experimental studies show that flaxseed is characterised by an increased content of proteins and fat, which account for 66-68% of the total weight (Table 2).

Table 2 Chemical composition of flaxseed.

Indices	Features of flaxseed, %
Moisture	9.26
Fat	36.55
Protein	30.65
Sugar	4.43
Pentosans	7.80
Cellulose	13.30
Ash	4.18

The seeds' lipids are of particular physiological and nutritional value; they can be used as a natural source of physiologically active forms (Omega-3 and Omega-6) of polyunsaturated fatty acids **[41]**. Flaxseed tocopherols are also essential functional components that positively impact human health.

The results of experimental studies **[42]** of the fractional composition of lipids in flaxseed show that neutral lipids dominate in flaxseed, which make up 98% of its total amount (Table 3).

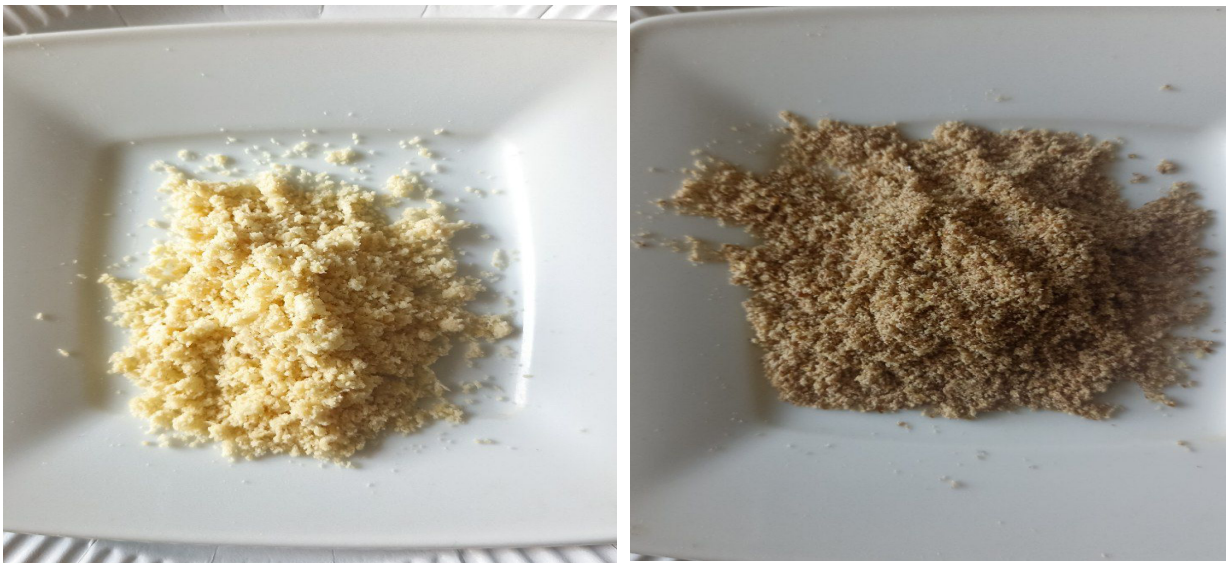
Table 3 Fractional composition of lipids in flaxseed.

Composition of lipids	Features of flaxseed
Triglycerides	97.83
Phospholipids	0.83
Free fatty acids	0.08
Sterols	0.46
Sterol esters	0.12
Mono- and diglycerides	0.11
Tocopherols, mg %	49
In particular, unsaturated fatty acids:	88.10 ±4.32
palmito-oleic	0.22 ±0.13
oleic	21.40 ±1.11
linoleic	12.40 ±1.03
linolenic	54.08 ±3.14

Having analysed the chemical composition and technological properties of blueberry extract and flaxseed, it should be noted that using these components in producing specialised food products for vegans is a promising solution. Blueberry extract and flaxseed's rich vitamin and mineral composition confirm the feasibility of using these ingredients in cooking falafel with chickpeas for vegan nutrition.

The proposed dry blueberry extract and flaxseed can be considered enrichment agents of vitamins A, E, F, and C and group B and minerals iron, calcium, zinc, phosphorus, and copper, which should additionally enter the body of a person who refuses to eat any products of animal origin.

The classic falafel recipe includes chickpeas, garlic, onion, parsley, cilantro, salt, flour, vegetable oil, and additives such as dry blueberry extract and flax seeds. Figure 2 shows smashed chickpeas and crushed flax seeds (b).



a b

Figure 2 Smashed chickpeas (a) and crushed flax seeds (b).

The development of technologies with different amounts of dry blueberry extract and flax seeds was carried out. To determine the optimal ratio of ingredients, experimental samples of falafel with model compositions based on chickpeas with the addition of dry blueberry extract and flax seeds were prepared. The model compositions of the experiments are shown in Table 4.

Table 4 Model compositions of falafel based on chickpeas with the addition of dry blueberry extract and flax seeds.

Name of ingredient	Control	Experiment 1	Experiment 2	Experiment 3
Chickpeas	60	60	60	60
Garlic	5	5	5	5
Onions	10	10	10	10
Parsley	5	5	5	5
Flour	15	10	10	10
Vegetable oil	5	-	-	-
Dry blueberry extract	-	2.5	5	7.5
Flaxseed	-	7.5	5	2.5
Output weight	100	100	100	100

The organoleptic evaluation of model compositions of falafel based on chickpeas with the addition of dry blueberry extract and flax seeds was carried out. The organoleptic parameters of falafel were identified, particularly appearance, colour, consistency, flavour, and odour. The organoleptic evaluation of experimental and control samples of falafel was carried out on a five-point system by generally accepted recommendations **[43]**. The results of the organoleptic assessment of experimental and control samples of cocktails are shown in Table 5.

Table 5 The organoleptic evaluation of falafel based on chickpeas with adding dry blueberry extract and flax seeds (points).

Quality indicators	Falafel based on chickpeas with the addition of dry blueberry extract and flax seeds			
	Control	Experiment 1	Experiment 2	Experiment 3
Appearance	4.8	4.7	4.7	4.7
Flavor	4.8	5.0	5.0	5.0
Odor	4.8	5.0	4.9	5.0
Colour	4.8	4.8	4.8	4.7
Consistency	4.9	4.9	4.7	4.7
Overall score	4.82	4.88	4.84	4.83

The model composition of falafel (Experiment 1) received the highest organoleptic evaluation, in which the complete amount of vegetable oil and a third of the total amount of flour were replaced with 2.5% dry blueberry extract and 7.5% flax seeds. A new type of falafel with blueberry extract and flax seeds was called „Falafel Active“. Figure 3 shows the experimental and control samples of falafel.

Figure 3 Samples of falafel: a - control, b - experimental 1, c - experimental 2, d - experimental 3

Figure 4 shows the serving of the ready-made dish ‘Falafel Active’.

Figure 4 'Falafel Active' dish for vegans using flax seeds and blueberry extract.

The developed technological scheme of cooking a 'Falafel Active' dish for vegan cuisine is shown in Figure 5.

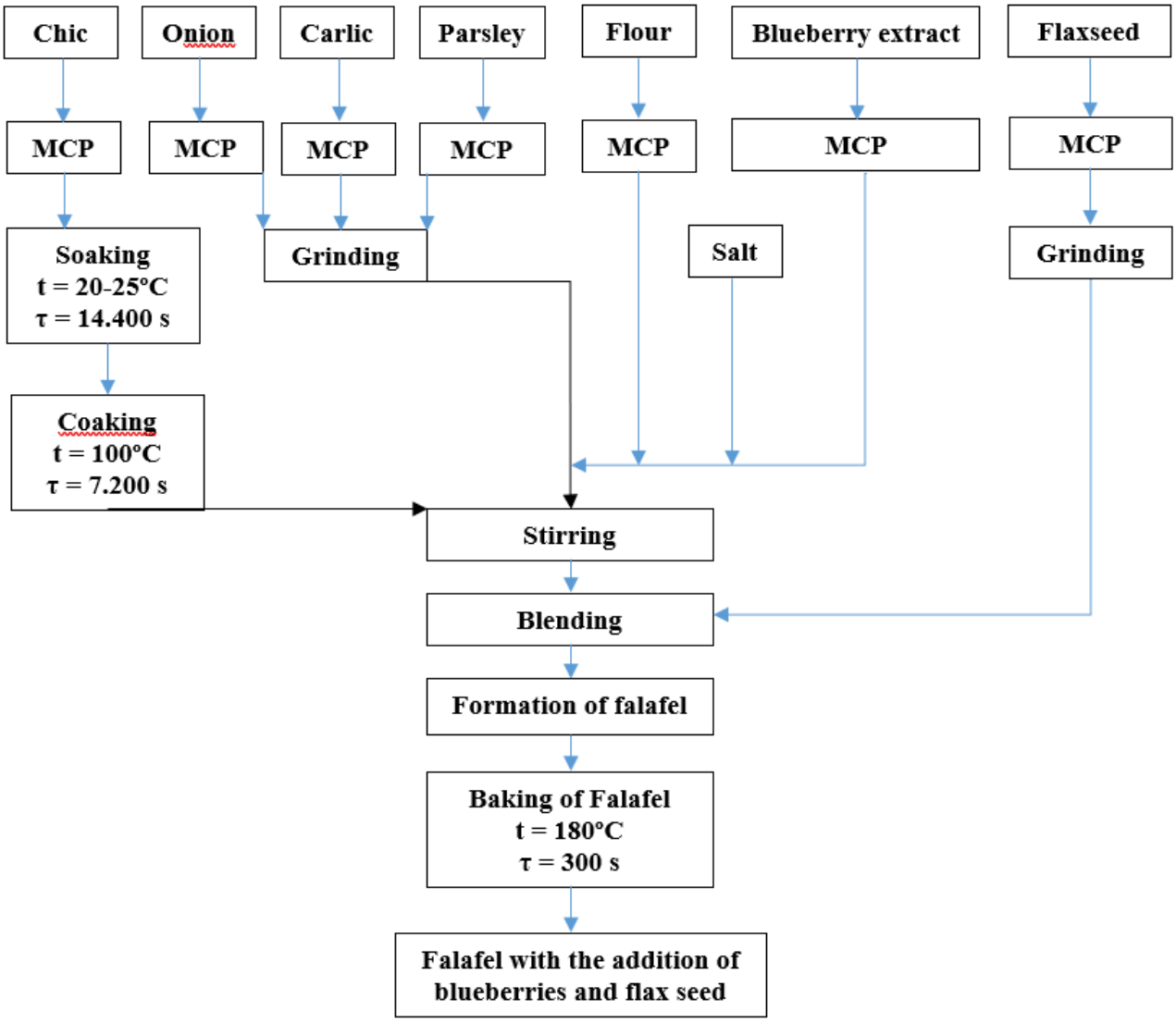


Figure 5 Technological scheme of cooking 'Falafel Active' dish for vegan cuisine.

The chemical composition of 'Falafel Active' based on chickpeas with the addition of dry blueberry extract and flax seeds was analyzed compared to the traditional recipe (Table 6). The content of biologically active substances increased in the developed 'Falafel Active' dish with the addition of 5% of dry blueberry extract and 5% of flax seeds: vitamin A – by 12%, vitamin C – by 17%, magnesium – by 31%, iron – by 40%, zinc – by 31%, phosphorus – by 53%. Vitamins B_1 and B_2 are almost absent in the control, and the amount of these vitamins in the developed product is 0.14 and 0.08 μg per 100 g of the product, respectively. It has been determined that, due to the use of a composition of flax seeds and blueberry extract in the traditional technology of cooking falafel, the developed dish has an attractive appearance, and the flavour of the dish has become more saturated. Most importantly, the content of biologically active substances has been significantly increased, namely the content of vitamins and micronutrients.

Table 6 Comparison of the chemical compositions of control and experimental samples of falafel.

Name of indicator	Control	Experiment 1	Difference, units	Difference, %
Energy value, kcal	321.00	294.00	-27.00	91.59
Proteins, g	13.00	14.00	1.00	107.69
Dietary fiber, g	6.90	7.40	0.50	107.25
Mono- and disaccharides	3.10	4.20	1.10	135.48
Saturated fatty acids	1.10	0.80	-0.30	72.73
Unsaturated fatty acids	2.50	3.50	2.50	126.43
Potassium, mg	738.20	771.30	33.10	104.48
Calcium, mg	143.70	146.40	2.70	101.88
Magnesium, mg	89.00	116.90	27.90	131.35
Sodium, mg	89.00	90.10	1.10	101.24
Phosphorus, mg	289.60	445.10	155.50	153.69
Iron, mg	2.20	3.10	0.90	140.91
Copper, μg	417.30	495.10	77.80	118.64
Zinc, mg	1.90	2.50	0.60	131.58
Vitamin A, μg	64.20	67.20	8.00	112.46
Beta-carotene, μg	0.40	0.40	0.00	100.00
Thiamine, B_1 μg	Traces	0.14	0.14	140.00
Riboflavin, B_2	Traces	0.08	0.08	8.00
Ascorbic acid, C, mg	9.40	11.00	1.60	117.02

The developed 'Falafel Active' dish, based on chickpeas using dry blueberry powder and flax seeds, is suitable for vegans and other categories of the population, namely for elderly people who need dietary nutrition.

Given that chickpeas are the main component of the 'Falafel Active' dish, research on the possibilities of using chickpeas for healthy nutrition was analyzed. The preclinical and clinical studies conducted **[44]** show that some components of chickpeas have several health benefits, including antioxidant capacity and antifungal, antibacterial, analgesic, anticancer, anti-inflammatory and hypocholesterolemic properties. Thus, developing new products with high biological activity creates new opportunities for research and application of chickpeas in food products.

The use of bioactive compounds of chick chickpeas ingredients in food products is also a promising area regarding the availability of their health benefits **[45]**. The results of research **[46]** on the production of chickpeas, trends of consumption, applications in the food industry, and most importantly, theologically active compounds and functional properties of the ingredients of chickpeas that need to be taken into account when developing new products, in particular when developing chickpea plant-based snacks, taking into account the biologically active compounds associated with healthy nutrition of patients with type 2 diabetes (DM2) **[47]**, are generalised.

It has been established that flax seeds are widely used to manufacture bakery products, cheeses, and sauces. Because flaxseed is a source of dietary fibre, complete protein, unsaturated fatty acids, minerals, and vitamins, it enriches bakery products of various assortments **[48]**. According to the research results, it has been established that the technologically possible dosage of crushed flax seeds in the wheat bread recipe is up to 20% by weight of flour. Products with developed porosity, a pleasant light-yellow colour of the crumb, and a pleasant nutty flavour are obtained at this dosage. In our research, the use of flax seeds is 7.5% of the product weight, which contributes to the fact that the 'Falafel Active dish has a pleasant nutty flavour and aroma.

Blueberries are widely used in the technology of cooking desserts and beverages **[49]**. The prospect of using dry blueberry extract is that blueberries contain many natural antioxidants. Modern research proves **[50]** that natural antioxidants of plant raw materials are also considered preservatives in various food products due to

innovative extraction methods and processes for stabilising their properties. The research has linked regular moderate consumption of blueberries or their anthocyanins to a reduced risk of cardiovascular disease and type 2 diabetes and improved weight maintenance and neuroprotection. These results are supported by data from human clinical trials based on biomarkers. Blueberries' most important beneficial properties are their anti-inflammatory and antioxidant effects and their beneficial effect on vascular and glucoregulatory function **[51]**. Blueberries' phytochemicals can affect the gastrointestinal tract's microflora and promote health.

"Falafel Active" is an innovative vegan product that offers numerous benefits. It combines the high content of omega-3 fatty acids from flaxseed and antioxidants from blueberries, providing a nutritious and delicious snack. Environmental and economic sustainability:

Locally grown ingredients: using raw materials grown on local farms reduces the carbon footprint by reducing transport costs and greenhouse gas emissions. It also helps preserve biodiversity and support local agricultural practices.

Supporting the local economy: purchasing ingredients from local producers contributes to the development of local businesses, job creation, strengthening the region's economic stability and increasing its well-being. Innovativeness:

The proposed combination of "Falafel Active" is unique on the market, offering a new approach to healthy eating, so there is no doubt that such a product will be able to satisfy the growing demand for healthy, sustainable and locally produced products among vegans and supporters of a healthy lifestyle. Thus, this product improves consumers' nutrition and contributes to the preservation of the environment and the support of the local economy.

The search for scientific research on using the composition of blueberries and flax seeds in food technologies showed no results. In our work, flax seeds and blueberry extract in vegan products have been investigated for the first time. Given that blueberries, like flax seeds, are the products that are grown in Ukraine and have long been used for the nutrition of Ukrainians, we can conclude that the research in the direction of applying the composition of such components as dry blueberry extract and flax seeds to develop the technologies of cooking various dishes is quite timely and promising.

CONCLUSION

The result of the research is the creation of the 'Falafel Active' *dish based on chickpeas* with the addition of dry blueberry extract and flax seeds. The optimal amount of dry blueberry extract and flax seeds, which is why the 'Falafel Active' dish has an increased content of minerals and vitamins and meets the specific needs of vegans, has been determined. It is established that the best results, according to the organoleptic evaluation, have been obtained for the experimental sample containing 2.5% dry blueberry extract and 7.5% flax seeds per 100 g of the product. The research results show an improvement in the organoleptic parameters of falafel. It is proved that the biological value of the 'Falafel Active' dish based on chickpeas with the addition of dry blueberry extract and flax seeds increases, as the content of phosphorus, potassium, calcium, zinc, magnesium, iron and vitamins A, C, B_1 and B_2, which are considered deficient for vegans, increases. It can be concluded that the developed 'Falafel Active product differs from the control by increasing the proportion of deficient vitamins and minerals, which makes it possible to increase the biological value of the new product. At the same time, the energy value of falafel decreases. Vegetable oil is wholly excluded from the falafel composition, and the flour amount is reduced by a third. Consequently, it can be concluded that it is advisable to use dry blueberry extract and flax seeds to cook a vegan dish – falafel based on chickpeas. The use of these nutritional supplements is a promising solution, and it allows for the expansion of the range of vegan dishes, enriching the flavour of a dish, contributing to ensuring the daily need for deficient minerals and vitamins, which contributes to improving the vegan diet and expanding the range of dishes in catering establishments. Scientists urgently need to develop technologies for cooking various health-improving dishes that use a composition of components useful for human health, such as dry blueberry extract and flax seeds.

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Funds:

This research received no external funding.

Acknowledgments:

We would like to thank you to Dr. Larysa Bal-Prylypko

Conflict of Interest:

No potential conflict of interest was reported by the author(s).

Ethical Statement:

This article does not contain any studies that would require an ethical statement.

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