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ECOLOGICAL AND NUTRITIONAL JUSTIFICATION OF RECIPE COMPONENTS FOR A NEW TECHNOLOGY OF MINCED FISH PRODUCTS

Purpose. To substantiate the use of pumpkin puree as a local vegetable raw material in the technology of minced fish products from the perspective of human ecology, sustainable nutrition, food safety, and resource-oriented restaurant production.

Methods. The study used an analytical review of current literature on sustainable healthy diets, dietary fiber, bioactive components of pumpkin and quality of fish products; normative analysis of raw material requirements; technological modelling of the formulation; calculated assessment of nutritional and energy value; descriptive organoleptic assessment of the experimental sample; and interpretation of microbiological indicators of the finished dish. Traditional fish patties without pumpkin puree were considered as a recipe prototype; however, quantitative experimental comparison with a control sample was not performed due to the lack of repeated primary measurements.

Results. The addition of pumpkin puree to the formulation of minced fish products had technological, nutritional, and preliminary Ecological significance. It increased the share of a locally available plant component, formed natural colour, supported juiciness and soft texture, and supplemented the fish protein base with dietary fibre, pectin substances, and carotenoids. According to calculated data for fish patties with pumpkin without potato garnish, 100 g of product contained 4.06 g of protein, 9.80 g of fat, 0.98 g of carbohydrates, and 105.73 kcal. The experimental sample had an even surface, an orange shade, homogeneous tender consistency, and a characteristic fish taste with a moderate sweet pumpkin aftertaste. Microbiological indicators did not exceed established limits; pathogenic microorganisms, including *Salmonella* spp., were not detected in 25 g of product.

Conclusions. The developed recipe and technological model can be considered a preliminary substantiated direction for ecological and nutritional improvement of minced fish products. Its ecological interpretation is based on the local origin of the vegetable raw material, the combination of animal and plant components, and the use of gentle heat treatment. Further validation requires control experiments, statistically confirmed sensory assessment, instrumental determination of quality indicators, and quantitative life-cycle-based environmental assessment.

KEY WORDS: human ecology, sustainable nutrition, fish products, pumpkin, dietary fiber, food safety

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Introduction

Nutrition is one of the leading determinants of population health; therefore, current research in human ecology increasingly considers a food product not only as an object of technology but also as an element of the “environment – food raw material – diet – health” system. Within this approach, nutritional value, biological value, safety, raw-material accessibility,

local origin, energy efficiency of technological processes, and the potential to reduce excessive resource use in food production are important. The concept of sustainable healthy diets combines nutritional adequacy with minimization of the negative environmental impact of food systems and with consideration of the socio-cultural acceptability of products [1].



According to WHO recommendations, the diet of individuals older than 10 years should include at least 400 g of fruit and vegetables per day and at least 25 g of naturally occurring dietary fibre [2]. At the same time, actual consumer diets often remain deficient in plant raw materials, dietary fibre, and products containing natural biologically active substances. This makes it relevant to develop dishes in which an animal protein base is combined with local plant components that can increase the biological value of the product without complicating the technology.

Fish raw material has high biological value owing to complete protein, minerals, and the lipid fraction. However, the current development of aquatic food systems requires careful and rational use of fish resources, the creation of products with high added value, and the integration of fish products into healthy diets [3]. A promising direction is the combination of a fish base with plant raw materials that can perform technological, sensory, and nutritional functions.

Pumpkin is a plant raw material widely cultivated in Ukraine and available at a relatively low cost. It contains dietary fibre, pectin substances, vitamins, carotenoids, polyphenols, mineral elements, and other biologically active substances. Current reviews highlight the potential of pumpkin for creating new functional foods and for implementing circular-economy approaches in food production [4, 5]. Dietary fibre supplied by plant raw materials affects the intestinal microbiota, metabolic processes, and the risks of non-communicable diseases, thereby forming the medical and ecological context of the study [6, 7].

A separate condition for the practical implementation of such products is their sensory

acceptability. Modern sensory science regards organoleptic properties as a key link between the technological parameters of a product, consumer expectations, and actual food choice [8-10]. Therefore, when developing combined fish-and-plant products, it is necessary to evaluate the recipe composition, technological feasibility, quality, safety, and ecological interpretation of raw-material use simultaneously.

An unresolved issue remains the scientific substantiation of the use of pumpkin puree in minced fish systems specifically from the perspectives of human ecology and sustainable nutrition. Most existing studies primarily emphasize technological or culinary advantages, whereas ecologically and nutritionally oriented research requires demonstrating the relationship between the selection of raw materials, their safety, nutritional value, and the environmentally oriented organization of nutrition.

The purpose of this study is to provide ecological and nutritional justification for the use of pumpkin puree as a local vegetable raw material in the technology of minced fish products in order to increase the nutritional value, sensory quality, and safety of the finished dish in the context of sustainable nutrition.

To achieve this purpose, the following tasks were set: to substantiate the choice of fish and vegetable raw materials; to develop a recipe model for the dish “Fish patties with pumpkin”; to evaluate the organoleptic properties of the experimental sample; to determine calculated indicators of nutritional and energy value; to interpret the microbiological indicators of the finished product; and to identify directions for further ecological validation of the technology.

Objects and Methods of the Study

The object of the study is the production technology of minced fish products with the use of pumpkin puree. The subject of the study is the recipe composition, technological operations, organoleptic properties, calculated indicators of nutritional value, and microbiological safety of the finished dish. The experimental sample is the recipe model “Fish patties with pumpkin”. Traditional fish patties without pumpkin puree were considered as the control recipe prototype.

The methodological scheme of the study included: 1) analysis of current sources on sustainable nutrition, dietary fibre, biologically

active substances of pumpkin, the quality of fish products, and sensory evaluation; 2) normative substantiation of the choice of raw materials; 3) formulation development; 4) calculation of nutritional and energy value; 5) descriptive organoleptic evaluation; and 6) analysis of microbiological compliance of the finished product. The approach corresponds to the principles of combining traditional and ecologically oriented analytical procedures in food science [11] (fig. 1).

Pike perch, bulb onion, pork back fat, garlic, pumpkin, table salt, ground black pepper, and butter were used to produce the experimental samples. Raw-material quality was



Fig. 1 – Conceptual scheme of ecological and nutritional justification for using pumpkin puree in minced fish products

assessed according to current normative documents, in particular those regulating live fish, pumpkin, salt, pepper, and butter [12-16] (table 1). Pumpkin puree was prepared by peeling the pumpkin, cutting the pulp into cubes, steaming it until softened, and grinding it to a homogeneous consistency. Steaming was selected as a gentler method of vegetable raw-material preparation compared with intensive frying. Organoleptic evaluation was carried out according to a descriptive scheme that considered appearance, colour, consistency, aroma, and taste. The results of organoleptic evaluation were interpreted as a descriptive profile of the experimental sample. For further validation, sensory

evaluation of samples produced in several batches is planned using a scoring scale followed by calculation of mean values and confidence intervals.

The nutritional and energy value was determined by a calculation method based on the recipe composition. The calculation was performed for fish patties with pumpkin. Microbiological indicators of the finished product were interpreted using the data provided in the source materials on the number of mesophilic aerobic and facultative anaerobic microorganisms, coliform bacteria, *Escherichia coli*, *Staphylococcus aureus*, *Proteus*, and pathogenic microorganisms, including *Salmonella* spp.

Table 1

Normative characteristics of the main raw materials for the experimental sample

Raw material	Normative document	Key quality and safety indicators
Pike perch	DSTU 2284:2010	Fresh fish with clean scales, clear eyes, red gills, elastic muscles, and a characteristic odour without foreign signs.
Pumpkin	DSTU 3190-95	Fresh, whole, clean, mature fruits without damage or foreign odour, with typical colouring and a moderately sweet taste.
Auxiliary raw materials	DSTU 3234-95; DSTU 3233-95; DSTU 3583:2015; DSTU ISO 959-1:2008; DSTU 4399:2005	Compliance with organoleptic and physicochemical requirements of normative documents; absence of foreign impurities, signs of spoilage, and uncharacteristic odour.

The ecological interpretation was performed at the level of qualitative analysis and included the locality and determination of environmentally safe cultivation conditions for plant raw materials, the combination of

animal- and plant-based ingredients, the use of gentle heat-treatment methods, and the potential for reducing the proportion of ingredients associated with higher resource intensity.

Results of the Study

The recipe model was formed according to the principle of combining a lean fish base with a vegetable component that functions as a natural structure-forming agent, a source of

biologically active substances and dietary fibre, and a sensory modifier. Pike perch is the main protein component. Pumpkin puree was introduced as a local vegetable additive capable of

modifying the colour, consistency, and nutritional profile of the product (table 2).

From an ecological perspective, the use of pumpkin offers several advantages: the raw material is widely cultivated in Ukraine, demonstrates good storage stability, does not require complex preliminary processing operations, can be used seasonally or after short-term storage, and contributes to increasing the proportion of plant-based components in the dish. Such an approach is consistent with the modern perception of pumpkin as a crop cultivated under environmentally safe conditions that is important for food and nutritional security [17], as well as with applied studies on the

use of plant raw materials in food technologies [18, 19].

The technological process includes preparation of fish fillet and vegetable raw materials, preparation of pumpkin puree, grinding of components, formation of the minced mass system, portioning, shaping of products, poaching, addition of butter, and service with a garnish. In the new technology, pumpkin puree has a dual effect: it acts as a structure-forming component of the mince and increases the proportion of plant raw material in the dish, enriching the final product with biologically active substances. This makes it possible to obtain a new product of enhanced biological value and high organoleptic quality.

Table 2

Recipe composition of the experimental dish “Fish patties with pumpkin”

Raw material	Gross, g	Net, g
Pike perch	115	55
Bulb onion	5	4
Pork back fat	20.8	20
Garlic	1.3	1
Pumpkin	30	20
Table salt	1.3	1
Ground black pepper	1.3	1
Semi-finished product mass	-	102
Finished patties mass	-	112
Garnish: mashed potatoes	-	150
Butter	10	10
Yield of the complete dish	-	272

The organoleptic indicators of the developed product show that pumpkin puree not only enriches the recipe with a plant component but also affects the visual and textural properties of the product. The most noticeable effect is the formation of a natural light-orange color, which increases the visual attractiveness of the dish (tab.3).

The indicators of nutritional and energy value are presented in Table 4. Pike perch is the main source of protein in the developed product; the fat fraction is formed mainly by pork back fat and butter; and pumpkin provides the addition of a plant component, dietary fibre, vitamins, and polyphenolic substances.

Table 3

Organoleptic profile of the experimental sample

Indicator	Characteristic
Appearance	The products have an even surface and retain a rounded shape; they are served with butter.
Colour	A light-orange or orange shade caused by the addition of pumpkin puree.
Consistency	Tender, soft, and homogeneous; the product retains its shape when cut.
Aroma	Characteristic fish aroma with light vegetable and spicy notes.
Taste	Taste of the fish base with a moderate sweet pumpkin aftertaste.

Table 4

Nutritional and energy value of fish patties with pumpkin per 100 g of product

Raw material	Water, g	Protein, g	Fat, g	Sugars, g	Starch, g	Dietary fibre, g	Ash, g	Energy value, kcal (kJ)
Pike perch	15.95	3.72	0.22	0.00	0.00	0.00	0.24	16.78 (70.23)
Bulb onion	1.26	0.02	0.00	0.07	0.01	0.02	0.01	0.60 (2.51)
Pork back fat	0.42	0.18	6.54	0.00	0.00	0.00	0.01	58.60 (245.34)
Garlic	0.21	0.02	0.00	0.00	0.09	0.01	0.01	0.53 (2.22)
Pumpkin	6.74	0.10	0.01	0.15	0.07	0.09	0.04	1.62 (6.78)
Table salt	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00 (0.00)
Ground black pepper	0.34	0.00	0.00	0.02	0.00	0.00	0.00	0.10 (0.42)
Butter	0.58	0.02	3.03	0.03	0.00	0.00	0.01	27.50 (115.06)
Total	25.50	4.06	9.80	0.27	0.17	0.12	0.69	105.73 (442.57)

The microbiological analysis demonstrated that the number of mesophilic aerobic and facultative anaerobic microorganisms in the finished product was 1×10^3 CFU/g. Coliform bacteria, *Escherichia coli*, *Staphylococcus aureus*, *Proteus* spp., and pathogenic microorganisms, including *Salmonella* spp., were

not detected within the established sample masses. These results indicate that the experimental batch complied with the basic microbiological safety requirements, provided that appropriate sanitary and hygienic conditions during production and serving were maintained.

Discussion

The obtained results confirm that the addition of pumpkin puree to minced fish mass has a complex effect. At the technological level, pumpkin puree acts as a component that improves water-holding capacity and contributes to the formation of a tender consistency. At the sensory level, it provides natural colouring and a moderate sweet taste that does not conflict with the flavour of the fish base. At the nutritional level, pumpkin increases the biological value of the final product by supplementing the formulation with dietary fibre, pectins, and carotenoids, which is consistent with current evidence on the functional potential of pumpkin raw materials [4, 5, 17].

From the perspective of human ecology, the key consideration is not the absolute increase in a single nutrient, but rather the trajectory of recipe modification through the combination of a complete protein base with locally sourced plant raw materials under the application of gentle technological processing regimes.

Such an approach is consistent with the concept of sustainable nutrition, according to which a food product should simultaneously be safe, nutritionally adequate, consumer acceptable, and resource-efficient [1, 2].

The practical significance of the results lies in the possibility of adapting the dish for restaurant enterprises that develop menus based on local ingredients, functional products, and more sustainable technological solutions. The use of pumpkin as an accessible plant raw material can be combined with current trends in gastronomy, emotional attractiveness of dishes, and the creation of competitive restaurant products [20, 21]. Consumer survey data on the orientation toward healthy eating also support the relevance of this direction [22-24].

Compared with traditional production technology, the emphasis of the developed technology for minced fish products with pumpkin is shifted from general restaurant innovation to ecological and nutritional justification.

Conclusions

The ecological and nutritional significance of the study was clarified: the use of pumpkin puree in minced fish products was substantiated as a means of combining a protein-rich fish base with locally sourced environmentally safe plant raw

materials possessing technological, sensory, and potential ecological value.

The developed recipe model for the dish "Fish patties with pumpkin" involves the addition of 20 g net pumpkin puree per portion. This pro-

vides a natural light-orange colour, a soft homogeneous consistency, and a moderate pumpkin aftertaste without losing the character of the fish base.

The nutritional and energy value of the developed fish patties with pumpkin was determined. A 100 g portion of product contains 4.06 g of protein, 9.80 g of fat, and 0.98 g of carbohydrates, with an energy value of 105.73 kcal.

The microbiological indicators of the experimental batch did not exceed established limits: pathogenic microorganisms, including *Salmonella* spp., were not detected in 25 g of product. This confirms the possibility of safe production of the dish, provided that sanitary and hygienic requirements for production and sale are observed.

The proposed recipe model may be considered a preliminarily substantiated direction for the

ecological and nutritional improvement of minced fish products.

Further scientific research will be aimed at comprehensive verification of the ecological advantages of the proposed product, identification of pathways and opportunities for obtaining certified environmentally safe raw materials, statistical processing of sensory and physicochemical indicators, and quantitative assessment of the environmental footprint using life-cycle-based ecological and technological methodologies. Such assessment will encompass different stages of the product life cycle, including production processes, preservation and storage under specified conditions, as well as packaging disposal for glass containers, metal lids, Pur-Pak, and Tetra Pak packaging systems.

Conflict of Interest

The author declares no conflict of interest regarding the publication of this manuscript. Furthermore, the author has fully adhered to ethical norms, including avoiding plagiarism, data falsification, and duplicate publication.

AI Statement

During the preparation of this manuscript, the artificial intelligence tool ChatGPT-5.5 (OpenAI, 2026) was used for structural, linguistic, and stylistic editing of the text in accordance with journal requirements. All factual data, recipe indicators, interpretations, and conclusions were verified by the author. The author bears full responsibility for the content, data, and conclusions of the manuscript.

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ЕКОЛОГО-НУТРИЦІЙНЕ ОБҐРУНТУВАННЯ РЕЦЕПТУРНИХ КОМПОНЕНТІВ НОВОЇ ТЕХНОЛОГІЇ СІЧЕНИХ ВИРОБІВ З РИБИ

Мета. Обґрунтувати доцільність використання гарбузового пюре як локальної рослинної сировини у технології січених виробів з риби з позицій екології людини, сталого харчування, харчової безпеки та ресурсно-орієнтованого виробництва продукції ресторанного господарства.

Методи. Застосовано аналітичне узагальнення сучасних наукових джерел щодо сталих здорових раціонів, харчових волокон, біоактивних компонентів гарбуза та якості рибної продукції; нормативний аналіз вимог до сировини; технологічне моделювання рецептури; розрахункову оцінку харчової та енергетичної цінності; дескриптивну органолептичну оцінку дослідного зразка; інтерпретацію

мікробіологічних показників готової страви. Контрольним рецептурним прототипом розглянуто традиційні рибні котлети без гарбузового пюре.

Результати. Доведено, що додавання гарбузового пюре до рецептури рибних січених виробів забезпечує технологічне, нутриційне й попередньо екологічне значення: підвищує частку рослинного компонента місцевого походження, формує природне забарвлення, сприяє соковитості та м'якій консистенції виробу, а також доповнює рибну білкову основу харчовими волокнами, пектиновими речовинами, вітамінами та каротиноїдами. За розрахунковими даними для рибних котлет з гарбузом на 100 г продукту вміст білків становить 4,06 г, жирів – 9,80 г, вуглеводів – 0,98 г, енергетична цінність – 105,73 ккал. Дослідний зразок має рівну поверхню, помаранчевий відтінок, однорідну ніжну консистенцію, характерний рибний смак із помірним солодкуватим післясмаком гарбуза. Мікробіологічні показники не перевищують встановлених обмежень: патогенні мікроорганізми, зокрема *Salmonella* spp., не виявлені у 25 г продукту.

Висновки. Розроблена рецептурно-технологічна модель може розглядатися як попередньо обґрунтований напрям еколого-нутриційного удосконалення рибних січених виробів. Її екологічна інтерпретація ґрунтується на локальності рослинної сировини, поєднанні сировини тваринного та рослинного походження та використанні щадних режимів теплової обробки, що дозволяє отримати новий продукт підвищеної біологічної активності із високими органолептичними показниками. Для підтвердження заявлених переваг плануються подальші контрольні експерименти, статистично підтверджена сенсорна оцінка, інструментальне визначення якості та кількісне оцінювання екологічного сліду за методологією життєвого циклу.

КЛЮЧОВІ СЛОВА: екологія людини, стале харчування, січені вироби з риби, гарбуз, біологічна цінність, безпечність

Конфлікт інтересів

Автор заявляє про відсутність конфлікту інтересів щодо публікації цього рукопису. Крім того, автор повністю дотримувався етичних норм, включаючи уникнення плагіату, фальсифікації даних та дублювання публікацій.

Декларація про використання ШІ

Під час підготовки цього рукопису для структурного, лінгвістичного та стилістичного редагування тексту відповідно до вимог журналу використано інструмент штучного інтелекту ChatGPT-5.5 (OpenAI, 2026). Усі фактичні дані, рецептурні показники, інтерпретації та висновки були перевірені автором. Автор несе повну відповідальність за зміст, дані та висновки рукопису.

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