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DEVELOPMENT OF A DEHYDRATED PROTEIN FOOD PRODUCT FOR MILITARY PERSONNEL

The object of research is the process of developing a dehydrated protein food product enriched with lupine flour, intended for nutrition of military personnel in extreme conditions. The use of lupine flour is promising in technologies to produce dehydrated products for military personnel. It contains more protein than other legumes and has a less pronounced effect on the organoleptic quality of finished products.

It was determined and experimentally proved that white food lupine is a protein enricher in the diet of military personnel, which allows authors to obtain a combined meat and vegetable product balanced in chemical composition. The average protein content in lupine flour is 36–40 % by dry matter, which is 3 times higher than that of first-grade wheat flour and 2.2 % higher than that of soybean flour. A recipe for experimental meat and vegetable protein minced meat with 10 % beef meat substitution was developed. It was found that with an increase in the content of lupine flour in the minced meat, the protein content increases to 10.3 %. It was found that the meat and vegetable protein minced meat of the experimental sample corresponds to the control in taste, smell, color, consistency, but is better in juiciness and has a high rating. The microstructure of the developed meat and vegetable protein minced meat was determined. A technological scheme of production was drawn up and a volunteer test of the production of a dehydrated food product in the diet of military personnel based on meat and vegetable protein minced meat was conducted. The hygienic control of the production of health food products for military personnel was carried out. The express method of hygienic quality control showed that the luminometer readings were within the range of 1.356–1.793 RLU, which is clean, confirming compliance with the hygienic standards of the technological process.

The technology of a health product for nutrition of the military personnel of the Armed Forces of Ukraine in extreme conditions was developed. The influence of lupine flour on the protein content in the technology of meat and vegetable protein health-improving minced meat was scientifically substantiated. The possibility of introducing the technology into the diet for dry rations, according to Norm No. 10 for military personnel, was confirmed.

Keywords: *dehydrated food, diet, HACCP, lupine flour, meat and vegetable product, military personnel, protein.*

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1. Introduction

The use of health and preventive nutrition is the most important component of life support for the functioning of the human body both in normal conditions and in extreme situations. Today, in the context of the Russian-Ukrainian war, there is a stressful situation and an increase in energy consumption of the military personnel of the Armed Forces of Ukraine in such conditions.

Since February 2022, the Armed Forces of Ukraine have been involved in a full-scale Russian-Ukrainian war. Today, these are people from the territorial defense forces, volunteers, and other groups. The main factors that ensure the stability of the body's homeostasis of the military personnel and increase resistance to external factors are the diet and quality of nutrition. In unfavorable conditions, military personnel suffer from protein deficiency, which negatively affects their health, performance, life expectancy, and fatigue. The lack of protein, as well as micronutrients and vitamins, not only negatively affects health, but also changes the kinetics of metabolism, increasing the absorption of radionuclides in the gastrointestinal tract and prolonging the time of their excretion from the body. That is why the development of meat and vegetable protein minced meat to produce dehydrated healthy food products in the diet of military personnel is relevant today.

Military nutrition has been studied in many scientific works by foreign scientists [1–3]. The theoretical and practical aspects of developing rations for servicemen of the Armed Forces of Ukraine are considered in the scientific works [4, 5]. Modern requirements for the nutritional composition of nutrition and the state of food supply of the military personnel of the Armed Forces of Ukraine are covered in the research [6, 7]. The issue of optimizing the rations of military personnel is considered by scientists [8, 9].

The problem of improving the nutritional ration of the Armed Forces of Ukraine is extremely relevant today, especially due to the Russian-Ukrainian war. Against the backdrop of recent events, it has become clear that previously, in the context of annual budget cuts in the Armed Forces of Ukraine, scientists paid insufficient attention to the scientific substantiation and development of food products for military personnel, particularly in extreme conditions [5, 10].

Ukrainian and foreign scientists have made a significant contribution to the development of innovative technologies and health food products [11, 12]. In particular, many papers are devoted to meat-containing culinary semi-finished products with increased nutritional value [13, 14]. Scientists are forced to search for alternative sources of complete proteins among varieties of agricultural legumes [15–18]. One of them is lupine, which has the highest protein content in its seeds [19].

Therefore, *the aim of the research* is to develop meat and vegetable protein minced meat to produce dehydrated food for military personnel of the Armed Forces of Ukraine. It is one of the most effective and cost-efficient ways to correct the existing deficiency of essential substances in the extreme conditions of military personnel.

2. Materials and Methods

The object of research is a dehydrated protein food product created using lupine flour as a healthy food for military personnel in extreme conditions.

The following research methods were used in the study: organoleptic (appearance, color, smell, taste, consistency, juiciness), physicochemical (mass fraction of moisture, protein, fat, ash), histological (microstructure of minced meat), express method (hygiene of quality control according to the HACCP principle using the Clean-Trace™ NG luminometer), system analysis.

To prepare the natural minced meat, it was combined with raw fat, white bread crumb, and onion in a meat grinder, salt and pepper were added, and mixed. It was prepared according to the collection of recipes and requirements for natural minced masses.

Then the composition of the basic minced beef mass and the minced beef mass with the addition of protein enrichment (lupine flour) was studied. As the percentage of lupine flour in ground beef increased, the moisture content of the experimental samples increased compared to the control. This is due to the ability of this ingredient to provide maximum moisture retention, which in turn increases the yield of the finished product.

The paper investigates the effect of the use of lupine flour on the chemical composition of the developed experimental minced meat. The results of the study of the developed samples of minced meat in comparison with the control.

Histological studies revealed structural changes in the model minced meat, the degree of interconnectedness of the minced meat structure elements, consistency density and a decrease in syneresis in the minced meat.

The organoleptic analysis of the experimental product was carried out according to the relevant criteria. The results were processed by mathematical statistics.

Monitoring in the HACCP system was determined by measuring a process parameter at a control critical point (CCP) and comparing the data obtained with critical limits. The Clean-Trace™ NG luminometer was used to determine the hygienic quality control of the development of the technological process to produce dehydrated food for military personnel and the hygiene of the technological process points was determined.

3. Results and Discussion

The widespread use of health and preventive nutrition is an essential component of life support for the human body's functioning both in normal conditions and in extreme situations. In this case, priority is given to a range of products selected in optimal proportions and containing enough nutrients necessary for the body: proteins, fats, carbohydrates, vitamins, minerals, etc.

It is quite clear that rational healthy nutrition as one of the basic natural needs of the body, including new special purpose foods, ensures the normal course of physiological processes, preserves human health, performance, and military capability in extreme conditions [20].

The nutrition of military personnel is of particular importance during military operations. In this case, when choosing the structure and diet, it is necessary to consider the impact of such negative factors as increased nervous and emotional and physical overload against the background of unstable environmental parameters, which lead to increased catabolism of proteins, vitamins, and other vital nutrients.

Therefore, the existing balanced approach to the structure of nutrition, which is based on the normative provision of macro- and micronutrients in accordance with human physiological needs, requires significant adjustments when developing food products for military personnel [10].

In the extreme conditions in which the military personnel of the Armed Forces of Ukraine are currently defending their homeland, food products produced by the domestic industry should:

- compensate for the deficiency of biologically active components that occur under the influence of unfavorable conditions;
- improve the functional state of organs and body systems;
- improve the protective functions of the body's immune system;
- increase physical capacity, promote the strengthening of the body's adaptive reserves and psychological stability in extreme situations;
- accelerate the recovery of metabolic processes after increased environmental, physical, nervous, and emotional stress;
- improve the health and well-being of military personnel.

On August 4, 2023, the Cabinet of Ministers of Ukraine, by Resolution No. 821, amended the nutritional standards for military personnel of the Armed Forces and other military formations. It was analyzed Norm No. 10, an everyday set of dry products consisting of: galettes made from first-grade wheat flour (300 g), canned meat (breakfast meat of the highest grade) (325 g), canned meat (liver pates) (100 g), canned meat and vegetable products (assorted porridges with meat) (650 g), natural honey (40 g), sugar (90 g), instant coffee (2 g), natural black tea (4 g), paper napkins (3 pcs.), hygienic napkins (3 pcs.). It is estimated that the total weight of the set is 1517 g. Thus, considering the departure of soldiers to participate in military operations for 3 days, this set will weigh about 4550 g [4]. So, the challenge was to minimize the weight of dry sets, as the soldier must carry enough heavy weapons, as well as daily water supplies.

White food lupine is one of the most promising legumes and deserves special attention. Lupine seeds, as well as processed products, are increasingly used in various food industries as an inexpensive source of complete proteins, unsaturated fatty acids, and pectin.

The Institute of Agriculture of the Ukrainian Academy of Agrarian Sciences has developed a new variety of lupine – white alkaloid-free food, the seeds of which contain 38–42 % protein, 10–14 % fat, 10–12 % pectin, 28 % dietary fiber. At the same time, the protein is well balanced in terms of amino acid composition [21]. The seeds of the new food varieties "Volodymyr", "Borky", and "Diet" are natural concentrates of biologically complete proteins and pectin.

The optimal chemical composition of white alkaloid-free lupine seeds makes it possible to use them in the following areas:

- production of flour from whole grains or from kernels cleaned of seed hulls separately;
- production of canned fruit and vegetables with the addition of lupine seeds that have undergone endofermentation;
- obtaining a surrogate coffee beverage and a sorbing carrier of a flavoring composition based on roasted seeds.

In addition, because of complex processing of seeds, defatted flour and protein concentrate, lupine oil and separated seed hulls can be produced.

In modern varieties of white lupine created by artificial mutagenesis, the content of alkaloids is very low and ranges from 0.002 to 0.008 %. In addition to proteinase inhibitors, whole-grain legume flour also contains a-galactosides (raffinose and stachyose), lectins, saponins, phytates, tannins, etc. However, it is generally accepted that a significant part of the anti-nutrients in legume seeds is inactivated during heat treatment [22].

Table 1 shows the chemical composition of lupine flour.

Based on an analytical review of the literature [21–23], it was found that the use of lupine flour is promising in the technologies to produce dehydrated products for military personnel based on meat and vegetable protein minced meat. Unlike other legumes, it contains more

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protein and has a less pronounced effect on the organoleptic quality of finished products, which will help solve the problem of protein, nutritious, balanced, ecological, and healthy nutrition.

Table 1

Chemical composition of lupine flour

Nutritional value	Per 100 g
Energy	1561 kJ/374 kcal
Fats	12.0
– of which saturated fatty acids	1.7
– of which monounsaturated fatty acids	7.0
– of which polyunsaturated fatty acids	3.4
Carbohydrates	10.0
– of which sugar	7.0
Protein	43.0
Salt	<0.01
Amino acids	Per 100 g
Isoleucine	4.1
Leucine	7.1
Lysine	4.6
Methionine + cysteine	2.0
Phenylalanine + tyrosine	8.0
Threonine	3.3
Tryptophan	0.6
Valine	3.7

Meat and meat products are among the most important foods in the diet of military personnel and occupy a significant share as a source of complete proteins, minerals, saturated and polyunsaturated fatty acids, vitamins, and other nutrients. These components are in the optimal quantitative and qualitative ratio and ensure a high degree of assimilation of meat products by the body of military personnel [14].

To prepare natural minced meat, cutlet meat (beef) was combined with raw fat, white bread crumb, onion chopped in a meat grinder, salt and pepper, and everything was thoroughly mixed (Table 2). The minced meat and vegetable protein were prepared in accordance with the collection of recipes and requirements for minced natural masses.

Table 2

Minced beef with the addition of protein enrichment – lupine flour

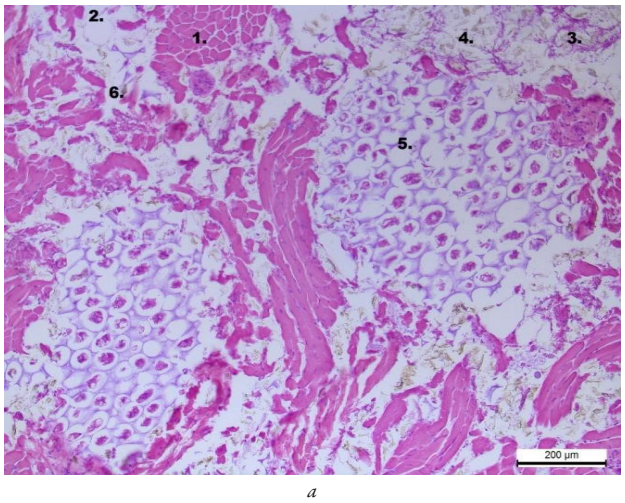
Raw materials	Raw material consumption per 1000 g of finished product, g
	Net
Beef (cutlet meat)	900
Raw fat	40
Onion	100
Ground black pepper	1
Salt	10
Parsley (herbs)	7
White bread (pulp)	25
Water	35
Lupine flour	100
Total	1218

Meat – the surface is clean, dried, pale pink in colour. The surface of a fresh cut is slightly moist, but not sticky. The consistency is dense, elastic, the smell is pleasant, characteristic of this type of meat.

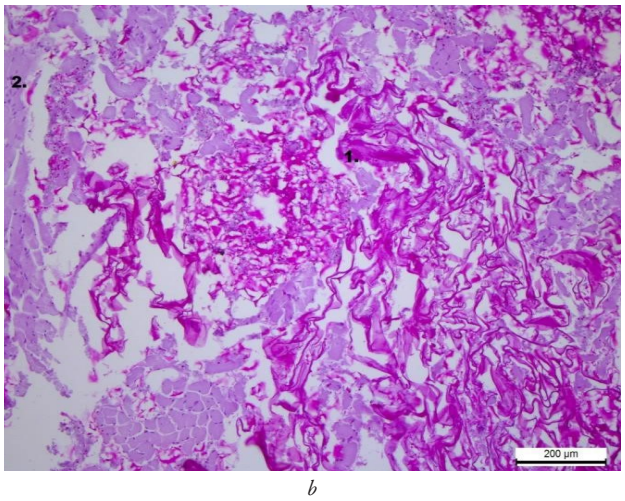
According to the increase in the percentage of lupine flour in the minced beef meat mass, the moisture content of the experimental sample increases compared to the control. This is due to the ability of this ingredient to provide maximum moisture retention, which in turn increases the yield of the finished product. It was found that the optimal amount of application is 10 % of the protein enrichment with the replacement of beef meat.

Histological studies can reveal structural changes in model minced meat, the degree of interconnectedness of the elements of the minced meat structure, consistency density and reduction of syneresis in minced meat. Therefore, the microstructural analysis of raw materials, semi-finished products or finished products can determine the presence of certain types of tissues, organs, spices, as well as low-value additives not provided for in the recipe, re-used raw materials. At the same time, the microstructural method can be used to quantitatively analyze the individual components of a product [4, 19].

Fig. 1, *a* shows a cut of minced meat with 10 % replacement of beef meat with lupine flour. Hematoxylin and eosin staining with eyepieces 10 and objective 10 revealed the presence of polygonal muscle fibers 1 with a clear contour, large reticular and oval cells – fatty tissue 2, fibers with a loose shape – onion 3, single loose fibers – bread 4, spherical polygonal vacuoles with nuclei in the center of cells with a large accumulation – lupine flour 5 and single fibers of a clear shape – pepper 6. The structure of the minced meat has slight stratification and there is no uniform mixing of the components included in the minced meat, as lupine flour absorbs moisture.



a



b

Fig. 1. Histological section of meat and vegetable protein minced meat to produce a protein product: *a* – eyepiece 10, objective 10 (1 – muscle fibers, 2 – fatty tissue, 3 – onion, 4 – bread, 5 – lupine flour, 6 – pepper); *b* – eyepiece 10, objective 10 (1 – vegetable part, 2 – meat part)

In Fig. 1, *b*, vegetable 1 and meat 2 fractions of minced meat were determined by the SEM reaction (histochemical method) with eyepieces 10 and objective 10.

The next step was to study the effect of using lupine flour on the chemical composition of the developed experimental minced meat. The study was conducted at the State Research Control Institute of Veterinary Medicinal Products and Feed Additives using appropriate research methods and certified equipment. The results of the study compared to the control are presented in Table 3.

It has been established that the protein content of the experimental sample increases by 10.3 % compared to the control, which confirms the feasibility of developing a health product for military personnel nutrition.

Technological scheme for the preparation of meat and vegetable protein minced meat to produce dehydrated product for military personnel of the Armed Forces of Ukraine is shown in Fig. 2.

According to the developed recipe, the technological scheme of meat and vegetable protein minced meat for the production of a dehydrated product for the nutrition of the military personnel consists of a number of steps.

The process of raw material preparation involves the following technological operations: receiving, weighing, washing, and cutting meat. The raw materials are received chilled with an internal temperature of –2 °C to +4 °C, packed in cardboard boxes of TM Galytska Svizhyna – "Minced beef trim with appropriate side fat content". Raw materials are weighed on electronic scales. Meat is washed at a temperature of 18–20 °C. The raw materials are cut into smaller pieces on the production table with a chef's three-knife on a silicone red board.

The raw meat is ground in a meat grinder with a grid diameter of 2–5 mm. The additional ingredients (onion and bread) also need to be prepared. The onion is washed, peeled, and cut into 4 slices with a three-pronged knife. Soak the bread (soft part) with water in a gastronorm container. Additional raw materials are ground in a meat grinder with a mesh diameter of 2–5 mm.

Preparation of lupine flour includes sifting the flour through a sieve with a mesh size of 150 μm, hydration with water at a temperature of 95–98 °C and intensive mixing for 2 min, followed by cooling to t = 18–20 °C.

At the stage of making the minced meat, add the prepared lupine flour, salt, and pepper. Next, mix the minced meat and then knock it out manually with gloves on for 5–10 minutes in a gastronorm container. The temperature of mixing of the finished minced meat is controlled, it should not exceed 8–10 °C.

The meat products are formed with a pastry bag using a nozzle with a diameter of 5 mm. Then the 5–7 cm long kabanoski sausages are placed on silicone trays and subjected to dehydration in the Ezidri 1000 dehydrator at 60 °C for 6 hours.

Finally, the finished products are vacuumed with a mass of 100 grams. These products can be used to supplement dry rations when military personnel go on combat operations.

Table 4 shows the organoleptic analysis of the experimental product according to the relevant criteria.

The results are processed by mathematical statistics. It was found that the meat and vegetable protein minced meat of the experimental sample corresponds to the control in taste, smell, color, consistency, but is better in juiciness and has a high rating.

One of the methods of improving the HACCP system is the Clean Trace monitoring system by 3M (USA). Monitoring in the HACCP system is determined by measuring a process parameter at a control critical point (CCP) and comparing the data obtained with critical limits. The device determines the amount of ATP (adenosine triphosphoric acid) on surfaces or in rinse water. The amount of ATP indicates the degree of contamination with organic residues and microorganisms [11].

Table 3

Chemical composition of meat and vegetable protein minced meat for military nutrition

Samples	Mass fraction of protein, %	Mass fraction of fat, %	Mass fraction of ash, %	Mass fraction of moisture, %
Control	12.6±0.1	11.0±0.1	1.4±0.1	40.4±0.1
Experimental sample	13.9±0.1	11.6±0.1	1.2±0.1	41.6±0.1

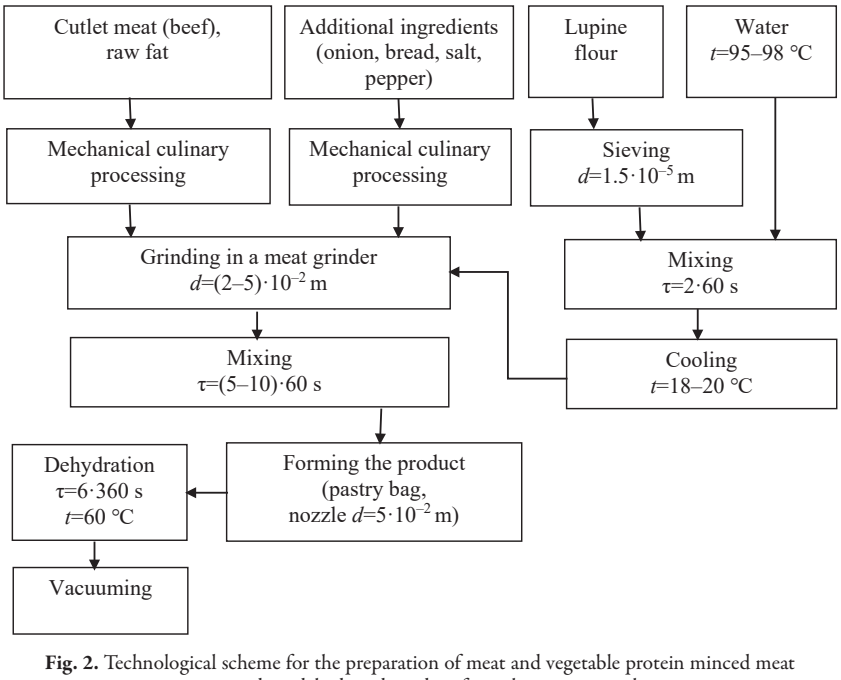


Fig. 2. Technological scheme for the preparation of meat and vegetable protein minced meat to produce dehydrated product for military personnel

Table 4

Organoleptic characteristics of meat and vegetable protein minced meat

Samples	Product rating on a 5-point scale						
	appearance	color	smell	consistency	taste	juiciness	total score, in points
Control	5.0	5.0	5.0	4.5	5.0	4.5	4.83
Experimental sample	4.8	5.0	5.0	4.8	5.0	5.0	4.93

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This type of analytical data collection is in line with the principles of the HACCP system. It also involves the continuous improvement of the production process in accordance with the concept of identifying, assessing and managing hazards that affect product safety. The Clean-Trace™ NG luminometer was used to determine the hygienic quality control of the development of the technological process for the production of dehydrated food for military personnel in the conditions of the PRO100HUB Gastronomic Space and the hygiene of the technological process points was determined. The express method of hygienic quality control showed that the luminometer readings were within the range of 1.356–1.793 RLU, which is clean, confirming compliance with the hygienic standards of the technological process.

Research limitations. It is worth noting raw material limitations, as the quality and availability of lupine flour can vary depending on the region and season. The dehydration process may partially affect the nutritional value and taste of the final product. The cost of developing and producing a dehydrated product is relatively high. In addition, there are consumer restrictions due to possible allergic reactions to lupine flour intolerance.

Prospects for further research. Further research could focus on the optimal ingredient ratio to improve the product's taste and nutritional value. Study of technological innovations, including introducing new dehydration methods that allow the preservation of the maximum amount of nutrients and improve the product's texture. Researching the shelf life and storage conditions of the product to ensure its quality for a long time. Of course, the impact of regular consumption of the product on the health of military personnel, including possible allergic reactions and other side effects.

4. Conclusions

The use of new and well-known raw materials in meat product formulations is an important task in achieving high quality, nutritional and biological value of products. This can be achieved through a scientifically based combination of meat and non-traditional vegetable raw materials with high protein content, natural antioxidants and prebiotics. Among the large number of plant-based raw materials that contain protein, lupine is of particular importance. In our opinion, it is important to use non-traditional raw materials, in particular, lupine flour as a vegetable filler and protein enrichment for minced meat. It improves the biological effect of food on the human body, improves the taste, aroma and other properties of the product.

The research paper presents an example of the development of meat and vegetable protein minced meat for the production of a dehydrated product with the addition of 10 % lupine flour. Unlike other legumes, the average protein content of lupine flour is 36–40 %, 25–40 % of nitrogen-free extractives, 10–12 % of fat rich in oleic acid and a-tocopherol, 3–4 % of ash, a complex of vitamins, macro- and microelements and other biologically active substances. In addition, lupine flour is almost completely free of anti-nutrients. The high functional and technological characteristics of lupine flour confirm the feasibility and prospects of using this vegetable raw material in the technology of meat products.

It has been experimentally proven that white food lupine is a protein enricher in the diet of military personnel, which allows to obtain a combined meat and vegetable product with a balanced chemical composition and increased protein content by 10.3 %.

The microstructure of the developed meat and vegetable protein minced meat was also determined and hygienic control of production was carried out. The paper presents a technological scheme for the preparation of meat and vegetable protein minced meat to produce dehydrated product for military personnel of the Armed Forces of Ukraine. Finally, the production of dehydrated food was tested at the volunteer center of the PRO100HUB Gastronomic Space.

Thus, the development of meat and vegetable protein minced meat for the production of a dehydrated product can partially solve the problem of protein deficiency in the diet of military personnel and expand the range of dry rations.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this study, including financial, personal, authorship, or any other, that could affect the study, and its results presented in this article.

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Data availability

The manuscript has no associated data.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating this work.

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