Development of foods with antioxidant and anticancer potential

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DEVELOPMENT OF FOODS WITH ANTIOXIDANT AND ANTICANCER POTENTIAL

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Abstract: *Malignant tumors have become one of the main causes of mortality of the population, people who are faced with a diagnosis of "cancer" especially need proper nutrition. Due to insufficient intake of essential nutrients, a person's condition may worsen, with the subsequent development of the disease. The aim of the work was to develop oatmeal cups with berry marmalade layers, which have antioxidant and anticancer potential. As raw materials, products of autochthonous origin were used: sea buckthorn, black currant, pink grapes, honey, sunflower seeds, walnuts, pumpkin seeds, etc. Research methods included the technological development of recipes for bars to obtain the most harmonious combination of all components used. The analysis of the studied samples of berry juices with free radical DPPH· and the analysis of UV spectra of the studied samples were also carried out. The highest values of antioxidant activity were obtained for sea buckthorn and grape samples, amounting to 92.52% and 90.45%, respectively. The analysis of UV spectra confirmed the content of such antioxidant components as polyphenolic compounds in them, characteristic of all the studied samples and registered at a wavelength of 220 nm. For the sea buckthorn sample, a second peak was recorded at a wavelength of 350 nm, characteristic of antioxidant components such as carotenides. The results of the sensory evaluation showed that the bar with sea buckthorn marmalade layer had the most pleasant sensory properties. Based on all the results obtained, it can be concluded that the developed type of products can be recommended for consumption by consumers and introduction to the market.*

Keywords: *functional food, antioxidant and anticancer potential, technological process, food development.*

INTRODUCTION

Environmental and dietary changes have been identified as major causes of globally noncommunicable diseases such as aging-related diseases and cancers (Tasdemir, S.S., &Sanlier, N., 2020). It seems the consequently interaction among environmental and genetic factors that also involves changes caused by biological, physical, chemical carcinogens such as viruses, bacteria, or parasitic infections (Golemis, E.A., Scheet, P., Beck, T.N., Scolnick, E.M., Hunter, D.J., Hawk, E., & Hopkins, N., 2018). According to World Health Organization (WHO) data, globally second main reason of death is cancer, where with 9.6 million deaths are expected due to cancer in 2018, about 1 in 6 deaths is due to cancer (WHO, 2020). It is known that 30–40% of cancer can be prevented by modifiable risk factors and behavioral changes, including dietary habits.

With the active development of public catering enterprises, especially establishments specializing in fast food, people stopped caring about the quality of their diet (Küster-Boludaa, I., & Vidal-Capilla, I., 2017). Many have discounted the importance of a healthy balanced diet. However, it is nutrition that can cause diseases such as obesity, diabetes mellitus, plaque formation on the walls of blood vessels and the development of cancer (Robu, E., Sergeeva, E., & Popovici, C., 2022). According to statistics, every year more than 5 million people become victims of cancer. Malignant tumors are becoming one of the main causes of mortality in the population (WHO, 2020).

This topic is more relevant than ever today, people who are faced with a diagnosis of "cancer" especially need proper nutrition (Song R., Wu, Q., Zhao L., & Zhenyu Y., 2019). Due to insufficient intake of essential nutrients, a person's condition may worsen, the disease will progress (Birben, E., Sahiner, E., Sackesen, C., Erzurum, S., & Kalayci, O., 2012).

Currently, there is an extremely small amount of food that would have a high antioxidant and anticancer potential. Taking into account this information, the main goal of the study was to develop food products with an increased content of antioxidants and anticancers, namely bars based on oat flakes with a berry marmalade layer.

MATERIALS AND METHODS

Materials

To expand the range and develop food products with antioxidant anticancer properties, raw materials were used that differ in the content of natural antioxidant and anticancer substances: sea buckthorn (*Hippophaë Rhamnoides* L.), black currant (*Ríbes nígrum* L.), pink grapes (*Vitis vinifera* L.), as well as oat flakes, raisins, dried apricots, prunes, honey, seeds pumpkins and sunflowers, walnuts, almonds.

When planning the development of food products with antioxidant and anticancer properties, it was stipulated that the ingredients in their composition should preserve all valuable substances as much as possible, while the finished products should have an attractive appearance, aroma and taste.

Research design

As part of the study, 3 types of oatmeal bars with berry marmalade layers were proposed. Their development took into account the addition of antioxidant and anticancer properties and certain qualitative indicators to the final food products. This process included the stage of modeling and adjusting the formulation and technology of obtaining products. Figure 1 shows the methodology according to which food products with anticarcinogenic and antioxidant potential were obtained.

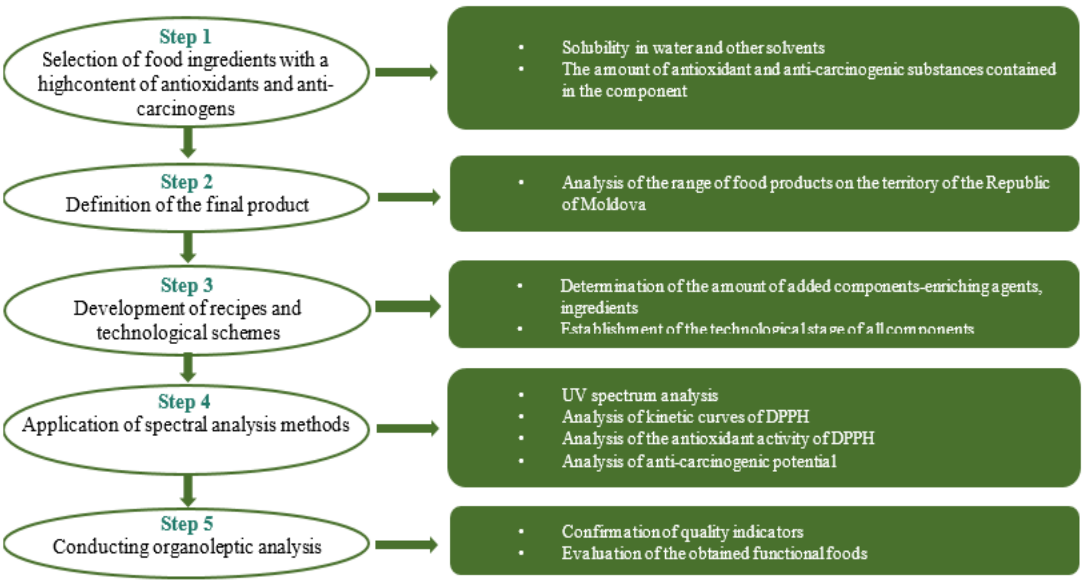


Fig.1. Research design

In parallel with the necessary useful substances that were used as the main raw material, dietary fiber was additionally introduced into the formulation of the products being developed.

Another important stage in the creation of food products with antioxidant and anticancer potential was to optimize the formulation and technological schemes, as they affect the formation of product quality indicators. At the same stage, a variation of the assortment was developed and checked for compliance with the needs.

DPPH radical scavenging activity

The antioxidant activity of samples as well as the kinetics of inhibition of free radicals were studied in terms of radical scavenging ability using the stable $DPPH^{\bullet}$ method (Brand-Williams W., Cuvelier M. E., & Berset., C., 1995). 0.1 ml of the sample was added to 3.9 ml of 60 µM solution of $DPPH^{\bullet}$ in methanol. The reaction was carried in dark conditions and the absorbance was recorded at 515 nm to determine the concentration of remaining $DPPH^{\bullet}$. Methanol as instead of $DPPH^{\bullet}$ solution was used as blank solution. The values of $[DPPH^{\bullet}]_t$ at each reaction time were calculated according to the calibration curve (in the concentration range of 0.38-38 µg/ml): $A_{515\ nm} = 0.0293\ [DPPH^{\bullet}]_t - 0.0072$, where the concentration $[DPPH^{\bullet}]_t$ is expressed in µg/ml. The coefficient of linear correlation of the above relation is R = 0.9999. The radical scavenging activity (RSA) was calculated using the equation (Popovici, C., Saykova, I., & Tylkowski, B., 2009):

$$RSA = 100\% \bullet ([DPPH^{\bullet}]_0 - [DPPH^{\bullet}]_{30}) / [DPPH^{\bullet}]_0 \quad 1)$$

where $[DPPH^{\bullet}]_0$ is the concentration of the $DPPH^{\bullet}$ solution (without sample) at t=0 min and $[DPPH^{\bullet}]_{30}$ is the remained $DPPH^{\bullet}$ concentration at t=30 min. Lower $[DPPH^{\bullet}]_t$ in the reaction mixture indicates higher free radical scavenging activity.

UV/Vis spectra and calculation of extraction factors

The UV/Vis spectra were recorded following the process described in our prevois stidies with small modifications (Popovici, C., Gîtin, L., & Alexe, P., 2012). Samples were dissolved in distillated water to obtain the the ratio 1 to 10 of tested solution. UV/Vis spectra were measured in UV/Vis spectrophotometer HACH-LANGE DR-5000 (Germany) in the range of 200 - 1100 nm using quartz tubes 10×10 mm. There were identified the maxima wavelengths specific for different compounds.

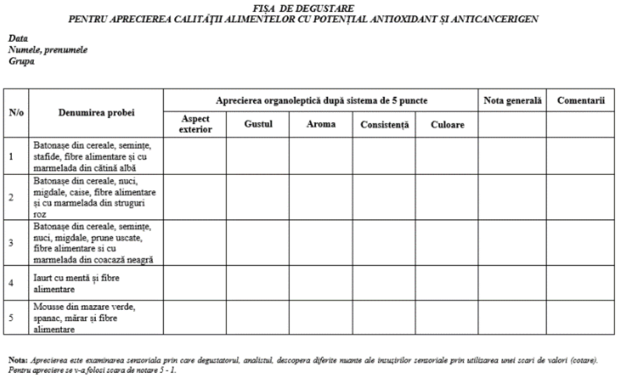
The Extraction Factors of bioactive molecules from the samples were calculated, considering the absorption values ($A_{\lambda max}$) recorded for each λ_{max}, multiplied with the dilution factor (d). The formula applied was:

$$EF = A_{\lambda max} \times d \quad 2)$$

The results were expressed as mean values of two samples per raw material.

Sensory analysis

Within the framework of the study, a tasting commission was created, consisting of 15 people, whose members were assistants of the Technical University of Moldova, and second year students of Bachelor studies in Food Technologies (groups TMAP-201 and TMAP-202). For the tasting, tasting sheets were developed, according to which each developed food product had to be evaluated in terms of appearance, color, aroma, taste and consistency (Fig. 2). When assessing sensory indicators, a scale from 1 to 5 was used (rating 5 being the maximum). Tasters were asked to describe the sensory properties of the analyzed products, as well as to indicate the main differences between them, if there were any.



FIȘA DE DEGUSTARE
PENTRU APRECIEREA CALITĂȚII ALIMENTELOR CU POTENȚIAL ANTIOXIDANT ȘI ANTICANCERIGEN

Data
Numele, prenumele
Grupa

N/o	Denumirea probei	Aprecierea organoleptică după sistema de 5 puncte					Nota generală	Comentarii
		Aspect exterior	Gustul	Aroma	Consistență	Culoare		
1	Batonașe din cereale, semințe, stafide, fibre alimentare și cu marmelada din cătină albă							
2	Batonașe din cereale, nuci, migdale, caise, fibre alimentare și cu marmelada din struguri roz							
3	Batonașe din cereale, semințe, nuci, migdale, prune uscate, fibre alimentare si cu marmelada din coacază neagră							
4	Iaurt cu mentă și fibre alimentare							
5	Mousse din mazare verde, spanac, mărar și fibre alimentare							

Nota: *Aprecierea este examinarea senzoriala prin care degustatorul, analistul, descopera diferite nuante ale insușirilor senzoriale prin utilizarea unei scari de valori (cotare). Pentru apreciere se v-a folosi scara de notare 5 - 1.*

Fig. 2. Conductingsensory analisys

In front of each member of the commission were placed: plates with 3 samples of bars, disposable cups, water, forks, napkins, as well as a tasting sheet. The use of the tasting sheet made it possible to qualitatively and accurately assess the sensory properties of the analyzed bars with a berry marmalade layer.

Statistical analysis

Variance analysis of the results was carried out by least square method with application of Microsoft Office Excel program. Differences were considered statistically significant if probability was greater than 95% ($q < 5\%$). All assays were performed at room temperature, 20 ± 1ºC. Experimental results are represented according to standard rules.

RESULTS AND DISCUSSIONS

Development of recipes and technologies for making oatmeal bars

The creation of oatmeal bars with berry marmalade layers took place in several stages, during which the ratios of ingredients and their combination were optimised. The final recepies are presented in table 1.

Tabale1. Recepies of developed oat bars with berries marmalade layers [g/100 g]

Name of Product / Name of raw materials	Oatmeal bar with sea buckthorn marmalade layer	Oatmeal bar with grape marmalade layer	Oatmeal bar with black currant marmalade layer
Oat flakes	25	25	20
Honey	20	20	20
Pumpkin seeds	8	-	5
Sunflower seeds	7	-	5
Raisin	10	-	-
Sea buckthorn juice with pulp	14	-	-
Water	5.5	5.5	5.5
Walnuts	-	8	8
Dried apricots	-	10	-
Almond	-	7	7
Grape juice with pulp	-	14	-
Prunes	-	-	5
Black currant juice with pulp	-	-	14
Fiber	10	10	5.5
Agar-agar	0.5	0.5	0.5

The technological process of developing oatmeal bars with a berry-marmalade layer began with the preparation of all the necessary ingredients and their primary processing. The percentage of raw material waste, as well as the level of nutrient losses, depends on the method and conditions of its implementation. At this stage, during the development of oat bars, standard processing methods were used, mainly washing, removal of foreign and damaged particles of raw materials. Further, at the initial stage, mechanical processing was carried out, which included cutting the ingredients, dosing them, forming the prescription mass. All the main technological processes used in the creation of oatmeal bars with a berry-marmalade layer are presented in the developed technological scheme (Fig. 3).

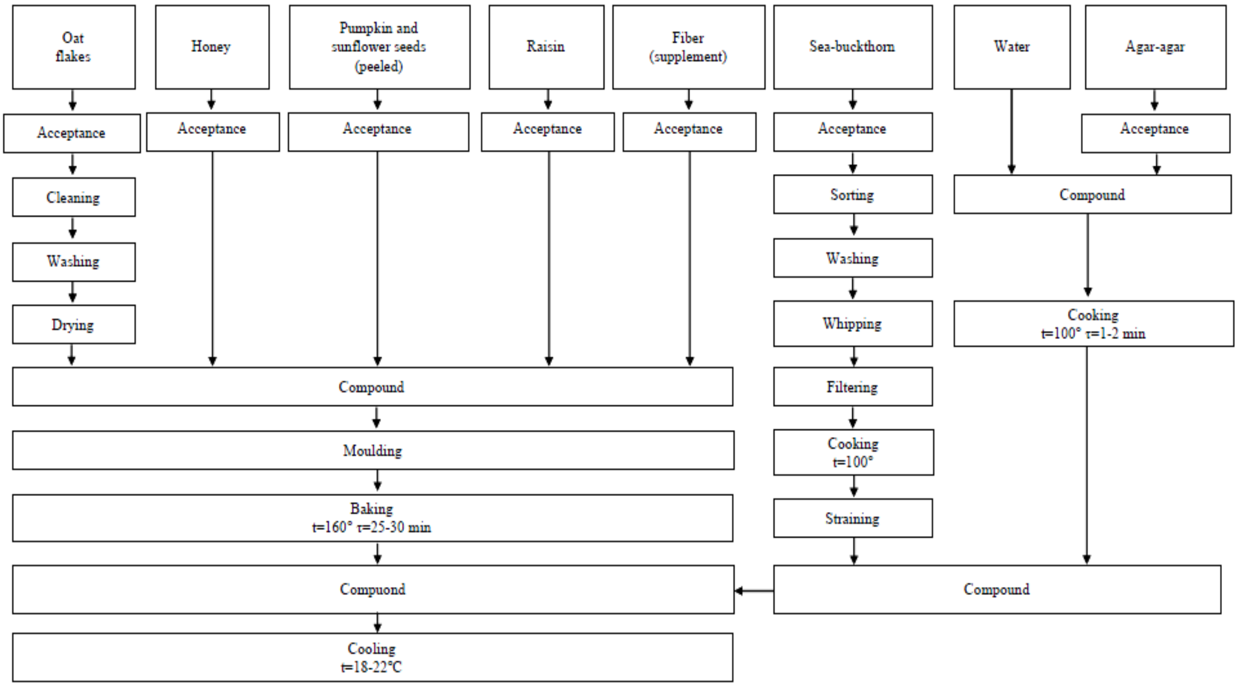


Fig. 3. Technological scheme of preparation of oatmeal bars with berry marmalade layer

In order to preserve most of the nutrients of the products, it was decided to minimize the application of heat treatment for the raw materials used. The oat bars with berry marmalade layer developed in accordance with the optimized recipe and technological process are shown in Fig. 4.

1 **2** **3**

Fig. 4. Developed oatmel bars with berries marmalade layer:
1 - Oatmeal bar with sea buckthorn marmalade layer; **2** - Oatmeal bar with grape marmalade layer; **3** - Oatmeal bar with marmalade layer of black currant

Nutritional and biological value of the developedproducts

The study carried out a detailed calculation and analysis of the chemical composition of the developed oat bars with a berry marmalade layer, in terms of the content of amino acids, lipids, carbohydrates (mono- and disaccharides, starch, fibers and other polysaccharides) and mineral compounds. Calculations and analysis were carried out on the basis of optimized recipes of the developed bars (Fig. 5, 6).

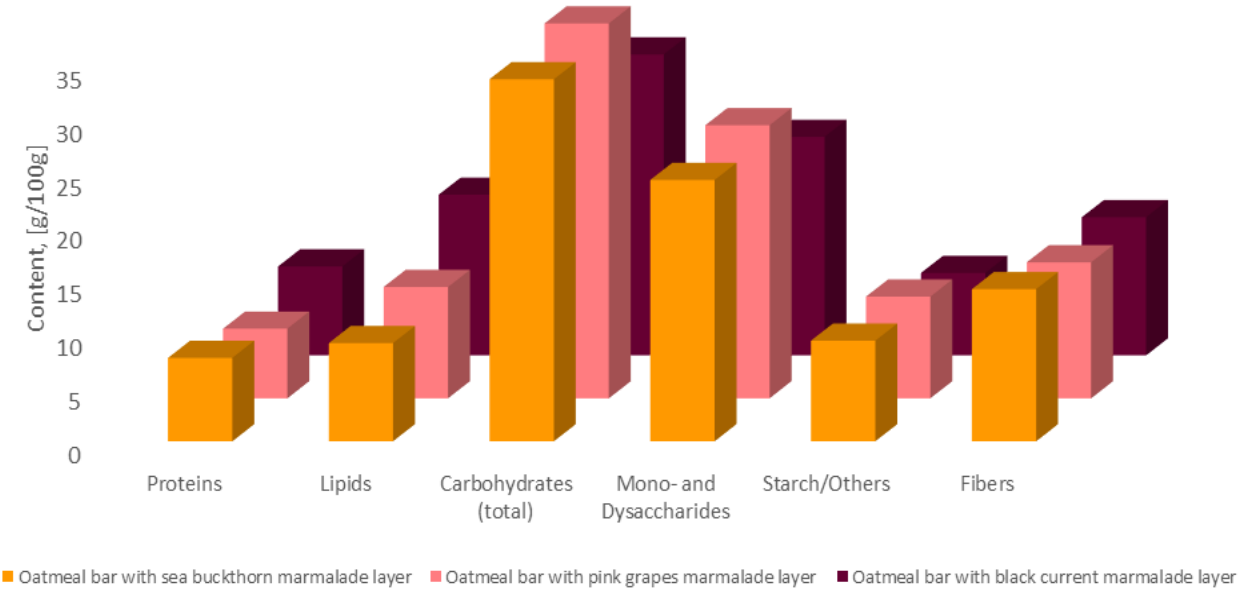


Fig.5. Macronutrient content of oatmeal bars with berry marmalade layers

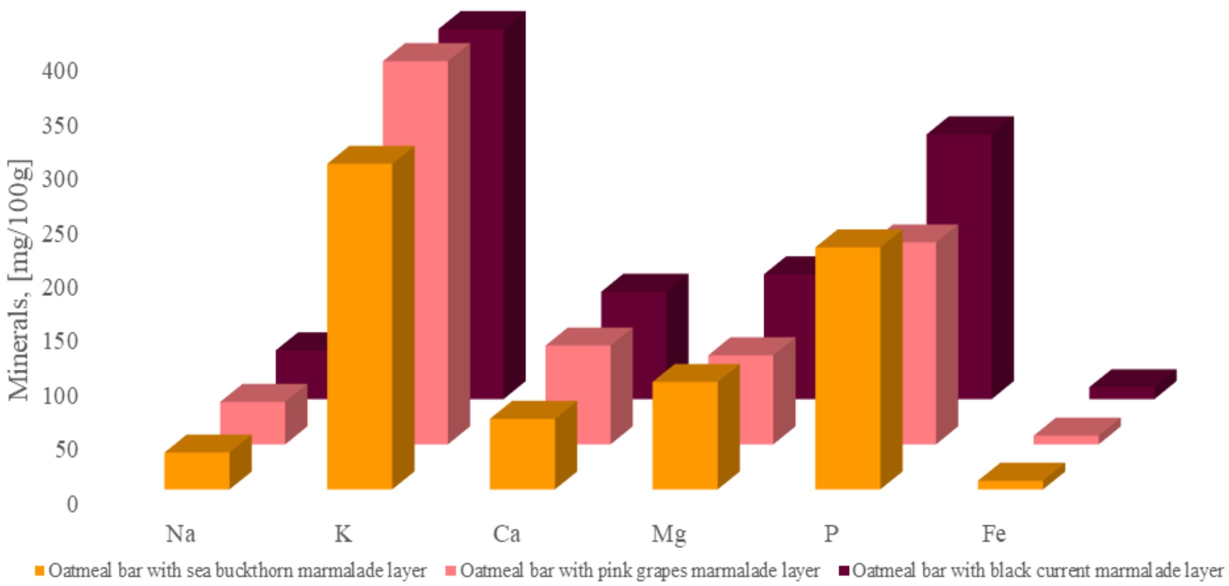


Fig.6. Mineral content of oatmeal bars with berry marmalade layers

The analysis of the obtained data showed that the oat bar with a black currant marmalade layer surpasses the other two versions of bars in energy value (365 kcal/100 g), in the total content of essential (2347 mg/100 g) and nonessential (5148 mg/100 g) amino acids, as well as in the content of saturated (1.67 mg/100 g), monounsaturated (5.56 mg/100 g) and polyunsaturated (8.42 mg/100 g) fatty acids. In terms of carbohydrate content, most monosaccharides (23.14 mg/100 g) are in the composition of an oat bar with a grape marmalade layer, and disaccharides (2.3 mg/100 g) in an oat bar with a sea buckthorn marmalade layer.

DPPH˙radical scavenging activity

To determine the antioxidant properties of the studied samples of berries of the objects, studies were carried out on a spectrophotometer using a free radical solution DPPH˙. The obtained results were interpreted in the form of graphical dependences of the change in the absorption of the free radical DPPH˙ on the time of the reaction with antioxidants contained in the studied samples (Fig. 7).

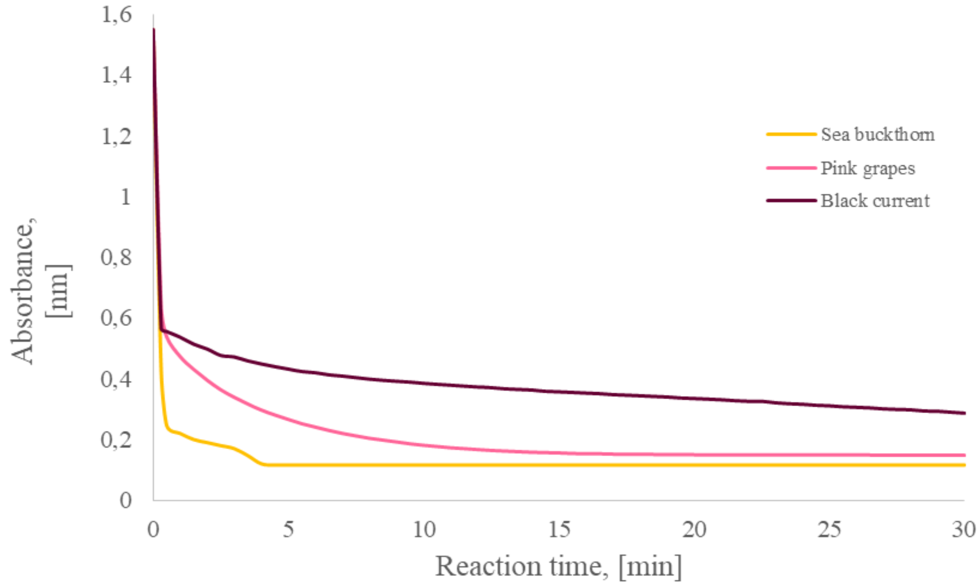


Fig.7. Kinetic curves of interaction of the studied plant objects containing antioxidant compounds with free radical DPPH˙

The presented dependences show a decrease in the activity of the free radical DPPH· as a result of interaction with antioxidants of the studied samples of sea buckthorn, grapes and black currant used in the creation of food products with antioxidant and anticancer potential.

During research, the DPPH˙ radical scavenging activity of the studied samples was determined (Fig. 8).

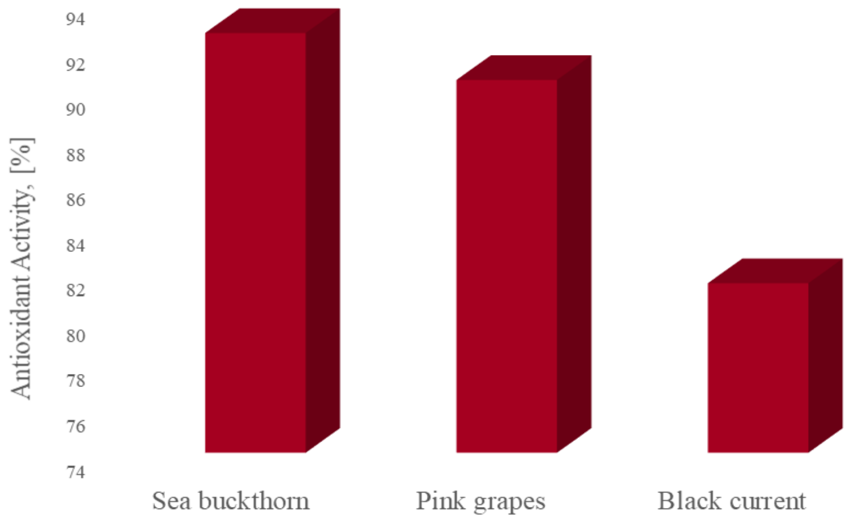


Fig. 8. DPPH· radical scavenging activity of studied berries

As can be seen from the experimental data (Fig. 8), the highest values of DPPH˙ radical scavenging activity are characteristic for sea buckthorn and grape samples, amounting to 92.52% and 90.45%, respectively. A sample of black currant also had a significantly high antioxidant potential, the value of which was 81.48%.

UV-spectra analysis

The UV spectra of the studied berry samples were also studied in terms of the content of certain compounds with antioxidant potential. The data obtained are presented in Fig. 9.

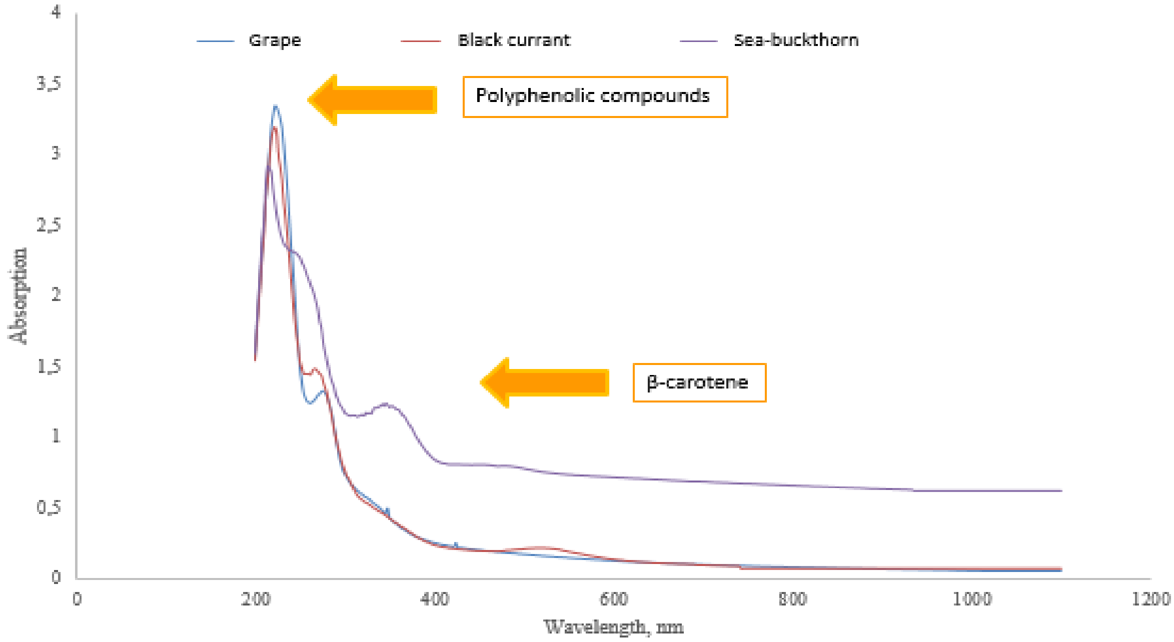


Fig. 9. UVspectraofthestudiedstudiedberries

The analysis of the UV spectra of the analyzed berry samples used in the work to create bars with antioxidant and anticancer potential confirmed the content of such antioxidant components as polyphenolic compounds in them, characteristic of all the studied samples and registered at a wavelength of 220 nm. For the sea buckthorn sample, a second peak was recorded at a wavelength of 350 nm, characteristic of such an antioxidant as β-carotene.

Sensory analysis

According to the results of the sensory analysis, it was concluded that all the bars developed were positively evaluated by all members of the commission. A more liked product was an oatmeal bar with a sea buckthorn marmalade layer (Fig. 10).

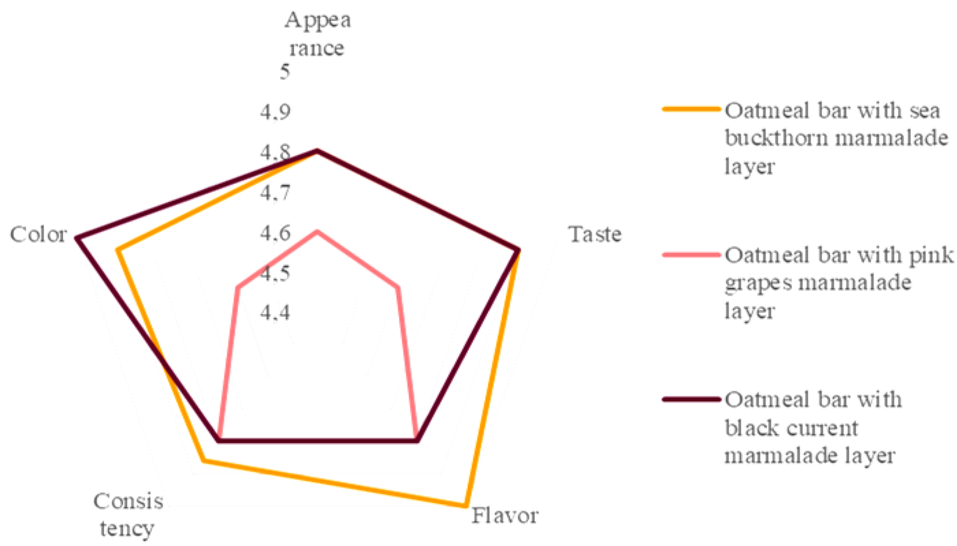


Fig. 10. Tasting profile of the developed oatmeal bars with marmalade layers of berries

According to the average values in terms of consistency and smell, the first sample of sea buckthorn marmalade bars is superior to the other two samples (4.9 points). Less liked products, according to the tasters, were the second and third types of bars with a grape marmalade layer and a berry layer of black currant, the average score of which was 4.6.

During the study regarding the development of oatmeal bars with berry marmalade layers, food labels were proposed and created for each developed bar with sea buckthorn, grape and blackcurrant marmalade layer Fig. 11.

Fig. 11. Design of labels for oatmeal bars with berry marmalade layers of sea buckthorn, pink grapes and black currant

CONCLUSIONS

The topic of research is more relevant than ever in our days, people who are facing with a diagnosis of cancer especially need proper nutrition. The market of fortified foods with macro- and micronutrients is a specific and dynamic segment, but it is underdeveloped in many countries. This is one of the main factors that influenced the idea to develop oatmeal bars with increased antioxidant and anticancer potential.

Experimental data on interaction of free radical $DPPH^{\cdot}$ with the studied samples of plant objects such as sea buckthorn, pink grapes and black current showed that the highest values of $DPPH^{\cdot}$ radical scavenging activity were obtained for the samples of sea buckthorn (92.52%) and pink grapes (90.45%). A sample of black currant also had a significant amount of $DPPH^{\cdot}$ radical scavenging activity (81.48%).

Analysis of the UV-spectra of plant objects used in the research regarding the development of oatmeal bars with berries marmalade layer confirmed the content of such antioxidant compounds as polyphenols, which were registered in all studied samples (recorded at a wavelength of 220 nm). For the sea buckthorn sample, a second peak was recorded at the wavelength of 350 nm, which is specific for β-carotene.

Sensory analysis demonstrated that all oat bars with berries marmelady layers were positively evaluated by all members of the commission. According to the average values in terms of consistency and smell, the sample of oat bar with sea buckthorn marmalade layer was superior to the other two developed samples (4.9 points).

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