SUMMARY

of the doctoral thesis entitled:

DEVELOPMENT OF NEW FOODS ENHANCED WITH BIOACTIVE INGREDIENTS FROM FOOD WASTES AND BY-PRODUCTS

Ph.D-student: STANCIU Ioana Loredana

Scientific coordinator: *Professor, PhD.* POPA Mona Elena

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By-products and waste from the food industry and agriculture are part of the main international problems, because their amount is increasing in developed countries and the problems associated with their pollution are increasingly emphasized. So, proper waste management is the most viable solution. The circular economy is intended to be the long-term solution that can be used for the recovery and reuse of by-products from the food industry. The goal is to reintroduce the resulting by-products on the production line as bioactive ingredients, to obtain new products with important health benefits and with added value through sustainable technologies for the extraction of nutritional components (Osorio et al., 2021) .

Effective waste management and the ability to convert food waste into secondary products in both industrialized and developing countries could greatly influence the so-called "three pillars of sustainability" - social, economic and environment (Purvis, et al., 2019) .

The fruit and vegetable industry is the largest and fastest growing global agri-food market, trading in various products such as juices, jams and dried products, followed by grain processing, chocolate, beer and vegetable oils. Similarly, the root and tuber processing industry generates a large amount of waste many times improperly disposed of in landfills (Osorio, et al., 2021) .

Considering that the modern concerns regarding the design of sanogenic foods have also been implemented in the bakery industry, worldwide there is a lot of research on the addition of innovative ingredients in the composition of bread.

Bread is part of the list of basic products in human nutrition, so it must have valuable nutritional characteristics and high energy value. White flour, obtained from the endosperm of the wheat grain, is poor in vitamins, minerals, fibers and proteins, unlike flour with a low degree of extraction, in which particles from the shell are also found (Pircu and Turtoi, 2020) .

In order to improve its bioactive properties, it can be fortified by adding different bioactive ingredients.

Sea buckthorn fruits (*Hippophae rhamnoides*) represents an important source of bioactive compounds, such as: vitamins (C and E), carotenoids (α-carotene, lycopene, lutein and zeaxanthin), flavonoids (isorhamnetin , quercetin , kampferol) organic acids, amino acids, micro and macronutrients (Guo et al., 2019; Larmo et al., 2008) .

The choice of the doctoral thesis "Development of new improved foods with bioactive ingredients obtained from food waste and by-products" was based on the fact that the last decade has brought a series of imported innovations in the design of food products, currently around 25% of the products on the market have the modified nutritional composition (Ospanov et al., 2014), being argued by three important elements:

1. Bread is an important food in Romania, the annual consumption being significantly higher than the world consumption average, and it represents an important matrix for the design of healthy food products .
2. The existence of an important resource of bioactive substances in sea buckthorn.
3. The need to make better use of by-products from other sectors of the food industry in the bakery sector, respecting the current fundamental guidelines regarding the circular economy, ensuring food security in the medium and long term and economic sustainability.

The valorization of sea buckthorn is carried out in pharmaceutical or cosmetic chains, obtaining oils after pressing, teas after drying, cosmetic products such as creams or scrubs , which have anti-aging and antioxidant effects on the skin and body.

In the food industry, products such as cookies or biscuits with sea buckthorn are made, in a very small percentage (1.2%) and supplemented with other additions (such as flax seeds), they are marketed by Velrom , under the Poieni brand.

Romanian researchers had the initiative to study and exploit sea buckthorn during their doctoral studies, Corbu Alexandru Radu, in his doctoral thesis "Possibilities of using some by-products of vegetable and fruit processing to increase the functionality of food products" and Sidor Anca - Mihaela in the doctoral thesis "Research on the valorization of sea buckthorn through alcoholic fermentation "

The general objective of experimental research is to develop new improved food products with bioactive ingredients obtained from food waste and by-products, with an improved nutritional level and a high degree of consumer acceptability, using sea buckthorn powder in different percentages of flour replacement of wheat.

Development of new foods improved with bioactive ingredients obtained from food waste and by-products	
Part I BIBLIOGRAPHICAL STUDY	Bibliographic study on the current state of knowledge related to the use of bioactive ingredients in bakery products and their influence on specific quality indicators
	Technological challenges and perspectives on the use of sea buckthorn by-products and waste in baking
Part II PERSONAL RESERCH	The purpose and objectives of the research
	Establishing the materials, work methods and analysis methods used for the elaboration of the work
	Obtaining sea buckthorn powder
	Research on the compositional characterization of sea buckthorn powder and wheat flour
	Determining the percentage of sea buckthorn powder added to the bread dough
	Experimental research on the evolution of bread quality after the addition of bioactive ingredients
	Research on consumer behavior towards bread enriched with organic sea buckthorn waste
Part III CONCLUSIONS	General conclusions and recommendations

To achieve this objective, a series of specific objectives were established:

- Evaluation of the current state of bakery products with the addition of ingredients with a bioactive role and their importance in human nutrition;
- Technological challenges and perspectives regarding the use of sea buckthorn by-products in the bakery industry;
- Choosing the optimal technological process for obtaining sea buckthorn powder, without influencing the content of bioactive substances;
- physical -chemical and nutritional point of view ;
- Experimental evaluation from the physico -chemical, rheological, enzymatic and nutritional point of view of wheat flour mixtures with sea buckthorn powder in different replacement percentages;
- Obtaining and characterizing nutritionally and sensory optimized baking samples;

Evaluation of consumer behavior towards bakery products with obtained biactive ingredients .

The originality of the research carried out in the paper consists of the integrated way in which the documentary and experimental researches were carried out, taking into account the technological stages of new product development and the determination of consumer behavior.

This thesis is structured in 3 parts. The first part includes 2 chapters, in which a bibliographic study is carried out regarding the current state of development of bakery products with the addition of bioactive ingredients to obtain functional products, and the use of sea buckthorn by-products.

The 2nd part includes 6 chapters related to experimental research on the materials and work methods used, experimental research on the evolution of the quality of the bakery products obtained. At the beginning of this part, the purpose and objectives of the research are also discussed.

The 3rd part, being the last part of the thesis, includes a chapter containing general conclusions, original contributions, the dissemination of the results obtained from the research carried out and future research directions.

The doctoral thesis entitled " ***DEVELOPMENT OF NEW FOODS IMPROVED WITH BIOACTIVE INGREDIENTS OBTAINED FROM FOOD WASTE AND BY-PRODUCTS*** ", is structured in 8 chapters, written on 213 pages, illustrated with 35 figures and graphs and 45 tables. The work is supplemented by a series of bibliographic data consisting of 232 bibliographic references and a section with 14 pages of appendices.

Chapter 1 (24 pages) titled " ***BIBLIOGRAPHIC STUDY ON THE CURRENT STATE OF KNOWLEDGE RELATED TO THE USE OF BIOACTIVE INGREDIENTS IN BAKERY PRODUCTS AND THEIR INFLUENCE ON SPECIFIC QUALITY INDICATORS "*** includes important elements on the classification and terminology of functional foods, a study on bakery products with added bioactive ingredients and their importance in human nutrition, a study on biologically active substances in functional foods and legislative, European and national regulations regarding the products containing functional ingredients. The need to validate the beneficial effects of a food with bioactive ingredients based on numerous clinical studies is a clear conclusion of this bibliographic study. The compounds with a bioactive role that can easily be introduced into the composition of food products are fibers, unsaturated fatty acids, flavonoids , carotenoids , minerals, prebiotics, probiotics , vitamins, which can come from by-products or waste from the food industry, if they are stored and preserved accordingly, to meet all the conditions imposed by food safety.

In the same chapter I have presented a series of research carried out on the raw materials used in the bakery industry. Research on the sources of bioactive compounds resulting from the processing of fruits and vegetables indicates that we can use a wide range of by-products and wastes from this segment of the food industry that are excellent sources of nutrients .

In **Chapter 2** (8 pages) " ***TECHNOLOGICAL CHALLENGES AND PERSPECTIVES REGARDING THE USE OF BY-PRODUCTS AND WASTE FROM HABITAT FRUITS IN BAKERY*** " we discover the benefits of hawthorn berries, the content of bioactive substances in sea buckthorn and the influence of the addition of sea buckthorn powder on the characteristics of bakery products. Studies show that sea buckthorn powder can be used as a bioactive ingredient due to its properties. The content of polyphenols and antioxidant activity is highlighted in products with the addition of sea buckthorn powder, and the sensory characteristics and textural parameters are improved. For this reason,

organic sea buckthorn fruits from three varieties grown in Romania, namely Mara, Clara and Sorana, were used as a source of bioactive compounds.

Part II called " ***EXPERIMENTAL RESEARCH"*** includes the following 6 chapters of the thesis.

" ***OBJECTIVES AND METHODOLOGY OF EXPERIMENTAL RESEARCH*** " contains the main objectives and research methodology that are the basis of the experimental activities within the thesis.

Chapter 3 (14 pages), named ***"ESTABLISHMENT OF MATERIALS, WORKING METHODS AND ANALYSIS METHODS USED FOR THE PREPARATION OF THE WORK "*** presents the multi-criteria analysis that formed the basis of the choice of by-products from sea buckthorn fruits as a source of bioactive compounds and the principles of physical methods -chemical, spectrometric, microbiological, rheological and textural used to characterize the raw materials, namely sea buckthorn powder, wheat flour and their ingredients , as well as the final product with the addition of bioactive ingredients .

Chapter 4 (18 pages) " ***OBTAINING SEA BUCTHORN POWDER "*** describes the procedures by which sea buckthorn powder can be obtained. In this chapter, the methods of squeezing, drying and grinding sea buckthorn fruits are presented and the best variant is chosen in terms of the bioactive ingredient content . This chapter also presents the results of the determinations to which sea buckthorn borhot, dry sea buckthorn borhot and sea buckthorn powder are subjected to observe the loss of bioactive substances during thermal treatments. Choose the thermal treatment option, with the established parameters. The obtained results demonstrated that conventional drying at a temperature of 50°C for 12 hours is the most viable from a qualitative and nutritional point of view.

In **Chapter 5** (7 pages), entitled " ***EXPERIMENTAL RESEARCH ON THE COMPOSITIONAL CHARACTERIZATION OF SEA BUCKTHORN POWDER AND WHEAT FLOUR***", the results of the determinations to which the two main ingredients are subjected, buckthorn powder and wheat flour, which will represent the raw material, are presented for obtaining bakery products with bioactive ingredients.

Chapter 6 (14 pages), called " ***DETERMINING THE PERCENTAGE OF SEA BUCKTHORN POWDER ADDED TO THE BREAD DOUGH***" presents the results of laboratory determinations for different technological, nutritional and sensory indicators. The mixtures are made from wheat flour mixed with different percentages of sea buckthorn powder, 4%, 6%, 8%, 10%, these being subjected to rheological, physico - chemical analyzes (water activity, humidity, acidity, color), the content of bioactive substances (minerals, antioxidant activity, polyphenols). In this chapter, the percentage of sea buckthorn powder used in the baking samples is established, which is 6%, 8% and 10%.

In **Chapter 7** (17 pages) "***EXPERIMENTAL RESEARCH ON THE EVOLUTION OF BREAD QUALITY AFTER THE ADDITION OF BIOACTIVE INGREDIENTS",*** both the technology for obtaining bakery products, bread with sea buckthorn powder, and the recipe are established depending on the results of the analyzes in chapter 7. In this chapter, the results of the physico -chemical, nutritional, sensory and microbiological

analyzes are discussed and analyzed, in order to establish which is the finished product that meets the conditions of a safe product, with biological value and acceptability from consumers so that it can be marketed on a large scale. The bread with 8% addition of sea buckthorn powder is the one for which the texture, color and microbiological analyzes continue, these being necessary for the presentation of a commercial product on the shelf.

In **Chapter 8** (9 pages) ***"RESEARCH ON CONSUMER BEHAVIOR TOWARDS BREAD ENRICHED WITH ORGANIC SEA BUCKTHORN WASTE "*** *in which the* joint study is presented , the conclusions being that I maintain the following, namely: the product is manufactured in Romania, from a brand known on the local market, with a price of 7.5 lei for 400g, with the mention "Product enriched with sea buckthorn" and "We reduce food waste, we use all the fruit" are the most appreciated by the target group of consumers used in the joint study .

Part III " ***CONCLUSIONS"*** includes a single chapter, **Chapter 9** (2 pages) " ***GENERAL CONCLUSIONS AND RECOMMENDATIONS"*** where the achievement of the objectives contained in the research is assessed. The main direction of the request aimed at the development of a bakery product that has in its composition bioactive ingredients, accepted by the consumer and that has a positive impact on the reduction of food waste has been fully realized