„DUNĂREA DE JOS” UNIVERSITY OF GALAŢI

Doctoral Schoolof Fundamental Science and Engineering

DOCTORAL THESIS

SUMMARY

THE DESIGN AND PRODUCTION OF SPECIAL PURPOSE FOODS

Ph.D student,

Luiza-Andreea TĂNASE (BUTNARIU)

Scientific coordinator,

Prof. dr. eng. Elisabeta BOTEZ

Seria I.7: FOOD ENGINEERING NO. 23

GALAŢI

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CONTENT

Keywords: plants with lactogenic potential, bioactive compounds, ready-to-eat

Introduction

According to the WHO (World Health Organization), infants should be exclusively breastfed for the first 6 months of life in order to have optimal physical and psychomotor growth and development. All over the world, women have encountered lactation failure, thus making it necessary to adopt a proper diet and a healthy lifestyle. Also, due to increasingly busy schedules, people are increasingly turning to faster options, such as Ready-To-Eat products.

The selection of the doctoral thesis "The design and production of special purpose foods" was based on the opportunity to exploit the potential of lactogenic plants used since ancient times, together with an intake of nutrients necessary for a healthy lifestyle.

The doctoral thesis entitled "The design and production of special purpose foods" aimed to obtain Ready-To-Eat products with special purpose, through the determination and phytochemical characterization of aqueous extracts made from different lactogenic plants, as well as their use for the purpose of obtaining products of animal and vegetable origin with added value. The research carried out during the doctoral studies aimed at the following scientific objectives:

- Realization of aqueous extracts from medicinal plants, followed by the identification and quantification of the active principles from the extracts (total polyphenol content, total flavonoid content, antioxidant activity)
- Realization of Ready-To-Eat products of animal origin, followed by the complex characterization of special purpose products by identifying and quantifying the active principles.
- Realization of ready-to-eat products of plant origin, followed by the complex characterization of special purpose products by identifying and quantifying the active principles.

The doctoral thesis is structured in two parts, as follows:
I. **THE DOCUMENTARY STUDY**, including in 3 chapters that present recent data from the specialized literature related to nutrition during pregnancy and breastfeeding, to plants with lactogenic potential, and to the characterization of the micronutrients in their composition as well as the extraction methods. The

raw materials of animal and plant origin are also presented and characterized, together with data from the specialized literature regarding the thermal processing techniques currently used in their processing.
II. **EXPERIMENTAL STUDY**, structured in 3 chapters that include the results of the research studies carried out during the doctoral internship, briefly presented as follows:

CHAPTER 4, titled **"OBTAINING AND CHARACTERIZATION OF AQUEOUS EXTRACTS FROM PLANTS WITH LACTOGENIC POTENTIAL"**, presents the results obtained in the extraction experiments and the phytochemical characterization of aqueous extracts obtained from 8 plants with lactogenic potential, by using spectrophotometric methods.

CHAPTER 5, entitled **"OBTAINING AND CHARACTERIZATION OF MEAT PRODUCTS WITH ADDED AQUEOUS EXTRACT OF LEMON BALM/WILD THYME"** presents the results obtained in the thermal processing stages of different types of meat (turkey, pork and beef), as well as the complex characterization (phytochemical, textural, rheological) of the Ready-To-Eat type products with added aqueous extract from lactogenic plants (lemon balm/wild thyme).

CHAPTER 6, entitled **"OBTAINING AND CHARACTERIZING VEGETABLE PURES WITH ADDED AQUEOUS EXTRACT OF ANISE/FENNEL"** presents the results obtained in the stages of thermal processing and development of Ready-To-Eat product variants with addED aqueous extract from lactogenic plants (anise/fennel) and their phytochemical, textural and rheological characterization.

Each chapter of the experimental study is structured as follows: General aspects, Objectives of the study, Materials, Methods, Results and discussions, Partial conclusions and Bibliographic references.

GENERAL CONCLUSIONS, presents the main conclusions resulting from the determinations made in the present doctoral thesis.

ORIGINAL CONTRIBUTIONS AND PERSPECTIVES FOR FURTHER RESEARCH describes the main contributions made to the development of knowledge in the subject covered and new perspectives for further research.

DISSEMINATION OF THE RESULTS presents the main publications and participation in national and international scientific events, which aimed to capitalize on the results obtained in the present doctoral thesis.

The doctoral thesis comprises 139 pages, in which 35 figures and 18 tables are included. The documentary study represents 25% and the experimental part 75%.

Finally, the original contributions of the doctoral thesis are presented, including the impact on the development of knowledge in the field and the prospects for further research, as well as the dissemination of the results obtained in the addressed research field. The research results were disseminated through the elaboration of xx scientific articles, 1 article published in the rated magazine ISI Proceedings journal (*10th Central European Congress on Food*), 5 articles published in ISI rated journals (2 articles in *Molecules,* one in *Processes* and 2 articles in *The Annals of the University Dunarea de Jos of Galați*), as well as 22 communications at representative scientific events in the field of food engineering, national and international.

The research activities of the doctoral thesis were carried out with the support of the Integrated Center for Research, Expertise and Technology Transfer (BioAliment-TehnIA) (www.bioaliment.ugal.ro), within the Faculty of Food Science and Engineering, University "Dunărea de Jos" from Galați.

The thesis was carried out under the scientific coordination of Prof. dr. eng. Elisabeta BOTEZ, as PhD supervisor and of the guidance committee made up of: Ș.l. dr. eng. Oana-Viorela NISTOR, L. dr. eng. Doina-Georgeta ANDRONOIU and Ş.l. dr. eng. Gabriel-Dănuț MOCANU.

CHAPTER 1. Plants with lactogenic potential

1.1. Nutrition during pregnancy and breastfeeding

Nutrition is the main problem facing humanity today. People's ignorance of nutrition results in several modern diseases, such as metabolic syndrome, characterized by high blood pressure, diabetes, atherosclerosis, and cardiovascular disease in general *(Verbanac et al., 2019).*

Pregnancy represents a challenge from a nutritional point of view, because the intake of micronutrients in the periconceptional period and during pregnancy directly contributes to the development of the fetal organs and the mother's health. Poor nutrition can lead to numerous deficiencies and cause numerous problems, such as abortion, intrauterine growth restriction (IUGR), preterm birth, and preeclampsia (PE) *(Milman et al., 2016)*.

Nutritional requirements are different during pregnancy than at other stages of life, as the mother's body must support the embryo's development, then the fetus. Poor or unsafe nutritional intake during pregnancy can lead to infections, poor or excessive fetal growth, and an increased risk of metabolic disease. The negative effects of poor nutrition during pregnancy can extend over decades for both mother and child (eg. diabetes and obesity) *(Cannon et al., 2020)*.

A common myth that needs to be dispelled is that pregnant women should "eat for two". There can be harmful effects on the health of the fetus and the mother when eaten in excess. Recommendations for energy intake during pregnancy in the UK are to increase intake by around 200 calories (about 837 kJ) per day and only in the third trimester. An extra 200 calories is roughly equivalent to adding a banana and yogurt to your regular diet. These recommendations are based on the assumption that fetal development and gestational weight gain remain within optimal parameters, so monitoring both throughout pregnancy is essential to confirm that energy intake is adequate for the individual *(de Seymour et al., 2019)*

1.2. Plants with lactogenic potentital

Over the years, the role of breast milk has become increasingly recognized as beneficial in reducing morbidity among infants, especially among preterm infants. Breast milk is known to be the ideal form of nutrition for a baby in the first 6 months of life, as it provides the nutrients necessary for healthy development *(Özalkaya et al., 2018)*. Breastfeeding also confers several benefits to mothers, which include reduced risk of breast, endometrial, and ovarian cancer, along with faster return to pre-pregnancy weight and improved psychological well-being of the nursing mother *(Grzeskowiak et al., 2019)*.

Insufficiency of breast milk was frequently reported as the main reason for discontinuation of breastfeeding. Many women, especially those who gave birth prematurely, experienced difficulties in producing the required amount of milk *(Shawahna et al., 2018)*.

During the postpartum period, many women experience acute and chronic health problems (cough, infections, back pain, migraine, depression and more) and require drug treatment. This case is one of the women's self-reported reasons for stopping breastfeeding. In addition, many healthcare professionals lack scientific knowledge of the medication and may advise women to discontinue breastfeeding during treatment *(Saha et al., 2015)*.

It has been claimed that at least 5% of women experience insufficient lactation (called agalactia), while approximately 15% of women experience an inadequate supply of breast milk (called hypogalactia) at 3 weeks postpartum and the number is constantly increasing *(Oppong Bekoe et al., 2019)*.

Galactogogues are foods, pharmaceuticals or herbal supplements that are used to support the initiation, maintenance or increase of breast milk production *(Nur Hayati et al., 2019)*. They also increase prolactin secretion and provide psychological comfort and a marginal contribution to breast milk production. Human milk production is a complex physiological process involving physical and emotional factors and the interaction of several hormones, the most important of which is considered to be prolactin *(Brodribb, 2018)*.

As stated in the definition, galactogogues are:

• foods, such as banana flower, lemon basil, Thai basil, chicken, fish, pumpkin and others *(Buntuchai et al., 2017)*;

• pharmaceuticals, such as metoclopramide, domperidone, chlorpromazine and sulpiride;

• medicinal herbs.

There are numerous plants around the world known as galactogogues. The most commonly used herbs in commercial preparations and formulations are fennel, anise, star anise, shatavari, torbangun, cumin, dill, fenugreek, milk thistle, thyme, thyme and many others *(Khorshidian et al., 2019)*.

CHAPTER 2. Raw materials used to obtain special purpose ready-to-eat products

2.1. General aspects

The World Health Organization has estimated that in 2014, 300 million women in the world were obese, stating that when they become mothers, the chances of having obese children are much higher, especially if they develop gestational diabetes *(Watson, 2015)*.

However, consumer interest in food safety and quality has grown surprisingly in recent years, thus increasing the demand for ready-to-eat (RTE) products *(Nikmaram et al., 2018)*.

Food processing is a segment of the food industry that transforms raw materials of animal, plant and marine origin into value-added intermediate or finished food products that are safe for consumption. This transformation requires the application of labor, energy, machinery, and scientific knowledge to one step (unit operation) or to a series of steps (process) in achieving the desired transformation. From raw materials, value-added ingredients or finished products are obtained that satisfy the needs and convenience of consumers. At the same time, the shelf life of food materials is also extended, by preserving the product against biological, chemical and physical hazards *(Clark et al., 2014)*.

2.2. Characterization of the raw material of vegetable origin used for research

2.2.1. Red capsicum (Capsicum annuum L.)

A valuable vegetable is sweet capsicum pepper (*Capsicum annuum* L.). It is a widespread vegetable crop that is consumed and grown all over the world. Their popularity is constantly increasing due to their varied flavor, color (red, green and yellow) and nutritional value *(Kaur & Kaur, 2020)*. Red capsicum pepper belongs to the *Solanaceae* family and contains various bioactive compounds, such as carotenoids, capsaicinoids, phenolic compounds (flavonoids), vitamin C, vitamin E and numerous fatty acids *(Feng et al., 2022)*.

2.2.2. Zucchini (Curcubita pepo L.)

Zucchini (*Curcubita pepo* L.) is very popular in human nutrition due to its low calorie count (a medium-sized zucchini has only 25 calories) attributed to its high water content (about 96%). At the same time, they have a high nutritional value due to the significant content of potassium, folic acid and vitamin A. They also contain a high percentage of magnesium, phosphorus and vitamin C, which are necessary to build and maintain healthy bones. Regular consumption of zucchini helps treat asthma and can be used to prevent scurvy and bruising caused by a vitamin C deficiency *(Rolnik & Olas, 2020)*.

2.2.3. Beetroot (Beta vulgaris L.)

Beetroot (*Beta vulgaris* L.) is a tuber belonging to the Chenopodiaceae family, originating from Europe and North Africa. It has preventive properties against many diseases, caused by the proliferation of free radicals, mainly due to its high content of bioactive compounds such as vitamins (C, B1, B2, B3, B6 and B12) and polyphenols (betalains and flavonoids) *(Ramírez-Melo and al., 2022)*. In addition, beetroot contains a significant amount of phenolic acids such as ferulic, protocatechuic, vanillic, p-coumaric and p-hydroxybenzoic and syringic acids *(Hidalgo et al., 2018)*. Numerous studies have reported that beetroot has beneficial health properties, such as antioxidant properties *(Sawicki et al., 2016)*, anti-inflammatory and antihypertensive as well as anti-carcinogenic properties, being an adjuvant in the prevention of cancer and cardiovascular diseases *(Mella et al., 2022)*. As a source of iron, it treats and prevents anemia, and the folic acid in beetroot can protect against birth defects, while dietary fiber can have a beneficial effect on the colon. Thus, it is a very popular vegetable from a nutritional and economic point of view *(Ropelewska et al., 2022)*. Due to its positive impact on health, beetroot has been easily incorporated into various food products such as wine, ice cream, yogurt, jam, pasta or biscuits *(Cui et al., 2022)*.

2.2.4. Sweet potato (Ipomoea batatas L.)

Ipomoea batatas, commonly known as the sweet potato, belongs to the *Convolvulaceae* family. Its tubers were originally cultivated in South America and the Greater and Lesser Antilles. Various varieties of *I. batatas* are now widely cultivated in tropical, subtropical and warm temperate regions around the world between 40 °N and 32 °S. The tuber of *I. batatas* is rich in starch, dietary fiber, pectin, minerals, vitamins and bioactive compounds. It is a primary source of starch and a productive and adaptable crop. It is widely used in industrial and agricultural food production and has recently become a research focus due to its unique nutritional and functional properties that promote human health *(Jiang et al., 2019)*.

2.3. Characterization of the raw material of animal origin used for research

Like other sectors of the food industry, the meat industry is undergoing major transformations and is driven, among other things, by changes in consumer demands. One of the main trends shaping developments in the consumption of meat derivatives is consumer interest in the possibilities of improving health through food. Functional meat-based foods are seen as an opportunity to improve their “image” and address consumer needs as well as meet dietary nutritional goals *(Sánchez-Muniz et al., 2012)*.

Meat is a complex food with a highly structured nutritional composition. Thermal processing of meat products is essential for making a pleasant and safe product for consumption. Meat becomes edible and more digestible when it undergoes processing. However, heat treatment can lead to undesirable changes in meat quality, such as loss of nutritional value, mainly due to lipid oxidation and modification of some components of the protein fraction *(Białobrzewski et al., 2010).*

Meat is considered the best source of high-quality protein due to its balanced composition of essential amino acids and their high digestibility. In addition to their nutritional value, meat proteins have bioactive peptides encoded in their sequence, which can be released by enzymatic hydrolysis *(Martini et al., 2019)*. Minced meat products, known as "meatballs" are products obtained from minced meat that can be classified as restructured meat and are very popular in some countries in the Asian region and in some European countries. They can be prepared using beef, chicken, pork or fish, and the ones that are very popular and widely found in the market are beef products. In order to obtain economic benefits, the substitution of beef in meatballs with lower-priced meat such as pork is common.

2.3.1. Turkey tenderloin

Poultry meat is one of the most popular food products around the world. Poultry meat consumption has increased in recent decades in many countries due to, among other things, the relatively low production cost, low fat content and high nutritional value *(Karpińska-Tymoszczyk, 2014)*.

Poultry meat is a raw material that is prone to spoilage and the development of pathogens. For example, Campylobacter jejuni spoils raw or untreated meat, *Escherichia coli* O157:H7 contaminates raw meat, *Listeria monocytogenes* contaminates dry sausages, meat and meat products, *Clostridium* and *Salmonella* contaminate poultry in general. All these contaminations contribute to the number of foodborne diseases in the world *(Guyon et al., 2016)*.

2.3.2. Pork tenderloin

In recent decades, lifestyles regarding meat consumption have changed. Consumers have become more selective, especially in terms of product quality, functional and nutritional properties, awareness of the relationship between food and health, animal welfare and environmental care. Pork production amounts to about 50% of total meat production in Europe and according to a survey conducted by the Food and Agriculture Organization of the United Nations (FAO) in 2007, 75% of consumers include pork once a week in their diet *(Papadopoulou et al., 2011)*.

Also, pork is the most sold meat in the European Union, and its sales are estimated at 9% of total agricultural production according to a study carried out in 2015. A high proportion of sold pork (40%) is consumed in the form of minced meat. In addition, this value is predicted to increase due to consumer expectations, which are increasingly opting for convenience food *(Pogorzelska et al., 2018)*. In general, minced pork is appreciated by consumers for its convenience, although the shelf life is limited due to the large, exposed surface area that favors spoilage *(Papadopoulou et al., 2011)*.

2.3.3. Beef tenderloin

Beef is a raw material prone to deterioration and the development of pathogens. For example, *Escherichia coli* O157:H7 contaminates raw beef, especially minced meat *(Guyon et al., 2016)*. Thus, it is recommended that it is normally stored at refrigerated temperatures to maintain its microbial safety. Cold storage also allows the activation of proteolytic enzymes that mainly break down myofibrillar proteins *(Vaskoska et al., 2020)*.

CHAPTER 3. Thermal processing techniques

3.1. General aspects

Food safety is one of the most important issues worldwide. To prevent food spoilage and preserve food quality and sanitary conditions for human consumption, several types of physical, chemical and biological food treatments have been explored with various technologies *(Yeh et al., 2019)*.

Before being consumed, meat and meat products undergo processes that can affect the quality of the finished products. These include slaughtering, ripening, storage and others. Meat and meat products are rich in protein and, depending on the type of muscle, contain variable amounts and proportions of storage lipids (triacylglycerols) and structural lipids (phospholipids). For a long time, lipid oxidation in muscle foods was considered the main reaction affecting their qualities, especially sensory ones *(Guyon et al., 2016)*.

Processing is an indispensable process defined as the application of heat and/or other forms of energy to prepare food for consumption and is used to improve the palatability and nutritional availability of raw materials, along with improving their sensory characteristics (since certain heat-induced reactions can affect sensory qualities of the product) and food safety *(Ángel-Rendón et al., 2019; Ayadi et al., 2009)*.

Also, heat treatment is one of the most important methods of preserving vegetables. Thermal processing of food is primarily intended for the inactivation of pathogens and other degrading microorganisms capable of making them unfit for consumption, as well as the inactivation of enzymes. In addition, thermal processing improves the bioavailability of organic compounds present in food (eg. beta-carotene) because it breaks down the cellulose structure of plant cells. Unfortunately, the sensory properties of food, including nutrients, color and texture, change during the process. Kinetic models of thermal destruction are essential for the design of new processes that assume a safe food product and that provide preservation of product quality *(Dutta et al., 2006)*.

Thus, heat processing becomes a crucial processing step both in households and at industrial level to obtain a microbiologically safe, high-quality product with improved sensory properties *(Rabeler & Feyissa, 2018a, 2018b)*.

When it comes to minced meat products, heat processing is an essential element. In general, minced meat products are prepared by frying or boiling, but in this last method the quality is damaged, especially on the surface, due to the long time of exposure to high temperatures *(Engchuan et al., 2014)*. Meat undergoes numerous changes during heat treatment, both physical and chemical, including weight loss, changes in water-holding capacity, textural changes, muscle fiber contraction, color and flavor changes, which are strongly dependent on protein denaturation and of water loss. The quality characteristics of cooked meat products are also dependent on the composition and characteristics of the anatomical portions used, the heat treatment used, as well as the time/temperature evolution during cooking *(Mora et al., 2011)*.

Heat transfer is one of the fundamental processing principles applied in the food industry and has applications in various unit operations such as thermal processing, evaporation (concentration) and drying, freezing and thawing, baking and cooking. Heating is used to destroy microorganisms, provide healthy food, extend shelf life by destroying certain enzymes, and promote a product with acceptable taste, smell, and appearance. Heat transfer is governed by the heat exchange between a product and its surroundings. The extent of heat transfer generally increases with increasing temperature difference between the product and the environment *(Clark et al., 2014)*.

4. Obtaining and characterization of aqueous extracts from plants with lactogenic potential

4.1. General aspects

Breastfeeding saves lives and promotes physical and mental health throughout childhood and throughout the rest of life *(Khatun et al., 2018; Koko et al., 2019; Sankar et al., 2015)*. The reduced volume of breast milk is a major problem that can lead to rhythm disturbances in exclusive breastfeeding or even to the discontinuation of exclusive breastfeeding for good *(Bumrungpert et al., 2018)*.

Galactogens are drugs or other substances with stimulatory potential in initiating, maintaining, or increasing the volume of breast milk *(Brodribb, 2018)*. With information readily available through the Internet, social media, support systems, and healthcare professionals, women may choose to use galactogenic herbs prophylactically or in response to decreased breast milk secretion. In a 2012 study, estimates suggested that at least 15% of breastfeeding women would try herbal galactogens *(Zapantis et al., 2012)*.

All over the world and throughout history, women have used certain herbs to stimulate their lactation. Most of these herbs have not been scientifically evaluated, but their traditional use suggests safety and some efficacy. These medicinal plants include fenugreek, armory and many others *(Elemo et al., 2016)*. Previous scientific reports have mostly studied plants from the Apiaceae family and due to their strong antioxidant potential *(Kalleli et al., 2019; Bettaieb Rebey et al., 2018; Sayed Ahmad et al., 2018; Bettaieb et al., 2010)*.

4.2. Study objectives

- Selection of medicinal plants with the help of specialized literature, which could be used as ingredients in food with a special purpose, namely, for women during pregnancy/breastfeeding.
- Identifying the optimal methods of extracting the biologically active compounds of medicinal plants.
- Obtaining aqueous plant extracts by using different extraction methods: infusion, maceration, decoction and microwave-assisted extraction.
- Identification and quantification of the active principles from the extracts (total polyphenol content, total flavonoid content, antioxidant activity, by the DPPH and ABTS method).

4.5. Results and discussion

The coding of the extraction methods was done as follows:
I – Infusion;
M – Maceration;
D – Decoction;
MAE 30 – Microwave assisted extraction for 30 seconds;
MAE 75 – Microwave assisted extraction for 75 seconds;

The samples/aqueous extracts analyzed were coded as follows:
An – Anise (*Pimpinella anisum* L.);
Fe – Fennel (*Foeniculum vulgare* L.);
Ci – Thyme (*Thymus serpyllum* L.);
Ar – Milk thistle (*Silybum marianum* L.);
Ro – Lemon balm (*Melissa officinalis* L.);
Sc – Fenugreek (*Trigonella foenum-graecum* L.);
As – Star anise (*Illicium verum* L.);
Ch – Cumin (*Cuminum cyminum* L.).

4.5.2. Total polyphenol and flavonoid content of aqueous plant extracts

The total polyphenol content of some galactogenic plants (table 4.1) varied between 3.283±0.011 mg GAE/mL and 34.315±0.00 mg GAE/mL. Among all the plants, the extract from the leaves of the lemon balm (*Melissa officinalis* L.) recorded the highest total content of polyphenols (34.315±0.00 mg GAE/mL) obtained by decoction, while the seeds of Ar (*Silybum marianum* L.) had the lowest total phenolic content (3.283±0.011 mg GAE/mL) obtained with the MAE – 30 extraction technique. Similar results were reported by *Ulewicz-Magulska & Wesolowski, 2019* for some medicinal and culinary plants . As shown in Table 1, the highest total phenolic content was obtained by the decoction extraction technique, followed by MAE – 30 > MAE – 75 > infusion > maceration. According to *Iwansyah et al., 2016* this aspect can be explained by the fact that aqueous extracts can dissolve quickly, based on their polarity, carbonyl and organic acids. *Kormin et al., 2016* observed similar results for water-based extract compared to MAE and ethanol extract for Malaysian palm oil obtained from the trunk of epiphytic ferns. Also, *Mata et al., 2007* recorded similar values for five plants used as Portuguese spices. In the case of the galactogenic plants studied, the highest average of the total phenolic content was established for the sample Ro followed by Ci > An > Fe > As > Ch > Ar > Sc. The presented results emphasized the importance of total phenolic compounds in the antioxidant behavior of galactogogue plant extracts and indicated that phenolic components contributed significantly to the total antioxidant capacity values.

Flavonoids are the dominant class of phenolic compounds found in almost all vegetables and plants that have antioxidant properties. The highest total flavonoid content (table 4.1) of the studied lactogenic plant extracts was recorded for the leaves of Ro (*Melissa officinalis* L.) and As (*Illicium verum* L.) (5.779±0.014 and 3.517±0.22 mg EQ /mL), obtained by two different extraction techniques (decoction and MAE - 30). However, the seeds or leaves of Ar (*Silybum marianum* L.) and Sc (*Trigonella foenum-graecum* L.) showed the lowest total flavonoid content (0.181±0.00 and 0.145±0.00 mg EQ/mL). According to the results of the present study, the aqueous extract with the highest total flavonoid content was obtained by decoction. This aqueous extract is safe to consume on its own or in combination with various foods. A similar trend was reported by *Wong et al., 2014* for some wild edible plants in Malaysia namely *Helminthostachys zeylanica*, *Schismatoglottis ahmadii*, *Heckeria umbelatum, Lasia spinosa, Gonostegia hirta* and *Aniseia martinicense*.

The CTF/CTP ratio of Fe (*Foeniculum vulgare* L.) extract was much higher (0.61) compared to the other galactagogue plant extracts and was followed by Ar > Ch > An > Sc > As > Ci > Ro . This could contribute to its overall antioxidant capacity, as flavonoid components are the most active antioxidant phenolic compounds.

Different concentrations of total phenolics and flavonoids in galactagogue herb extract may result from several plant-specific factors, such as species, variety, influence of growing season, as well as climatic conditions, cultivation and harvesting time *(Iwansyah et al., 2016; Iwansyah & Mohd Yusoff, 2012; Saxena & Chagti, 2016; Srivastava et al., 2013)*.

Table 4.1. *Influence of extraction techniques on polyphenol and flavonoid content of galactogenic plant extracts*

Extraction method	**Galactogogue plants**							
	An	***Fe***	***Ci***	***Ar***	***Ro***	***Sc***	***As***	***Ch***
Results compared according to extraction method								
Total phenolic content (mg GAE/mL)								
Maceration	6.649±0.004 C	5.151 ±0.022 C	12.504±0.017 B	3.515 ±0.004 C	24.40 ±0.013 A	3.374 ±0.006 C	4.535 ±0.001 C	3.958 ±0.005 C
Infusion	7.207±0.05 C	5.335 ±0.01 C	17.922±0.03 B	4.201 ±0.02 C	27.453±0.04 A	5.025 ±0.01 C	8.266 ±0.01 C	4.417 ±0.00 C

Decoction	6.972±0,01^{C}	5.033±0.00^{C}	18.452±0.02^{B}	6.638±0.07^{C}	34.315±0.00^{A}	6.183±0.00^{C}	6.128±0.01^{C}	4.872±0.00^{C}
MAE - 30	7.058±0.013^{C}	5.465±0.009^{C}	11.515±0.015^{B}	3.283±0.011^{C}	28.822±0.021^{A}	4.735±0.003^{C}	12.335±0.01^{C}	4.272±0.005^{C}
MAE - 75	7.513±0.005^{C}	5.689±0.003^{C}	21.375±0.017^{B}	3.774±0.004^{C}	34.174±0.024^{A}	5.273±0.003^{C}	3.393±0.003^{C}	4.884±0.004^{C}
Total flavonoid content (mg EQ/mL)								
Maceration	1.023±0.01^{B}	0.774±0.01^{B}	2.556±0.04$^{A. B}$	0.534±0.01^{B}	4.969±0.08^{A}	0.389±0.01^{B}	1.053±0.02^{B}	0.752±0.06^{B}
Infusion	1.067±0.02^{B}	0.897±0.018^{B}	2.739±0.029$^{A. B}$	0.527±0.012^{B}	3.670±0.03^{A}	0.517±0.011^{B}	1.223±0.028^{B}	0.684±0.004^{B}
Decoction	1.175±0.011^{B}	0.820±0.009^{B}	3.267±0.016$^{A. B}$	1.122±0.014^{B}	5.779±0.014^{A}	0.905±0.019^{B}	0.902±0.013^{B}	1.207±0.014^{B}
MAE - 30	3.062±0.10^{B}	3.330±0.29^{B}	3.095±0.10$^{A.B}$	1.960±0.10^{B}	5.304±0.08^{A}	1.986±0.08^{B}	3.517±0.22^{B}	2.367±0.07^{B}
MAE - 75	0.359±0.01^{B}	0.366±0.01^{B}	0.308±0.00^{A,B}	0.181±0.00^{B}	0.399±0.01^{A}	0.145±0.00^{B}	0.224±0.00^{B}	0.371±0.00^{B}
Results compared according to lactogenic plants								
Ratio TFC/TPC								
Maceration	0.15	0.15	0.20	0.15	0.20	0.12	0.23	0.19
Infusion	0.15	0.17	0.15	0.13	0.13	0.10	0.15	0.15
Decoction	0.17	0.16	0.17	0.17	0.17	0.15	0.15	0.25
MAE - 30	0.43	0.61	0.27	0.60	0.18	0.42	0.29	0.55
MAE - 75	0.05	0.03	0.01	0.02	0.01	0.03	0.07	0.08

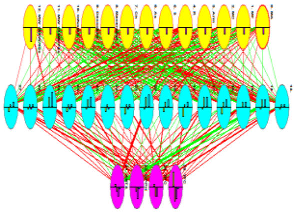
Values on the same row with different superscript (A-C) are significantly different ($p \leq 0.05$).

4.5.3. Artificial neural networks (ANN) used for the characterization of aqueous extracts

Empirical data were processed using artificial neural network models. The inputs are represented by the lactogenic plant extracts and the extraction techniques, while the outputs are represented by the results of determinations regarding the phytochemical profile of the extracts (CTP and CTF, as well as antioxidant activity determined by DPPH and ABTS assays).

Figure 4.3. shows the Artificial Neural Network for lactogenic plant extracts, where (a) represents the RNA architecture for the present study, while

(b) represents the performance of the error values resulting from the training process.



Learning rate	0.60000
Momentum	0.800000
Accelarator	0.000000
Maximum error	0.009957
Average error	0.001009
Minimum error	0.000036
Target error	0.010000
Training examples	40

(a) **(b)**

Figure 4.3. Artificial Neural Network for the galactogogue plant extracts (a) and the resulted error values (b)

From Figure 4.3 (a) it could be seen that the network includes only a hidden layer and a number of 32 neurons. After this step the network was trained using 192 learning cycles and the maximum error obtained was 0.01. The continuous decreasing of the error presented in the Figure 4.3 (b) indicates that the neural network is correctly built. After obtaining the ANN, it could be used for the establishing of the maximum efficiency for every analysis. It seems that the most feasible combination between the plant and the associated extraction techniques is represented by the lemon balm extract obtained by microwave, maceration or infusion. For the TPC, DPPH and ABTS analysis, the best results were registered for lemon balm, star anise, extracted by maceration and microwave, while for TFC the optimum plants are lemon balm and cumin, respectively, extracted by microwave. Even if there are many combinations in which any analysis could be important or relevant, the extraction techniques and the plant types are decisive.

4.5.4. FT-IR analysis of aqueous extracts

The FT-IR analysis of aqueous plant extracts aimed to reveal the presence of some specific compounds or functional groups, which are involved in the health benefits mechanism.

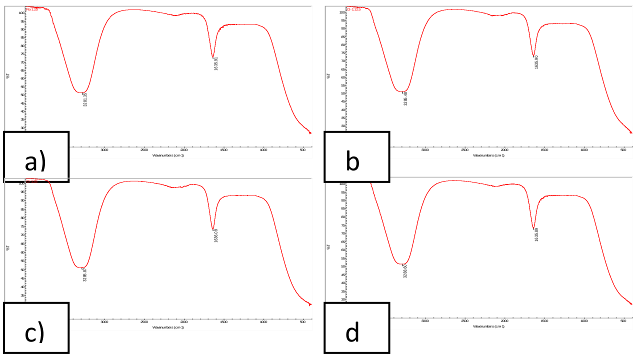


Figure 4.4. FT-IR determination for a) Ci - Thyme (aqueous 1:25); b) Ci - Thyme (aqueous 1:12,5); c) Ro - Lemon balm (aqueous 1:25); d) Ro - Lemon balm (aqueous 1:12,5).

The FT-IR spectra for both extracts revealed the presence of the bands at 3288.6 cm^{-1} is attributed to –OH stretching vibration which could be attributed to phenols, esters or other compounds which are native in these extracts. The absorption bands in the range of 1700 − 1500 cm^{-1} region is defined by amide I and II groups responsible for the peptide linkages in proteins. The 1635 cm^{-1} indicates the C=O stretching) coupled with N–H in-plane bending which are involved in maintaining the normal functions of the central nervous system *(Balan și al., 2019)*. The similarity of both extracts of thyme and lemon balm induced the idea that some specific and common components are present in the samples.

4.5.5. Confocal microscopy

The CLSM was used to determine the main bioactive compounds which are present in the extracts structure. This type of analysis could be useful to understand the phenomena and interactions between some compounds with health potential.

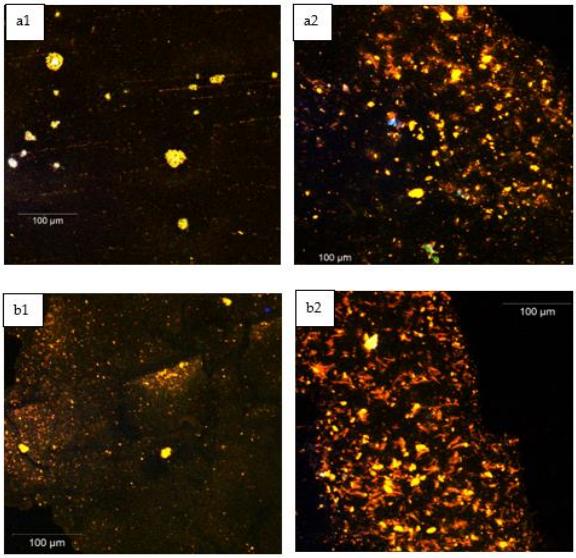


Figure 4.5. Confocal Laser Scaning Macroscopy images of Ci (a1 and a2) and Ro samples (b1 and b2)

Due to the strongest antioxidant activity that was recorded for thyme and lemon balm extracts, obtained by decoction, these were the samples selected for the confocal microscopy analysis. The high content of biologically active compounds from the extracts of these plants, their diversity and complexity, determined a wide fluorescence emission range, between 550-650 nm. The thyme extract obtained by decoction (aqueous extract1:25), highlighted the largest spherosomes with dimensions between 10-30µm (Figure 4.5 a1), while the thyme extract (aqueous 1:12.5), they were smaller and with a tendency to aggregate (Figure 4.5 a2). The finest spherosomes (1-2 µm diameter) were obtained by decoction from *Melissa officinalis* (aqueous 1:25) (Figure 4.5 b1), while in the second one (aqueous 1:12.5) favored the formation of large clusters of coacervates captured in a dense network with a predominantly red emission (620-650 nm). Point-by-point laser scanning images highlighted the biologically active compounds' richness that supports the intense antioxidant activity and justifies the use of the extracts in foods with a high nutritional value indicated in the diet of certain categories of people.

4.5.6. Principal Component Analysis (PCA)

In order to choose the extraction technique, which would ensure the highest efficiency of total phenolics extraction, total flavonoids extraction, DPPH scavenging activity and ABTS scavenging activity, the PCA (Figure 4) was applied to evaluate correlations between TPC, TFC, DPPH or ABTS (loads) and 8 different galactogogue herbs (scores).

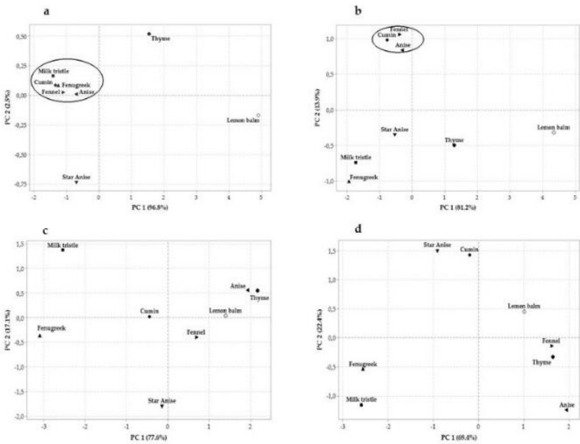


Figure 4.6. Principal component analysis (PCA) plots
a – TPC for galactogogue herb extracts; b – TFC for galactogogue herb extracts; c – DPPH in the galactogogue herb extracts; d – ABTS in the galactogogue herb extracts.

Figure 4.6 a and b shows the overall plot of total phenolic and total flavonoid content present in galactogogue herb extracts. Same tendencies were found when comparing quantities of total phenolic content presented in galactogogue herb extracts obtained with different extraction techniques, i.e. the highest TPC was found in the extract from leaves of Ro (*Melissa officinalis* L.), while the lowest TPC was obtained for the extract from seeds of Ar (*Silybum marianum* L.). For TPC it was found that some galactogogue herb extracts could be grouped together such as extracts from milk thistle (*Silybum marianum* L.), cumin (*Cuminum cyminum* L.), fenugreek (*Trigonella foenum-graecum* L.), fennel (*Foeniculum vulgare* L.) and anise (*Pimpinella anisum* L.).

Similar trends of TFC were found; in Figure 4.6 b one may notice that some galactogogue herb extracts can be grouped together, such as fennel (*Foeniculum vulgare* L.), cumin (*Cuminum cyminum* L.) and anise (*Pimpinella anisum* L.). This suggests the similarity between the extraction techniques used to determine TPC and TPC in the case of the analysed samples. When the results of DPPH or ABTS scavenging activity were examined (Figure 4.6 c and d) it was found that fennel, lemon balm, anise and thyme exhibit a high antioxidant activity and they are located diametrically opposite to cumin, fenugreek, milk thistle and star anise which possess a low antioxidant activity. We can suggest that the contribution of TPC and TFC on antioxidant activity in the case of these galactogogue plants is the lowest. These results are in accordance with (Hossain și al., 2011) who used PCA to classify different spices based on antioxidant activity and individual polyphenolic antioxidant compounds.

4.6. Partial conclusions

- To fulfill the main objective of this chapter, 8 lactogenic plants were used, which were subjected to extraction using water as a solvent, using 4 extraction methods, such as maceration, infusion, decoction and microwave processing.
- The present study demonstrates the high antioxidant activity, as well as the high content of polyphenols and flavonoids of the aqueous extracts of mullein that could be involved in maintaining the antioxidant status and protecting against the negative action of free radicals. Other lactogenic plants, such as star anise or chives, also show strong antioxidant activity.
- Modeling of experimental data using RNA demonstrated that antioxidant activity, phenolic compounds and flavonoid content can be predicted with high accuracy from several lactogenic plant extracts using 4 extraction methods.
- PCA analysis proved to be a very valuable statistical tool for the description of the extraction process using as a selection criterion the content of total polyphenols present in lactogenic plants. The PCA results indicate that mullein shows the highest values for total polyphenol content, flavonoids and antioxidant activity compared to other lactogenic plants.
- The HCA technique separated the extraction methods into four groups and identified remarkable similarities between groups a, b and c.
- Further in vitro digestibility studies could be developed on more combinations of plants and/or more concentrations of plants used as commercial ingredients in some foods.

5. Obtaining and characterization of meat products with added aqueous extract of lemon balm/wild thyme

5.1. General aspects

Meat is a highly nutritious food source necessary for a balanced diet, providing high-quality protein, minerals, vitamins (B complex) and many other micronutrients (iron, zinc, selenium, phosphorus) *(Pathare & Roskilly, 2016)*.

Meat consumption, especially red meat (beef and pork), dates back to ancient times and remains a necessity in a healthy lifestyle and a nutritionally indispensable lifestyle in modern society *(Jiang & Xiong, 2016).* In contrast, worldwide poultry consumption has increased by more than 30% in the last 10 years. In particular, turkey breast meat is popular among consumers due to its low fat and high protein content *(Rabeler & Feyissa, 2018a).*

The heat treatment of meat is a crucial processing step both in the domestic environment and in the food industry to obtain a microbiologically safe, high-quality product with improved sensory properties *(Rabeler & Feyissa, 2018a, 2018b)*. This is an essential element for the production of meat products.

Minced meat products are made and consumed industrially all over the world. However, their content varies from one geographic region to another *(Oz, 2021)*. In general, minced meat products are prepared by frying or boiling, methods that negatively influence especially the external appearance of the product due to the processing environment and exposure time to high temperatures or baking *(Engchuan et al., 2014)*. The quality characteristics of meat products are also dependent on the composition and characteristics of the anatomical portions used, the heat treatment used, as well as the evolution of time / temperature during processing. Meat undergoes numerous changes during heat treatment, both physical and chemical, including loss of mass, changes in water-holding capacity, changes in texture, contraction of muscle fibers, change in color and flavor, which are strongly dependent on protein denaturation and of water loss *(Mora et al., 2011)*.

5.2. Study objectives

- Making ready-to-eat products with a special purpose.
- Selection of meat types and anatomical portions from the point of view of nutritional intake but also from the economic point of view.
- Determination of the concentration of aqueous extract of cypress/dewberry added to the product of animal origin.
- Identifying the optimal types of heat treatment for making ready-to-eat products with special purpose.

- Obtaining and complex characterization of special purpose ready-to-eat products through identification and quantification of active principles, rheological and textural analysis and sensory analysis.
- Identification of compounds with a role in stimulating lactation present in the products by determining the FT-IR spectra.Realizarea unor produse de tip Ready-To-Eat cu destinaţie specială.

5.4. Results and discussion

Table 5.2 shows the coding of minced meat products.

Table 5.2. *Coding of minced meat products*

No.	Coding	Raw material	Type of thermal treatment	Type of aqueous extract
1.	HP	Pork tenderloin	Hot air convection	-
2.	ECPC	Pork tenderloin	Hot air convection	Wild thyme extract
3.	ERPC	Pork tenderloin	Hot air convection	Lemon balm extract
4.	SP	Pork tenderloin	Water vapor convection	-
5.	ECPA	Pork tenderloin	Water vapor convection	Wild thyme extract
6.	ERPA	Pork tenderloin	Water vapor convection	Lemon balm extract
7.	HT	Turkey tenderloin	Hot air convection	-
8.	ECCC	Turkey tenderloin	Hot air convection	Wild thyme extract
9.	ERCC	Turkey tenderloin	Hot air convection	Lemon balm extract
10.	ST	Turkey tenderloin	Water vapor convection	-
11.	ECCA	Turkey tenderloin	Water vapor convection	Wild thyme extract
12.	ERCA	Turkey tenderloin	Water vapor convection	Lemon balm extract
13.	HB	Beef tenderloin	Hot air convection	-

14.	ECVC	Beef tenderloin	Hot air convection	Wild thyme extract
15.	ERVC	Beef tenderloin	Hot air convection	Lemon balm extract
16.	SB	Beef tenderloin	Water vapor convection	-
17.	ECVA	Beef tenderloin	Water vapor convection	Wild thyme extract
18.	ERVA	Beef tenderloin	Water vapor convection	Lemon balm extract

5.4.5. FT-IR analysis of meat products with the addition of aqueous extract of lemon balm/thyme

Trans-anethole and estragole are considered two active estrogenic chemical compounds according to *Mokhtari & Ghoreishi, 2019*, present in most herbs intended to stimulate lactation. The FT-IR analysis of the minced meat products with the addition of aqueous extract of nightshade/chamber was aimed at revealing the presence of specific compounds or functional groups of estrogenic agents within the minced meat products. FT-IR spectra of all samples were recorded in the spectral range of 400-4000 cm^{-1} and are represented in figure 5.5.

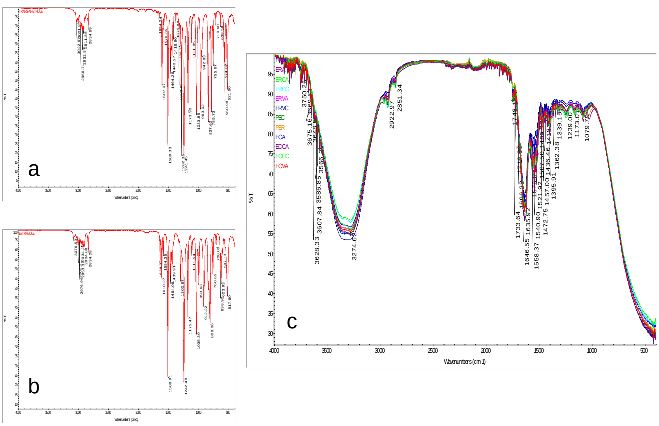


Figure 5.5. FT-IR spectra a) trans-anethole b) estragole c) minced meat products with the addition of aqueous extract

The FT-IR spectra revealed the presence of absorption bands at 3274 cm^{-1}, 1635 cm^{-1} and 1540 cm^{-1}, for all minced meat products with the addition of aqueous extract of lemon balm/wild thyme.

The most prominent peak (3274 cm^{-1}) in the FT-IR spectra for the analyzed samples is attributed to water (3200 cm^{-1}–3550 cm^{-1}), a fact that can be explained both due to the composition of the raw material that contains between 72-75% water *(Ahmad et al., 2018; Watanabe et al., 2018, Vaskoska et al., 2021)*.

Other prominent peaks, 1558 cm^{-1}, 1540 cm^{-1}, 1507 cm^{-1}, are found according to *Vaskoska et al., 2021* in the protein amide II region (1500 cm-1–1600 cm^{-1}). The slope between 2800 cm^{-1} and 3500 cm^{-1} is attributed to lipids (cholesterol, phospholipids) and creatine *(Vaskoska et al., 2021).*

The prominent absorption bands found in the region between 1700 - 1500 cm^{-1} are dominated by the stretching vibrations of the C = O and C − N group belonging to the amide groups, which comprise the peptide bonds in proteins *(Balan et al., 2019)*. The amide I band is the most prominent band in the IR spectrum, which arises from the stretching vibration of the C = O group with the involvement of N-H groups originating from protein folding. This is particularly sensitive to changes in the secondary protein structure, being identified in the range 1623-1637 cm^{-1} *(Caine et al., 2012)*. Two similar peaks (1635 cm^{-1} and 1624 cm^{-1}) were identified for the minced meat samples analyzed.

According to *Caine et al., 2012* in the range 1350 - 1200 cm-1 the amide III can be identified resulting from the in-plane folding of the N-H bond and the C-N stretching vibration. Similar to previous findings, amide III can be found in minced meat products by the presence of bands at 1339 cm^{-1} and 1239 cm^{-1}.

In agreement with *Sahayaraj JGowri et al., 2015* C=O stretching vibrations are found in the range 1650-1600 cm^{-1} due to ketone groups and C=C-C stretching vibrations in the range 1510-1450 cm^{-1} belonging to aromatic compounds. Absorption bands characteristic of ketone groups at 1635 cm^{-1} and 1638 cm^{-1} were identified for both minced meat and estragole samples. The peak corresponding to the value of 1507-1508 cm^{-1} is found both in the case of meat and trans-anethole samples. This is due to the presence of aromatic compounds in both matrices analyzed.

In the range 2935-2915 cm^{-1}, according to *Sahayaraj JGowri et al., 2015*, vibrations of the asymmetric stretching -CH(CH_2) due to saturated aliphatic compounds are found. These vibrations are also found in minced meat samples and in the case of trans-anethole at 2922 cm^{-1} and 2925 cm^{-1} respectively. Also, *Kurniawati et al., 2014; Rohman et al., 2011* report the asymmetric stretching vibration of the methylene group (–CH_2) at 2924 cm^{-1}.

According to *Sahoo et al., 2012*, in the range 1200-1250 cm^{-1}, stretching vibrations of the C-O-C bond are found. The presence of these types of bonds highlighted at 1241-1242 cm^{-1} was determined both in the minced meat samples and in the reference samples of trans-anethole and estragole.

The trans-anethole specific peak identified at 1440 cm^{-1} is found with a variation at 1436 cm^{-1} in minced meat products. It falls within the range of 1450-1400 cm^{-1} specific to the presence of stretching vibrations of the carbonyl group (C=O bond) *(Sahoo et al., 2012)*.

As a result, the constituent components of trans-anethole and estragole are found in minced meat products with the addition of aqueous extract of lemon balm/wild thyme.

5.4.9. *The influence of thermal treatments on the color parameters of meat products with the addition of aqueous extract of lemon balm/thyme*

The color of the meat is very important because it is the only criterion on the basis of which consumers can evaluate the product before purchasing it *(Guyon et al., 2016)*.

Minced meat products with aqueous extract of lemon balm/wild thyme were tested to evaluate the changes induced by the applied heat treatment (hot air convection, water vapor convection).

Table 5.5. *The effects of hot air convection processing on the color parameters of minced meat products with the addition of aqueous extract of lemon balm/wild thyme*

Parameters / Samples	ECPC	ERPC	ECCC	ERCC	ECVC	ERVC
L^*	50.47±2.26^B	51.37±3.76^B	57.58±0.33^A	57.75±0.29^A	42.08±0.64^C	40.93±0.59^C
a^*	4.65±0.12^B	4.83±0.48^B	2.68±0.02^C	2.30±0.01^C	6.99±0.30^A	6.97±0.09^A
b^*	7.33±0.11^A	7.39±0.03^A	6.55±0.09$^{B, C}$	6.44±0.21^C	6.77±0.14^B	7.15±0.14^A
ΔE	19.38±2.09^A	17.18±3.32^A	18.29±0.29^A	18.26±0.28^A	16.39±0.42^A	12.20±0.49^B
C^*	8.68±0.16^B	8.83±0.24^B	7.07±0.08^C	6.83±0.20^C	9.73±0.31^A	9.98±0.17^A
h^*	-0.01 ±0.02^B	0.03±0.03^B	-1.20 ±0.13^C	-2.93 ±0.76^D	0.69±0.03^A	0.61±0.01$^{A, B}$
WI	49.71±2.19^B	50.57±3.66^B	56.99±0.33^A	57.20±0.32^A	41.26±0.58^C	40.09±0.61^C

BI	22.12±0.62^{C}	22.13±1.11^{C}	15.20±0.24^{D}	14.47±0.48^{D}	29.25±0.43^{B}	21.22±1.06^{A}
YI	20.76±0.61^{C}	20.61±1.59^{C}	16.24±0.32^{D}	15.92±0.59^{D}	22.99±0.13^{B}	24.97±0.85^{A}

Means on the same row with different superscripts are statistically significantly different ($p<0.05$).

The differences recorded between the values of the red/green color component a* are due to the types of meat used, namely pork, turkey and beef.

The highest color difference (ΔE) was recorded in the case of the ECPC sample (19.38±2.09), while the lowest was obtained by the ERVC sample (12.20±0.49).

The white index recorded the highest value for the ERCC sample (57.20±0.32), the browning index for the ECVC sample (29.25±0.43), while the yellow index showed the highest value for the ERVC sample (24.97±0.85) .

Table 5.6. *The effects of water vapor convection on the color parameters of minced meat products with the addition of lemon balm/wild thyme aqueous extracts*

Parameters / Samples	**ECPA**	**ERPA**	**ECCA**	**ERCA**	**ECVA**	**ERVA**
L*	48.55±0.62^{C}	49.34±0.21^{C}	57.93±0.18^{A}	56.47±0.55^{B}	41.69±1.07^{D}	41.37±0.60^{D}
a*	4.83±0.04^{C}	4.78±0.07^{C}	2.10±0.04^{D}	2.11±0.01^{D}	6.39±0.16^{A}	6.12±0.04^{B}
b*	6.37±0.11^{B}	6.34±0.28^{B}	7.02±0.02^{A}	7.28±0.17^{A}	7.02±0.11^{A}	7.25±0.01^{A}
ΔE	17.48±0.60^{B}	15.29±0.23^{D}	18.83±0.18^{A}	17.20±0.47$^{B.C}$	16.44±0.81^{C}	13.09±0.42^{E}
C*	7.99±0.12^{B}	7.94±0.27^{B}	7.32±0.01^{C}	7.58±0.16^{C}	9.49±0.19^{A}	9.49±0.02^{A}
h*	0.26±0.01^{C}	0.25±0.04^{C}	5.35±2.13^{A}	3.13±0.73^{B}	0.51±0.01^{C}	0.41±0.01^{C}
WI	47.93±0.63^{C}	4872±0.24^{C}	57.30±0.18^{A}	55.82±0.57^{B}	40.92±1.03^{D}	40.60±0.59^{D}
BI	21.03±0.61^{B}	20.53±0.85^{B}	15.28±0.06^{C}	16.24±0.52^{C}	29.22±0.22^{A}	29.70±0.43^{A}
YI	18.75±0.57^{B}	18.36±0.90^{B}	17.30±0.00^{C}	18.24±0.61^{B}	24.04±0.26^{A}	25.04±0.41^{A}

Means on the same row with different superscripts are statistically significantly different ($p<0.05$).

In the case of minced meat products processed by steam convection. changes were observed in the values of the color parameters depending on the raw material used. In the case of pork minced meat samples, lower values (6.34±0.28; 6.37±0.11) were determined for the b* parameter, and significantly higher values for turkey minced meat products (7.02±0.02; 7.28±0.17) and meat minced beef (7.02±0.11; 7.25±0.01).

According to *Zwolan et al., 2020* the effect of plant extracts on the color of meat products presented in the scientific literature is ambiguous. It may partly depend on the type of raw material used to produce the extract, the type of extraction but above all on the amount introduced into the product.

The color of meat samples can be influenced by the degree of light scattering by the muscle, which is determined both by the three-dimensional structure of the muscle network and by the degree of refraction of the surrounding fluid. This latter fact could be correlated with the presence of the globular protein pigment called myoglobin *(Hughes et al., 2014)*.

Thermal treatment applied to minced meat products caused color changes ($p<0.05$) in all types of raw materials used: pork tenderloin, turkey and beef. The increase in the value of the color parameter L* was observed both after hot air convection processing and after water vapor convection processing. In the case of minced pork products, the luminosity (L*) increased by 50.6% when processed by hot air convection and by 44.7% when processed by steam convection. Minced turkey samples showed increases in the L* color parameter of 37.8% when processed by hot air convection and 36.7% when processed by steam convection. The brightness value (L*) registered the same increase (38.3%) in the case of minced beef products for both thermal processing methods. In conclusion, most minced meat products subjected to hot air convection treatment recorded higher L* color parameter values compared to patties processed by water vapor convection.

The temperature at which the meat is treated is an important factor that can affect the color of the meat. In general, high temperature treatments can have a major impact on the color of the finished product *(Bak et al., 2019)*. The data obtained agree with *García-Segovia et al., 2007*, who state that a higher value of the L* parameter indicates a lighter color, which is desirable to ensure that the meat products will benefit from greater consumer acceptability. This aspect was also supported by the results of the sensory analysis for the products evaluated in the present study.

According to *Hughes et al., 2014* the color parameters (a*,b*) tend to be strongly associated with the myoglobin pigment in the meat, while the lightness (L*) is related to the structural characteristics of the muscle and together determine the reflectivity of light that is sensory perceived by consumers. But the brightness values can also be explained by the fact that the meat fiber during heat treatment decreases in diameter, which causes a greater dissipation of light. According to *Sazonova et al., 2019* the contraction of muscle fibers creates large gaps between the fibers and the myofibrils appear to shrink, which would create a denser protein structure. Also, *Guyon et al., 2016* reported that changes in meat opacity can be caused by globin denaturation, heme group displacement, and aggregation of both myofibrillar and sarcoplasmic proteins.

During heat treatment, the color of the beef changes from a dark red to a gray-pink color with a light brown finish, changes associated with myoglobin denaturation according to *García-Segovia et al., 2007*.

Table 5.7. *The effects of hot air convection on the color parameters of minced meat products with the addition of aqueous extract of lemon balm/wild thyme, refrigerated for one week*

Parameters / Samples	ECPC	ERPC	ECCC	ERCC	ECVC	ERVC
L*	49.68±0.76^{B}	50.43±0.42^{B}	57.30±0.20^{A}	56.65±0.39^{A}	41.75±0.57^{A}	41.19±0.56^{A}
a*	3.23±0.02^{B}	2.70±0.00^{C}	1.93±0.07^{D}	1.58±0.06^{E}	3.59±0.08^{A}	3.56±0.01^{A}
b*	7.48±0.14^{A}	7.35±0.06$^{A, B}$	7.16±0.19$^{B, C}$	6.91±0.18^{C}	7.38±0.08$^{A, B}$	7.53±0.01^{A}
ΔE	19.18±0.69^{A}	17.18±0.37^{C}	18.35±0.20$^{A, B}$	17.68±0.30$^{B, C}$	18.21±0.49^{B}	14.83±0.35^{D}
C*	8.15±0.14^{A}	7.83±0.05^{B}	7.41±0.20^{C}	7.09±0.17^{D}	8.20±0.03^{A}	8.32±0.01^{A}
h*	-0.93 ±0.05^{D}	-2.25 ±0.13^{E}	1.58±0.13^{A}	0.36±0.31^{B}	-0.53 ±0.09^{C}	-0.60 ±0.01^{C}
WI	49.02±0.72^{B}	49.82±0.43^{B}	56.66±0.25^{A}	56.07±0.41^{A}	41.18±0.56^{C}	40.60±0.55^{C}
BI	20.75±0.02^{C}	19.36±0.30^{D}	15.52±0.38^{E}	14.77±0.40^{F}	25.38±0.30^{B}	26.15±0.34^{A}
YI	21.51±0.08^{C}	20.82±0.34^{D}	17.84±0.39^{E}	17.43±0.58^{E}	25.24±0.08^{B}	26.10±0.33^{A}

Means on the same row with different superscripts are statistically significantly different ($p<0.05$).

Table 5.8. *Effects of water vapor convection on the color parameters of minced meat products with the addition of aqueous extract of lemon balm/wild thyme, refrigerated for one week*

Parameters / Samples	ECPA	ERPA	ECCA	ERCA	ECVA	ERVA
L*	49.69±0.45^{B}	49.32±0.12^{B}	57.36±1.68^{A}	55.97±0.62^{A}	41.75±0.85^{C}	40.51±0.26^{C}

a*	2.80±0.01^{D}	2.99±0.13^{C}	1.16±0.02^{E}	1.32±0.06^{E}	3.50±0.09^{B}	3.67±0.12^{A}
b*	7.96±0.18^{A}	7.76±0.05^{A}	7.69±0.25^{A}	7.84±0.06^{A}	6.89±0.57^{B}	7.45±0.01^{A}
ΔE	19.41±0.40^{A}	16.07±0.04^{C}	18.78±1.44^{A}	17.22±0.45$^{B, C}$	18.16±0.44$^{A, B}$	14.31±0.25^{D}
C*	8.43±0.17^{A}	8.00±0.10$^{A, B, C}$	7.77±0.24^{C}	7.95±0.07$^{B, C}$	7.73±0.47^{C}	8.30±0.07$^{A, B}$
h*	-3.27 ±0.56^{B}	-1.33 ±0.26^{B}	4.38±4.17^{A}	-4.45 ±3.64^{B}	-0.44 ±0.26^{B}	-0.50 ±0.08^{B}
WI	48.99±0.47^{B}	48.69±0.10^{B}	56.65±1.61^{A}	55.26±0.60^{A}	41.24±0.90^{C}	39.93±0.27^{C}
BI	21.24±0.65^{C}	20.43±0.26^{C}	15.55±0.03^{D}	16.49±0.00^{D}	23.84±1.99^{B}	26.59±0.45^{A}
YI	22.87±0.72$^{B, C}$	21.51±0.09$^{C, D}$	19.14±0.06^{E}	20.01±0.08$^{D, E}$	23.58±2.44^{B}	26.28±0.22^{A}

Means on the same row with different superscripts are statistically significantly different ($p<0.05$).

Tables 5.7 and 5.8 present the color characteristics of the samples that were kept in refrigerated conditions (4°C) for one week and subjected to colorimetric determination.

In the case of both thermal treatments, the values of the red/green color parameter (a*) almost halved, and of the blue/yellow color component b* increased (0.5 – 19.1%) compared to the fresh samples, which determined changing index values. Thus, due to the increase in the value of the b* parameter, an increase (1.56 – 16.4%) of the yellowness index (YI) was also determined for all samples.

According to a study carried out *by Karpińska-Tymoszczyk, 2014* on minced turkey meat products, similar results were obtained for the parameter b*, which are correlated with the intensity of the oxidation process that occurs during storage and which tends to increase the value of the parameter YI of evidence.

According to *Karpińska-Tymoszczyk, 2014* an increase in the lightness (L*) of the color with increasing storage time could be correlated with the increased formation of metmyoglobin, which means that in the case of minced meat products obtained by convection, following refrigeration for a week there was a decrease in the amount of metmyoglobin, evidenced by the decrease in the L* parameter.

5.4.10. Differential scanning calorimetry of meat products with the addition of aqueous extract of lemon balm/thyme

Differential scanning calorimetry (DSC) can be used to monitor protein denaturation. According to *Bertram et al., 2006*, DSC studies on meat determined three stages of protein denaturation influenced by the application of thermal treatments, as follows: denaturation of myosin at 40-60 °C, denaturation of sarcoplasmic proteins and collagen at 60-70 °C, while actin denaturation occurs at 80 °C.

The variation of the heat flow of the pork, turkey and beef tenderloin was determined depending on the temperature, creating the graph shown in figure 5.9.

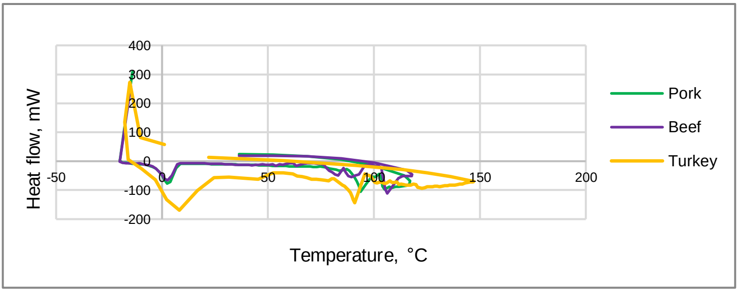


Figure 5.9. DSC thermograms (variation of heat flow as a function of temperature) of the three types of tenderloin used in obtaining the meatballs

From figure 5.9 it can be seen that all the samples suffer mass loss in the temperature range of 2-8 °C due to the defrosting process, the largest loss being recorded by the turkey tenderloin sample, and the smallest loss by the beef tenderloin.

According to *Jama et al., 2008* thawing loss refers to the loss of water from beef resulting from the formation of exudates after freezing and thawing. Such losses are lower after quick freezing compared to slow freezing.

Process loss is a critical factor in the meat industry as it influences the technological yield of processing. From a nutritional perspective, processing loss involves the loss of soluble proteins and vitamins *(Purslow et al., 2016)*.

Yarmand et al., 2013 classified processing losses into three temperature ranges and associated them with some structural components of the meat. Thus, the denaturation of myosin corresponds to the range 54-58 °C, the modification of the structure of collagen and sarcoplasmic proteins occurs at 65-67 °C, while the modification of the actin structure occurs at 80-83 °C.

Following differential scanning calorimetry on camel muscle, he reported losses at 58.17 °C, 68.48 °C and 84.16 °C attributed to the aforementioned phenomena.

Purslow et al., 2016 also argues that meat losses during processing for all types of meats are mainly caused by heat denaturation. At temperatures above 42 °C, myosin denaturation occurs by producing lateral contraction of muscle fibers, while at higher temperatures (70-80 °C) actin denaturation occurs due to longitudinal contraction of muscle fibers. In addition, he reported that white fiber myosin is less thermally stable, thus more susceptible to denaturation, than red fiber myosin in both beef and chicken.

5.4.11. Sensory analysis of meat products

According to *Pathare & Roskilly, 2016* processing methods and raw material quality change the sensory characteristics of the finished product. Among the reliable and consistent measures for evaluating meat characteristics is the sensory method. Thus, the acceptability of the analyzed product largely depends on the final consumer's decision.

In the sensory analysis of minced meat products, the following attributes were evaluated: external appearance, appearance in section, taste, aroma, aftertaste, mouthfeel, firmness, elasticity, cohesiveness, juiciness and general appreciation. Some of these attributes were chosen so that they could be correlated with the results of the instrumental analysis of the textural profile of the samples.

To evaluate the specific sensory attributes, a hedonic scale from 1 to 9 was used. In the case of minced meat products processed by hot air convection, the ERVC sample recorded the highest value corresponding to the general appreciation attribute, 8±0.67, at the pole opposite is the ERPC test with a score totaling 7±1.7.

In the case of minced meat products with the addition of aqueous extract of horsetail/chamber, processed by convection with water vapor, the highest value for the overall appreciation was recorded by the ERVA and ERPA samples with a score of 7.7±0.67 and 7.7± 0.48, while the ECPA sample obtained the lowest score, 7.1±1.37.

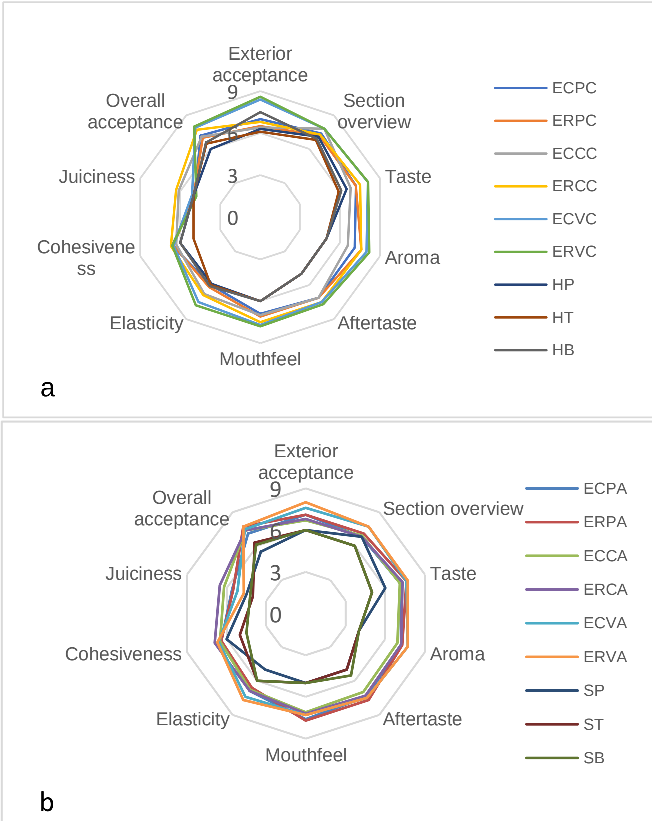


Figure 5.10. Comparative diagram of the sensory attributes specific to meatballs, obtained by a – hoair convection and b - steam convection;

Figure 5.10 represents the sensory analysis of minced meat products processed both by hot air convection and by water vapor convection, and it can be seen that in both situations there were no significant differences between the samples induced by the aqueous extract, which is supported and by the textural analysis of the samples.

The exterior appearance of the hot air convection minced meat products was rated as dry with a very thin crust, while the exterior appearance of the water vapor convection minced meat products was rated as slightly moist similar to from minced meat obtained by boiling. On the other hand, the crosssectional appearance of the hot air convection samples was found by the panelists to be smooth and moderately dry, and that of the water vapor convection samples was declared smooth and moderately moist. The evaluation of external appearance is critical because if the appearance is unacceptable, all other sensory attributes end up losing their significance in the eyes of consumers, resulting in a negative impact on their purchase decisions *(Pogorzelska et al., 2018)*.

5.5. Partial conclusions

- The statistical interpretation of the obtained results indicates that aqueous plant extracts have a significant impact ($p<0.05$) on the phytochemical content of minced meat products.

- The samples obtained from minced pork with the addition of lemon balm extract processed by hot air convection (ERPC), respectively those obtained from minced beef with the addition of thyme extract (ECVA) processed by water vapor convection recorded higher values of antioxidant activity. This aspect underlines the fact that the type of added extract, and the processing method used for the two types of meat significantly influence the antioxidant activity of the analyzed samples. The consumption of the two types of minced meat products can participate in the reduction of oxidative stress in the human body and the negative consequences that the excess of free radicals generates.

- The samples with the addition of aqueous extract of lemon balm, processed by hot air convection recorded the highest concentration of total polyphenols.

- In the case of the total content of flavonoids, the highest concentrations were noted in the samples obtained by water vapor convection with lemon balm aqueous extract.

- Colorimetric determinations revealed that minced beef products processed by hot air convection recorded the best intensity of brightness and red and yellow color parameters respectively, making them the most appreciated by consumers, followed by those obtained from minced pork processed by the same method.

- The influence of the heat treatment applied is a determining factor of the texture of minced meat products and in this case the processing by convection with water vapor determined a firmer texture for all samples compared to those obtained by convection with hot air. Also, the results of the textural determinations show that the samples of turkey tenderloin with the addition of aqueous extract of lemon balm/wild thyme, processed by hot air convection, but also those processed by water vapor convection, require a lower amount of energy during of the mastication process compared to the other analyzed samples.

- The FT-IR analysis determined the presence of several common peaks both for the compounds considered adjuvants of lactation, trans-anethole and estragole, as well as in the samples of minced meat with the addition of aqueous extract of lemon balm/wild thyme analysed.

- DSC analysis reveals three stages of protein denaturation influenced by the application of heat treatments: myosin denaturation in the 40-60 °C range, sarcoplasmic protein and collagen denaturation at 60-70 °C and actin denaturation at temperatures starting at 80 °C.

- Aqueous extracts of lemon balm and wild thyme qualify for use in the preparation of special purpose ready-to-eat foods both from the point of view of lactogenic properties determined by FT-IR analysis, as well as other properties that participate in improving the functioning of the human body.

6. Obtaining and characterizing vegetable purees with added aqueous extract of anise/fennel

6.1. General aspects

Vegetables are mainly marketed fresh, and most of them are highly perishable, being prone to deterioration immediately after harvesting. Processing is one of the various technological means possible to significantly increase their shelf life and availability throughout the year. Processing also increases palatability and stability, increases nutrient availability and generates added value to the finished product *(Wibowo et al., 2019)*. In addition, vegetables are rich sources of protein, fat, carbohydrates, minerals, antioxidants, fiber and water. Along with these, a high content of vitamins such as thiamin (B_1), riboflavin (B_2), niacin, pyridoxine (B_6), pantothenic acid (vitamin B_5), folic acid, ascorbic acid (vitamin C), beta-carotene (provitamin A) *(Bureau et al., 2015; Fabbri & Crosby, 2016)*.

According to recent research, there are several ways to increase nutrient availability by choosing the right heat treatment. The most common methods of vegetable processing are steam convection processing, roasting, boiling, sautéing, sous-vide processing, or microwave processing *(Fabbri & Crosby, 2016)*.

Foods are physically complex products with time- and process-dependent rheological and material properties. Thermal treatments were chosen to ensure safe consumption and preservation, but also to develop taste and aroma *(Fryer & Robbins, 2005)*. Comparing warm air convection with water vapor convection, *Richardson, 2004* stated that air flow is much more prone to developing turbulence than liquid flows, due to the fact that high Reynolds number values are obtained. Turbulence therefore increases the circulation speed of a fluid and the heat transfer to the surface in the case of baking. On the other hand, steam convection uses lower temperatures (60-100 °C) and consumes less energy.

6.2. Objectives

- Designing and making ready-to-eat vegetable products with a special purpose.
- Selecting some vegetables with bioactive potential and processing them into purees.
- Identification and choice of thermal treatments with minimal impact on the nutritional value of vegetables.

- Obtaining and complex characterization of ready-to-eat vegetable products with special purpose through the identification and quantification of bioactive principles.
- Identification of compounds with a role in stimulating lactation present in plant products using FT-IR spectra.

6.4. Results and discussion

Table 6.1 shows the coding of plant products with special purpose.

Table 6.1. *Codification of vegetable products with special destination*

Raw material	Coding	Type of thermal treatment	Type of aqueous extract
Sweet potato	CM_1	Water vapor convection	-
	EFCA		Fennel extract
	EACA		Anise extract
	CM_2	Hot air convection	-
	EFCC		Fennel extract
	EACC		Anise extract
Red capsicum	AM_1	Water vapor convection	-
	EFAA		Fennel extract
	EAAA		Anise extract
	AM_2	Hot air convection	-
	EFAC		Fennel extract
	EAAC		Anise extract
Zucchini	ZM_1	Water vapor convection	-
	EFZA		Fennel extract
	EAZA		Anise extract
	ZM_2	Hot air convection	-
	EFZC		Fennel extract
	EAZC		Anise extract
Red beetroot	SM_1	Water vapor convection	-
	EFSA		Fennel extract
	EASA		Anise extract
	SM_2	Hot air convection	-
	EFSC		Fennel extract
	EASC		Anise extract

(T_0) - determinations made immediately after processing the samples;
(T_7) - determinations made after refrigerating the samples for 7 days (4°C).

6.4.6. FT-IR analysis of vegetable purees with the addition of aqueous anise/fennel extract

According to *Mokhtari & Ghoreishi, 2019*, trans-anethole and estragole are considered two active estrogenic compounds present in most herbs intended to stimulate lactation. The FT-IR analysis of vegetable products with the addition of aqueous anise/fennel extract aimed to reveal the presence of specific compounds or functional groups of these estrogenic agents within the vegetable products. FT-IR spectra of all samples were recorded in the spectral range of 400-4000 cm^{-1} and are represented in figure 6.7.

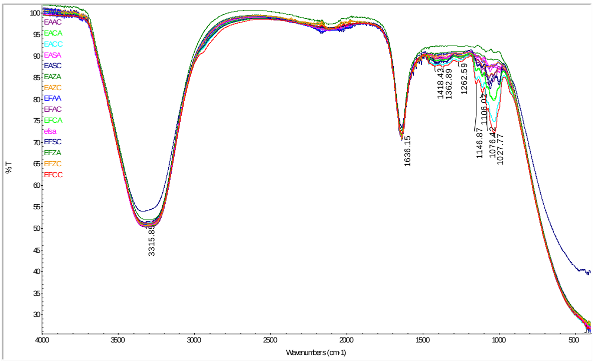


Figure 6.7. FT-IR spectra of vegetable products with the addition of anise/fennel aqueous extract

All plant products analyzed with the help of Fourier ransform infrared spectroscopy, recorded the presence of absorption bands at 3315 cm^{-1}, 1636 cm^{-1} and 1418 cm^{-1}.

The most prominent peak (3315 cm^{-1}) in the FT-IR spectra is attributed to hydroxyl groups -OH (3200 cm^{-1}–3550 cm^{-1}) *(Kaur & Kaur, 2020; Vaskoska et al., 2021)*. This is due to the chemical composition of the raw materials used. The relevant absorption bands in the region between 1700 - 1500 cm^{-1} are dominated by the stretching vibrations of the C = O and C − N group belonging to the amide groups, which comprise the peptide bonds in proteins *(Balan et al., 2019)*. The most prominent band in the IR spectrum is the amide I band, which arises from the stretching vibration of the C = O group with the involvement of N-H groups originating from protein folding. This band is particularly sensitive to changes in the secondary protein structure, being identified in the range 1623-1637 cm^{-1} *(Caine et al., 2012)*.

Vegetable products with the addition of aqueous anise/fennel extract recorded similar peaks assigned to the amide I band at 1635 -1636 cm^{-1}.

The study by *Sahoo et al., 2012* attributes the presence of the range 1450-1400 cm^{-1} as specific to the stretching vibrations of the carbonyl group (C=O bond). Within the plant products analyzed, the presence of these groups was highlighted at 1418 cm^{-1}.

The peaks present at 1558 cm^{-1}, 1540 cm^{-1}, 1507 cm^{-1}, are found in the amide II protein region (1500 cm^{-1}–1600 cm^{-1}) *(Vaskoska et al., 2021).*
Sahayaraj JGowri et al., 2015 attribute the presence of C=O stretching vibrations in the range 1650-1600 cm^{-1} to ketone groups and C=C-C stretching vibrations in the range 1510-1450 cm^{-1} to aromatic compounds. Both for plant samples and for estragole, absorption bands characteristic of ketone groups were identified at 1635 cm^{-1} and 1636 cm^{-1}. The peak corresponding to the value of 1507 cm^{-1} is found both in the case of vegetable samples and trans-anethole. This is due to the presence of aromatic compounds in both analyzed matrices.

In a study on mango purees, *Labaky et al., 2021* highlight the presence of absorption bands at 995 cm^{-1} and 1103 cm^{-1} and attribute them to sucrose and glucose. Similar peaks (995 cm^{-1} and 997 cm^{-1}) suggesting the presence of sucrose are also found in the case of beetroot samples with the addition of fennel/anise aqueous extract.

Vegetable products with the addition of aqueous anise/fennel extract obtained from sweet potatoes recorded prominent peaks at 1030 cm^{-1}. Following the research carried out on different types of bell pepper, *Kaur & Kaur, 2020* claims that these peaks denote the presence of phenolic compounds. Also, similar peaks (1034 cm^{-1}) were found in the case of capsicum pepper samples treated by hot air convection.

6.5. Partial conclusions

- Steam convection processing had little impact on the content of bioactive compounds in peppers and potatoes, while hot air convection was beneficial in beet and zucchini samples.
- The highest processing yield was recorded for zucchini by convection with water vapor, compared to the lowest, determined by the treatment of sweet potato by convection with hot air.
- The total content of residual polyphenols resulting from in vitro gastrointestinal digestibility, recorded the highest values in the case of samples obtained from sweet potato, at the opposite pole being the samples obtained from beetroot.

- The addition of aqueous fennel/anise extract contributed to the improvement of textural, rheological, but especially sensory characteristics of all analyzed samples.
- From a colorimetric point of view, the thermal processing of vegetables led to an increase in brightness in the case of the kapia pepper and beetroot samples compared to the sweet potato and zucchini samples, which registered a slight decrease in the L* parameter.
- According to the FT-IR analysis, constituent components of trans-anethole and estragole are found in the vegetable samples with the addition of anise/fennel aqueous extract.
- Sweet potato purees with the addition of aqueous anise extract obtained the highest overall acceptability score, in the case of both thermal treatments.

GENERAL CONCLUSIONS

- Research studies aimed at obtaining ready-to-eat products by combining vegetable and animal matrices, as well as by using the addition of aqueous extract from medicinal plants with lactogenic potential.

- Initially, eight medicinal plants with lactogenic potential were chosen and processed in order to obtain aqueous extracts with galactogenic properties, as well as the identification and quantification of the active principles from the extracts.

- Following the quantification of the active principles from the aqueous extracts made the extracts of fennel and fennel were chosen as optimal options to be added to products of animal origin and the aqueous extracts of anise and fennel to be used in products of vegetable origin.

- The results of the *in vitro* determinations highlighted the presence of polyphenolic compounds remaining after the two phases of simulated digestion both in the case of vegetable products and in the case of those of animal origin.

- The FT-IR spectra of all analyzed samples demonstrated the presence of trans-anethole and estragole compounds, compounds with an adjuvant role in stimulating lactation.

- The colorimetric studies carried out both at the time T0 and at the time T7 demonstrated the fact that the products show a good storage stability under refrigeration conditions in the case of all the ready-to-eat products made.

- The textural analyzes carried out as well as the quantification of the bioactive compounds and even the colorimetric determinations carried out led to the conclusion that the convection processing with water vapor had a lower impact on the products compared to the conventional processing with hot air.

- Also, the content of bioactive compounds, the results of the textural and rheological analyzes carried out as well as the colorimetric determinations support the conclusion that the addition of galactogogue aqueous extracts also contributes to the improvement of the textural and rheological properties along with obtaining products with health benefits.

ORIGINAL CONTRIBUTIONS AND PROSPECTS FOR FURTHER RESEARCH

The main objective of the doctoral thesis consisted of the design and production of ready-to-eat foods with a role in lactation stimulation.

The novelty of the experimental study consists in obtaining some aqueous extracts from medicinal plants recognized as lactation adjuvants, the use of the extracts as an addition in various products of plant and animal origin, as well as the phytochemical characterization of these ready-to-eat products.

The studies will be continued with the association of products of animal origin with the addition of aqueous extracts of chamomile and fennel with those of plant origin supplemented with aqueous extracts of anise and fennel. The final product will be microbiologically tested. Also, an important aspect is the choice of optimal packaging that contributes to preserving the sensory and microbiological characteristics of the product.

DISSEMINATION OF RESEARCH RESULTS

A. Articles published in ISI listed journals

1. **Tănase (Butnariu), L.-A.**, Nistor, O.-V., Andronoiu, D.-G., Mocanu, D.-G. and Botez, E. (2021) "Potential of herbs as galactogogues – A review", The Annals of the University Dunarea de Jos of Galati. Fascicle VI - Food Technology, 45(1), pp. 199-210. doi: https://doi.org/10.35219/foodtechnology.2021.1.13.

2. **Tănase, L.-A.**; Nistor, O.-V.; Andronoiu, D.-G.; Mocanu, G.-D.; Botezatu Dediu, A.V.; Botez, E. Different Types of Meatballs Enriched with Wild Thyme/Lemon Balm Aqueous Extract—Complex Characterization. *Molecules* 2022, *27*, 3920. https://doi.org/10.3390/molecules27123920.

3. **Tănase, L.-A.**; Nistor, O.-V.; Mocanu, G.-D.; Andronoiu, D.-G.; Cîrciumaru, A.; Botez, E. Effects of Heat Treatments on Various Characteristics of Ready-to-Eat Zucchini Purees Enriched with Anise or Fennel. *Molecules* 2022, *27*, 7964. https://doi.org/10.3390/molecules27227964.

4. **Tănase, L.-A.**; Andronoiu, D.-G.; Nistor, O.-V.; Mocanu, G.-D.; Botez, E.; Ștefănescu, B.I. Sweet Potatoes Puree Mixed with Herbal Aqueous Extracts: A Novel Ready-to-Eat Product for Lactating Mothers. *Processes* 2023, *11*, 2219. https://doi.org/10.3390/pr11072219.

5. Nistor, O.-V., Andronoiu, D.-G., **Tănase (Butnariu), L.-A.**, & Mocanu, G.-D. (2023). The influence of gentle processing of orange sweet potato on quality properties of purees. The Annals of the University Dunarea

De Jos of Galati. Fascicle VI - Food Technology, 47(2), 64-76, https://doi.org/https://doi.org/10.35219/foodtechnology.2023.2.04

B. Articles published in ISI proceedings indexed journals

1. **Tănase, L.-A.** și al. (2022). Galactogogue Herbs: Antioxidant Activity and Bioactive Compounds' Content Determined from Aqueous Extracts. In: Brka, M., et al. 10th Central European Congress on Food. CE-Food 2020. Springer, Cham. https://doi.org/10.1007/978-3-031-04797-8_12

C. Participation in national and international scientific conferences

1. **Tănase L.-A.**, Nistor O.-V., Andronoiu D.-G., Mocanu D.-G., Botez E., 2020, *Galactagogues - Medicinal plants used for lactation stimulation - A review*, 8th Edition of Scientific Conference of Doctoral Schools, "Dunărea de Jos" University, Galați, Romania

2. Mocanu D.-G., **(Butnariu) Tănase L.-A.**, Nistor O.-V., (Dima) Gheonea I., Chirilă A. C., Andronoiu D.-G., Constantin O. E., Barbu V. V., Pătrașcu L., Botez E., 2020, *Health promoters from potato and pumpkin instant purée*, 5th Edition of International Conference on Chemical Engineering, Iași, Romania

3. Nistor O.-V., Mocanu D.-G., Andronoiu D.-G., **Tănase (Butnariu) L.-A.**, Pătrașcu L., Barbu V. V., Ceclu L., 2020, *Novel technology to obtain pumpkin and quince puree*, 9th European Conference on Sensory and Consumer Research, Olanda

4. **Tănase (Butnariu) L.-A.,** Mocanu D.-G., Andronoiu D.-G., Nistor O.-V., 2020, *Potential benefits of galactogogues plants extracts,* National Scientific-Practical Conference "Innovation: Factor of Social-Economic Development", Cahul, Republic of Moldova.

5. Andronoiu D.-G., **Tănase (Butnariu) L.-A.,** Costandache D., Mocanu D.-G., Nistor O.-V., 2020, *Expectant and breastfeeding mothers' food habits – a survey in Romania*, Conferința Ştiințifico-Practică Naţională „Inovația: Factor Al Dezvoltării Social-Economice", Cahul, Republica Moldova.

6. **Tănase (Butnariu) L.-A.**, Nistor O.-V., Andronoiu D.-G., Mocanu D.-G., Ciortan S., Ștefănescu B. I., Botez E., 2021, *Development of special designed meatballs technology*, 2nd International Virtual Conference On Raw Materials To Processed Foods, 3-4 June 2021, Turkey.

7. **Tănase L.-A.**, Nistor O.-V., Andronoiu D.-G., Mocanu D.-G., Botez E., 2021, *Meatballs for special destination: technological approaches,* 9th Edition of Scientific Conference of Doctoral Schools, "Dunărea de Jos" University, Galați, Romania.

8. **Tănase L.-A.**, Nistor O.-V., Andronoiu D.-G., Mocanu D.-G., Botez E., 2021, *Healthy vegetables for maternal diet - A review*, 9th Edition of Scientific Conference of Doctoral Schools, "Dunărea de Jos" University, Galați, Romania.

9. Nistor O.-V., Andronoiu D.-G., **Tănase L.-A.**, Mocanu G.-D., Barbu V.-V., Botez E., *The development of melon sorbets with acacia or lavender syrup*, International Conference on Raw Material to Processed Foods, 3-4 June 2021, Turkey.

10. **Tănase L.-A.**, Nistor O.-V., Andronoiu D.-G., Mocanu D.-G., Botez E., 2021, *Galactogogue herbs: Antioxidant activity and bioactive compounds content determined from aqueous extracts,* 10th Central European Congress on Food, Sarajevo, Bosnia and Herzegovina.

11. **Tănase (Butnariu) L.-A.**, Andronoiu D.-G., Nistor O.-V., Mocanu G.l-D., Botez E., 2022, *Phytochemical characterization of sweet potato purees enriched with fennel/anise aqueous extracts*, Multidisciplinary Conference on Sustainable Development, „Regele Mihai I" University of Life Science, Timișoara, Romania.

12. Andronoiu D.-G., Bitere M., Nistor O.-V., Mocanu G.-D., **Tănase (Butnariu) L.-A.**, *Revaluating carrots pomace – technological variants to enhance food quality*, Multidisciplinary Conference on Sustainable Development, 26-27 May 2022, Section: Food Chemistry, Engineering & Technology, Food Engineering Faculty, Timișoara, Romania.

13. Manoliu A.G., Măntăilă S., **Tănase (Butnariu) L.-A.**, Andronoiu D.-G., Nistor O.-V., Mocanu G.-D., *Eco-efficient valorification of some by-products in order to obtain gellified products*, Multidisciplinary Conference on Sustainable Development, 26-27 May 2022, Secția: Food Chemistry, Engineering & Technology, Food Engineering Faculty, Timișoara, Romania.

14. **Tănase L.-A.**, Nistor O.-V., Andronoiu D.-G., Mocanu D.-G., Botez E., 2022, *Influence of hot air and steam convection on zucchini purees mixed with galactogogue aqueous extracts*,10th Edition of Scientific Conference of Doctoral Schools, "Dunărea de Jos" University, Galați, Romania.

15. **Tănase L.-A.**, Nistor O.-V., Andronoiu D.-G., Mocanu D.-G., Botez E., 2022, *Phytochemical characterization of red pepper puree enriched with anise or fennel aqueous extract,* 10th Edition of Scientific Conference of Doctoral Schools, "Dunărea de Jos" University, Galați, Romania.

16. **Tănase L.-A.**, Nistor O.-V., Andronoiu D.-G., Mocanu D.-G., Botez E., 2023, *Characterization of red beetroot purees enriched with aqueous herbal extract with a special destination,* 11th Edition of Scientific Conference of Doctoral Schools, "Dunărea de Jos" University, Galați, Romania.

17. Nistor O.-V., **Tănase (Butnariu) L.-A.**, Mocanu D.-G., Andronoiu D.-G., 2023, *Preliminary research on sweet potato ready to eat purees*, Nutricon, Ohrid, Macedonia.

18. Murgoci C. G., **Tănase (Butnariu) L.-A.,** Nistor O.-V., Mocanu D.-G., 2023, *Quality evaluation of different types of sunflower oils*, Multidisciplinary Conference on Sustainable Development, Food Engineering Faculty, Timișoara, Romania.

19. Popovici A. M., Măntăilă S., **Tănase (Butnariu) L.-A.**, Andronoiu D.-G., Mocanu D.-G., 2023, *Effects of different levels of basil (Ocimum basilicum L.) powder or extract on physicochemical, textural and sensorial characteristics of bread*, Multidisciplinary Conference on Sustainable Development, Food Engineering Faculty, Timișoara, Romania.

20. Popovici G. G., Măntăilă S., **Tănase (Butnariu) L.-A.**, Cotârleț M., Mocanu D.-G., 2023, *Influence of different drying methods on bioactive compounds, colour and antibacterial properties of some aromatic plants*, Multidisciplinary Conference on Sustainable Development, Food Engineering Faculty, Timișoara, Romania.

21. Glugă Ș., Vînă C. M., Iordache F. G., Nistor O.V., Mocanu G. D., **Tănase (Butnariu)** L., Andronoiu D. G., 2023, *VALORIZATION OF BLUEBERRY POMACE AS FUNCTIONAL INGREDIENT AT YOGHURT MANUFACTURING*, 11th International Symposium Euro-Aliment 2023 - Insights of Future Foods – From concepts and challenges to technological innovations, "Dunărea de Jos" University, Galați, Romania.

22. Ceclu L., **Tănase (Butnariu) L.-A.**, Nistor O.-V., 2023, *COMPARATIVE ASSESSMENT OF BIOACTIVE COMPOUNDS IN DRIED CHERRY TOMATOES UNDER DIFFERENT CONDITIONS*, 11th International Symposium Euro-Aliment 2023 - Insights of Future Foods – From concepts and challenges to technological innovations, "Dunărea de Jos" University, Galați, Romania.

D. Awards

1. Honorable mention - Prezentare, *Meatballs for special destination: technological approaches*, **Tănase L.-A.**, Nistor O.-V., Andronoiu D.-G., Mocanu D.-G., Botez E., 2021, 9th Edition of Scientific Conference of Doctoral Schools, "Dunărea de Jos" University, Galați, Romania.

2. Honorable mention – Prezentare, *Influence of hot air and steam convection on zucchini purees mixed with galactogogue aqueous extracts,* **Tănase L.-A.**, Nistor O.-V., Andronoiu D.-G., Mocanu D.-G., Botez E., 2022,10th Edition of Scientific Conference of Doctoral Schools, "Dunărea de Jos" University, Galați, Romania.

3. Honorable mention - Poster, *Phytochemical characterization of red pepper puree enriched with anise or fennel aqueous extract,* **Tănase L.-A.**, Nistor O.-V., Andronoiu D.-G., Mocanu D.-G., Botez E., 2022, 10th Edition of Scientific Conference of Doctoral Schools, "Dunărea de Jos" University, Galați, Romania.