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EcoAgriTourism, in the light of its multidisciplinary character, is a wide-open journal which brings together the opinions of specialists from both academic and economic environment, fostering fruitful collaborations.

The journal's structure covers all aspects of the fields approached, the focus being on original and current researches with applications in agriculture, food industry and rural tourism. Collaborators may feel free to undertake biological and technical aspects as well as aspects with social, cultural and environmental impact. Information of general interest is also welcome for the agriecology-food-tourism axis

Prof. Romulus Gruia Ph. D.

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STRATEGIC ASPECTS IN AGRI-FOOD PRODUCTION AND RURAL DEVELOPMENT

Strategic directions are needed for the post-2027 period. Protecting biodiversity within the European Union (EU) Common Agricultural Policy (CAP) is an important objective, reflecting growing concerns about the environment and sustainability. The CAP, one of the oldest and most significant EU policies, has evolved over time to include not only economic and social components, but also ecological ones. Biodiversity is one of the central themes of the new CAP (2023–2027), aligned with the European Green Deal and the 2030 Biodiversity Strategy. Regarding EU funding, it would be natural for it to be specifically targeted at the agricultural and rural development fields, in the sense that the approval of funds intended for this sector would NOT be conditioned by state reforms (of course useful), but which are not related to the agricultural sector, if all the requirements of the Commission and the European Parliament are met here.

**Director of the publication,
Prof. Romulus GRUIA, PhD,
PhD supervisor, Scientific Leader**

SUMMARY

Editorial: STRATEGIC ASPECTS IN AGRI-FOOD PRODUCTION AND RURAL DEVELOPMENT – Prof. PhD. GRUIA Romulus	
5	<i>PHYSICOCHEMICAL RESEARCH INTO THE PRODUCTION OF FRESH COW'S CHEESE WITH ADDED CANDIED CRANBERRIES AND DRIED BASIL</i> <i>M.A. CONSTANTINESCU, M.A. TIȚA, M.B. STÎNGACIU, O. TIȚA</i>
11	<i>SUSTAINABLE PLANT-BASED FORMULATIONS DEVELOPMENT</i> <i>C. POPOVICI, A. LADANIUC</i>
19	<i>MAINTAINING POTATO QUALITY UPON IMPACT WITH A SPECIFIC SURFACE BY USING A DIGITAL POTATO AND COMPUTER GRAPHICS FOR ASSESSING THE INFLUENCE OF THE POTATO CONVEYORS ANGLES ON IMPACT FORCES</i> <i>D.M. DĂNILĂ, D.C. OLA</i>
24	<i>THE INFLUENCE OF ARONIA POWDER ON THE TECHNOLOGICAL, NUTRITIONAL AND SENSORY QUALITY OF BREAD</i> <i>L. GACEU</i>
32	<i>ECOLOGICAL AND EFFICIENT COMBUSTION OF WOOD BIOMASS</i> <i>GH.C. SPIRCHEZ, A. LUNGULEASA, L. GACEU</i>
38	<i>IDENTIFICATION OF ANTIBIOTIC RESIDUES IN RAW COW'S MILK FOR THE PRODUCTION OF HIGH-QUALITY DAIRY PRODUCTS</i> <i>M.A. CONSTANTINESCU, M.A. TIȚA, O. TIȚA</i>
48	<i>HYGIENIC DESIGN OF PROFESSIONAL KITCHENS IN THE HORECA INDUSTRY. GREASE SEPARATORS IN PROFESSIONAL KITCHENS: CONCEPTS, TECHNOLOGIES AND PRACTICAL APPLICATIONS</i> <i>L. GACEU</i>
56	<i>CONTRIBUTIONS ON THE BASIC UNDERSTANDING OF HOW TO IDENTIFY LOW QUALITY FRUITS AND VEGETABLES IN THE SORTING PROCESS USING ARTIFICIAL INTELLIGENCE</i> <i>D.M. DANILĂ</i>
61	<i>THE ADMINISTRATIVE-TERRITORIAL REORGANIZATION MODEL BASED ON THE BIOHARMONISM OF ECOANTHROPOSYSTEMS</i> <i>R. GRUIA, L. GACEU</i>

70	<i>BISCUITS ENRICHMENT WITH HAWTHORN FRUITS (CRATAEGUS MONOGYNA): TEXTURAL EVALUATION OF DOUGH CHARACTERISTICS</i> <i>R.I. RUS (CĂLBOREAN), M. OGNEAN, C. F. OGNEAN</i>
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PHYSICOCHEMICAL RESEARCH INTO THE PRODUCTION OF FRESH COW'S CHEESE WITH ADDED CANDIED CRANBERRIES AND DRIED BASIL

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Abstract: Fresh cheese offers numerous health benefits, being a nutritious, easily digestible, and versatile food high in protein, calcium, and vitamins. Research on the incorporation of plant ingredients containing bioactive compounds into dairy products is increasing due to the reduced need for synthetic chemical preservatives in processed foods. The objective of this study is to produce a novel dairy product by enhancing fresh cow's cheese with candied cranberries and dried basil. The ingestion of basil confers considerable health benefits due to its antioxidant, anti-inflammatory, and antimicrobial properties. These properties contribute to the regulation of the immune response, cell protection, and support for digestive functions by stimulating the secretion of gastric juices. The incorporation of cranberries into one's diet has been demonstrated to promote health through their antioxidant, anti-inflammatory, and antibacterial properties. This results in the effective prevention of urinary diseases, the improvement of cardiovascular disease, and the protection of cells against oxidative stress. A series of samples was obtained from fresh cheeses with varying concentrations of cranberry and basil. The stability of the physicochemical properties during the storage period was then evaluated. The influence of various concentrations of added additives is evident, and the fresh cheese sample with 1.5 g of dried basil and that with 5 g of dried cranberries gave the most satisfactory results. Consequently, these two additions signify a promising material due to their multifaceted health benefits. This information is necessary to evaluate the safety and efficacy of candied cranberries and dried basil, and it may serve as a foundation for future studies.

Keywords: fresh cheese, candied cranberries, dried basil, novel dairy product, health benefits

1. Introduction

The cheese manufacturing sector constitutes a substantial segment of the dairy industry, wherein innovative concepts for enhancing cheese quality are a growing concern (Bielska et al., 2023; Pham et al., 2021; Falcão et al., 2023).

Fresh cow's milk cheese is a type of fresh cheese produced through the coagulation of cow's milk using acid or enzymes, followed by the removal of whey. (Răducuță, 2004; Galatanu, 2014). It is characterized by its numerous health benefits, including its high nutritional value, ease of digestion, and versatility in culinary applications. The ingestion of cheese confers considerable health benefits, as it provides calcium, protein, and essential fats that support bone development, muscle mass maintenance,

and proper nervous system function (Usturoi, 2007; Banu, 2009).

The growing popularity of diets based on the consumption of fruits, vegetables, herbs, and spices can be attributed to the antioxidant and anti-inflammatory properties inherent in these dietary components (Musachio et al., 2023).

Basil (*Ocimum basilicum*) is an annual aromatic plant belonging to the *Lamiaceae* family. It is native to tropical Asia, but it is now cultivated throughout the world. The plant is valued for its intensely fragrant leaves, which are used in both cooking and for medicinal or ritual purposes. The ingestion of basil confers considerable health benefits due to its antioxidant, anti-inflammatory, and antimicrobial properties, which contribute to the regulation of the immune response, the protection of cells, and the support of digestive

functions by stimulating the secretion of gastric juices (Imeri et al., 2014; Spence, 2024; Song et al., 2024).

Cranberries (*Vaccinium macrocarpon*) are diminutive, vividly hued fruits with a tart and somewhat bitter taste that grow on small shrubs. Cranberries are well-known for their high vitamin C, antioxidant, fiber, and mineral content. The ingestion of cranberries has been demonstrated to promote health through their antioxidant, anti-inflammatory, and antibacterial properties. These properties have been shown to be effective in the prevention of urinary tract diseases, the improvement of cardiovascular diseases, and the protection of cells against oxidative stress (Shamilov et al., 2020; Zielinska et al., 2018; Araya et al., 2024).

Research on the incorporation of plant ingredients containing bioactive compounds into dairy products has seen a surge in recent years (Santos et al., 2022). This trend is driven by two key factors. Firstly, there is a growing recognition of the reduced necessity for synthetic chemical preservatives in processed foods (Oliveira et al., 2024). Secondly, from a manufacturer's perspective, the introduction of these products can potentially enhance sales and diversify product offerings (Luz Arelis et al., 2023; Bătușaru, 2019; Bătușaru and Sbârcea, 2023). Consequently, there is a necessity to conduct scientific studies to determine whether dairy products with added fruits, vegetables, herbs, or spices have nutritional and functional properties, as well as special characteristics and flavors that can not only attract consumers but also contribute significantly to their health (Sarmiento et al., 2019). The objective of this study is to develop a novel dairy product by enhancing fresh cow's cheese with candied cranberries and dried basil, which are rich in bioactive compounds. A series of samples comprising fresh cheeses with varying concentrations of cranberries and basil was obtained, and the stability of their physicochemical properties during storage was subsequently evaluated.

2. Materials and methods

2.1. Obtaining samples of fresh cow's milk cheese with added candied cranberries and dried basil

The samples were obtained and the tests were performed in the laboratory of the Research Center for Biotechnology and Food Engineering (CCBIA) at the "Lucian Blaga" University of

Sibiu. The fresh cow's milk cheese was processed in laboratory conditions according to a recipe developed by the research team, using the following ingredients: cow's milk purchased from an organic farm in Sibiu County, liquid rennet produced by IDEAL STILL EXIM SRL, candied cranberries produced by EcoNatur, and dried basil produced by Cosmin.

The pasteurization of raw milk occurs at temperatures ranging from 65 to 70°C, followed by a cooling process to a temperature of 34°C. Once the desired cooling temperature is attained, liquid rennet is introduced at a rate of 1 milliliter per 5 liters of milk. The seeded milk is then subjected to a 90-minute room temperature coagulation period. Subsequent to a 90-minute period, the curd is processed and removed via a gauze sieve to facilitate the drainage of whey. Subsequent to the draining of the whey, the mixture is subjected to processing, wherein candied cranberries and desiccated basil are incorporated. Following a series of attempts, the proportions in Table 1 were established.

Table 1. List of ingredients for samples

Sample code	Fresh cow's cheese [g]	Candied cranberries [g]	Dried basil [g]
CS	100	-	-
CC3	100	3	-
CC5	100	5	-
CC7	100	7	-
CB0.5	100	-	0.5
CB1	100	-	1
CB1.5	100	-	1.5

The cheese samples were hermetically sealed in plastic containers with a capacity of 300 cm³ and stored at a temperature of 4 °C.

2.2. Physicochemical analysis of raw milk

To establish the conformity of raw milk, a series of tests was carried out to verify its quality, safety, and compliance with established standards.

The Thörner method was employed to ascertain the acidity levels of raw milk. In the experiment, 10 cm³ of raw milk was titrated with 0.1 N NaOH in the presence of 1% phenolphthalein until a pink color appeared that persisted for at least 30 seconds (Tița, 2002).

The areometric method was employed to ascertain the density of the raw milk sample. The thermolactodensimeter is immersed in the milk sample, which is brought to 20°C. Thereafter, the

density value can be obtained by reading the meter (Tița, 2002).

The protein titre was determined through a comparison solution that was prepared from 25 mL of raw milk, 1 mL of a 28% potassium oxalate solution, and 0.5 mL of a 5% cobalt sulfate solution. The actual solution was prepared by combining 25 mL of milk, 0.25 mL of a 2% phenolphthalein solution, and 1 mL of a 28% potassium oxalate solution.

The sample was then titrated with 0.143N NaOH until the color matched that of the reference solution. Subsequently, 5 mL of 40% formic aldehyde was added to the sample, and titration was continued until the color was identical to that of the comparison solution (Tița, 2002).

The boiling test was employed to ascertain the freshness of the milk. A quantity of milk was placed in a test tube and subjected to boiling (Tița, 2002).

2.3. Physicochemical analysis of fresh cheese samples

The method employed to ascertain acidity entails the titration of a sample quantity with 0.1N NaOH in the presence of 2% phenolphthalein until a pink coloration manifests, which must persist for a minimum of 30 seconds. The working method is delineated in the paper published by Tița et al. in 2024 (Tița et al., 2024).

The pH was determined using an Orion 2-Star pH meter (manufactured by Thermo Scientific). The method was first described in a 2024 paper by Tița et al. (Tița et al., 2024) and then in a 2020 paper by Łopusiewicz et al. (Łopusiewicz et al., 2020).

The sample was evaporated at 150°C using an AND ML-50 moisture analyzer (Drăghici, 2021; Olugbuyiro et al., 2011).

The argentometric titration method was employed to ascertain the salt content. A quantity of 30 mL of hot water was added to 5 g of the sample, thereby forming a suspension. This suspension was subsequently transferred into a 100 cm³ volumetric flask. Following a cooling period, distilled water was introduced to the mark, allowed to stand for 15 minutes, and subsequently filtered. In a 50-mL sample of filtrate, 5% potassium chromate was added and titrated with 2.906% AgNO₃ until a brick-red color appeared (Tița, 2002).

LabMaster-aw, a product manufactured by Novasina AG, was utilized to ascertain water activity at 25°C (Novasina, 2021).

3. Results and discussions

3.1. Physicochemical analysis of raw milk

Table 2. Results of physicochemical analysis of raw milk

Acidity [°T]	Density [g/cm ³]	Freshness	Protein content [g/100mL]
19	1.0292	Fresh	3.4

As illustrated in Table 2, the results obtained from the physicochemical analysis of raw milk are presented. The results obtained in this study are in accordance with the quality standard for whole raw milk, indicating its suitability for the production of fresh cheese samples.

3.2. Physicochemical analysis of fresh cheese samples

As illustrated in Table 3, the data clearly show that storage time influences various physicochemical properties of cheese samples. These properties include acidity, pH, dry matter content, water activity, and salt content.

During the storage period, an increase in the acidity of the cheese samples is observed, attributable to the accumulation of lactic acid. The accumulation of lactic acid has also been confirmed by Pham et al. in 2020 in their research on fresh cheese made from powdered milk (Pham et al., 2020). The control sample exhibited the lowest acidity on the first day of storage; however, during storage, lactic acid accumulated at a significantly faster rate compared to the other samples. The incorporation of candied cranberries has been demonstrated to modulate the acidity levels of the mixture, with the highest acidity observed in the sample containing 7 g of cranberries from the first day until the 14th day.

The samples containing basil exhibited a more gradual increase in acidity compared to the control sample, a phenomenon attributable to the inhibitory effect it exerts on microorganisms. According to Sarmiento et al. (2019), the change in acidity may also be directly related to the addition of fruit or spice.

Consequently, it can be deduced that the increase in acidity of fresh cheese samples with added candied cranberries and dried basil is more consistent, with values rising marginally during storage compared to the control sample (Sarmiento et al., 2019).

The pH of the cheese samples exhibited a similar trend to the titratable acidity, with a

decrease observed during the storage period. Fujita et al. (2017) confirm the decrease in pH in soy milk samples during storage (Fujita et al., 2017). The quantity of candied cranberries and dried basil employed exerts a significant influence on the pH of the samples, with higher amounts resulting in a decrease in pH. The graph illustrates a pronounced decrease in pH for the control sample and the samples with cranberries. From day 1 to day 14, a gradual decrease is observed in the cheese samples with added basil, due to its antimicrobial effect.

The increase in dry matter during storage is attributable to the loss of whey from the samples. The incorporation of cranberries has been shown to enhance the dry matter content in comparison to the addition of basil, which has been observed to exhibit lower values.

The findings of this study are consistent with the existing body of literature on the subject. Bjekić et al. (2021) conducted an analysis of the dry matter content of fresh cheese samples, determining that the range of results falls between 37.40 and 49.83%, contingent upon the utilized starter culture (Bjekić et al., 2021).

Water activity is defined as the amount of free water in food that microorganisms can use for growth. The correlation between bacterial growth and the value in question is negative (de Azevêdo et al., 2014). During the storage process, there is a slight increase in water activity. The control sample exhibited higher water activity levels throughout the storage period when compared to the samples that contained additives. The incorporation of basil, a natural antimicrobial agent, results in a reduction of water activity compared to samples containing candied cranberries.

During the storage period, a slight decrease in salt content was observed in all samples. It is evident that the magnitude of the salt content is directly proportional to the quantity of salt added. The highest values are recorded on the first day of storage, and the lowest values are recorded on the 14th day of storage. The samples containing dried basil exhibited a reduced salt content relative to those comprising candied cranberries, which approached the values of the control sample.

Table 3. Evolution of acidity, pH, dry matter content, water activity and salt content in cheese samples during the storage period

Item	Sample	Storage time [days]		
		1	7	14
Acidity [°T]	CS	26.833±0.289	51.333±0.577	89.167±0.289
	CC3	47.667±0.577	68.167±0.289	84.000±0.000
	CC5	50.167±0.289	70.833±0.289	89.167±0.289
	CC7	58.167±0.289	80.167±0.289	91.833±0.289
	CB0.5	39.167±0.289	44.167±0.289	49.000±0.000
	CB1	41.000±0.000	47.167±0.289	54.833±0.289
	CB1.5	43.833±0.289	51.167±0.289	58.167±0.289
pH	CS	6.5567±0.00577	6.4167±0.00577	4.9533±0.00577
	CC3	6.4667±0.00577	5.6533±0.00577	5.0167±0.00577
	CC5	6.4333±0.00577	5.4167±0.00577	4.9633±0.00577
	CC7	6.4033±0.00577	5.0733±0.00577	4.9067±0.00577
	CB0.5	6.5333±0.00577	6.4833±0.00577	6.4533±0.00577
	CB1	6.5133±0.00577	6.4533±0.00577	6.4033±0.00577
	CB1.5	6.4867±0.00577	6.4167±0.00577	6.3733±0.00577
Dry matter [%]	CS	25.433±0.0577	27.433±0.0577	29.833±0.0577
	CC3	30.867±0.0577	31.567±0.0577	32.333±0.0577
	CC5	33.033±0.0577	33.733±0.0577	34.167±0.0577
	CC7	34.333±0.0577	34.633±0.0577	34.867±0.0577
	CB0.5	28.833±0.0577	29.267±0.0577	29.767±0.0577
	CB1	30.833±0.0577	31.167±0.0577	31.867±0.0577
	CB1.5	32.633±0.0577	32.867±0.0577	33.067±0.0577
Water activity	CS	0.98500±0.000000	0.98667±0.000577	0.98833±0.000577

	CC3	0.98167±0.000577	0.98267±0.000577	0.98433±0.000577
	CC5	0.98067±0.000577	0.98233±0.000577	0.98333±0.000577
	CC7	0.98033±0.000577	0.98067±0.000577	0.98233±0.000577
	CB0.5	0.97767±0.000577	0.97900±0.000000	0.98367±0.000577
	CB1	0.97733±0.000577	0.97833±0.000577	0.98433±0.000577
	CB1.5	0.97467±0.000577	0.97733±0.000577	0.98167±0.000577
Salt content [g/100 g product]	CS	0.20333±0.00577	0.17667±0.00577	0.16667±0.00577
	CC3	0.20333±0.00577	0.19000±0.000000	0.17667±0.00577
	CC5	0.20667±0.00577	0.19667±0.00577	0.18333±0.00577
	CC7	0.24333±0.00577	0.21667±0.00577	0.20667±0.00577
	CB0.5	0.20000±0.000000	0.18333±0.00577	0.16667±0.00577
	CB1	0.22333±0.00577	0.20667±0.00577	0.19667±0.00577
	CB1.5	0.22667±0.00577	0.21667±0.00577	0.20333±0.00577

* Results are presented in the form of mean ± standard deviation (n = 3). The results in the same column are not significantly different (p < 0.05). The results in the same row are not significantly different (p < 0.05).

4. Conclusions

In summary, the present study demonstrates the positive effect of incorporating candied cranberries and dried basil into fresh cow's milk cheese, a food commonly consumed due to its health benefits. The influence of varying concentrations of the added ingredients is evident, and the fresh cheese samples with 1.5 g of dried basil and 5 g of candied cranberries obtained the most satisfactory results in terms of physical-chemical properties and stability during storage.

Consequently, the two additives hold considerable promise due to their multifaceted health benefits. This information is necessary for assessing the safety and efficacy of candied cranberries and dried basil and could serve as a starting point for future studies. In the subsequent phase of research, the objectives will be to assess the consumer acceptability of the fresh cheese samples and to conduct antioxidant and antimicrobial analysis.

References

- Araya, V., Gatica, M., Uribe, E., Román, J.: *In Silico Analysis of the Molecular Interaction between Anthocyanase, Peroxidase and Polyphenol Oxidase with Anthocyanins Found in Cranberries*. Int. J. Mol. Sci., vol. 25, 2024, p. 10437.
- Azevedo, L., et al.: *Camu-camu (Myrciaria dubia) from commercial cultivation has higher levels of bioactive compounds than native cultivation (Amazon Forest) and presents antimutagenic effects in vivo*. J. Sci. Food Agric., vol. 99, 2019, p. 624-631.
- Banu, C.: *Tratat de industrie alimentară Vol.2 Tehnologii alimentare*, Ed.: ASAB, 2009.
- Bătușaru, C.M.: *Sustainability of the small business environment in Romania in the context of increasing economic competitiveness*. Manag. Sustain. Dev., vol. 11(2), 2019, p. 37.
- Bătușaru, C.M., Sbârcea, I.R.: *Harmonizing Circularity: Romania's Progressive Efforts Towards Circular Economy Integration in Europe*. Manag. Sustain. Dev., vol. 15(1), 2023, 62–74.
- Bielska, P., Cais-Sokolinska, D.: *Fresh White Cheeses from Buttermilk with Polymerized Whey Protein: Texture, Color, Gloss, Cheese Yield, and Peptonization*. Appl. Sci., vol. 13, 2023, p. 11692.
- Bjekić, M., et al.: *Protein characterisation and antioxidant potential of fresh cheese obtained by kombucha*. Mljekarstvo, vol. 71(4), 2021, p. 215-225.
- Drăghici O.: *Evaluation of mathematical models which describe the process of drying goat meat*. scientific papers series management. Sci. Pap. Ser. Manag. Econom. Eng. Agric. Rural Dev, vol. 21, 2021, p. 37-40.
- Dobreva, K., et al.: *Chemical Composition and Antioxidant Activities of Three Bulgarian Garden Thyme Essential Oils*. Appl. Sci. 2024, 14(22).
- Falcão, R.L., et al.: *Nutritional Improvement of Fresh Cheese with Microalga Chlorella vulgaris: Impact on Composition, Structure and Sensory Acceptance*. FTB, vol. 61(2), 2023, p. 259-270.

11. Fujita, A., et al.: *Effects of Spray-Drying Parameters on In Vitro Functional Properties of Camu-Camu (Myrciaria dubia Mc. Vaugh): A Typical Amazonian Fruit*. J. Food Sci., vol. 82(5), 2017, p. 1083-1091.
 12. Galatanu, D.: *Compozitia laptelui*. 2014, <https://www.gazetadeagricultura.info/informatii-utile/15764-compozitia-laptelui.html> (access date: 14.03.2025);
 13. Imeri, A., et al.: *Essential oil composition in three cultivars of Ocimum L. in Albania*. In: Arch. Biol. Sci., vol. 66(4), 2014, p.1641-1644.
 14. Łopusiewicz, L., et al.: *The Effect of Fermentation with Kefir Grains on the Physicochemical and Antioxidant Properties of Beverages from Blue Lupin (Lupinus Angustifolius L.) Seeds*. Molecules, vol. 25(24), 2020, p. 5791.
 15. Luz Arelis, M.O., et al.: *Ice cream consumption preferences in Sullana, Peru*. Curr. Res. Nutr. Food Sci., vol. 11(1), 2023, p. 267-275.
 16. Musachio, E.A.S., et al.: *The Amazonian Camu-Camu Fruit Modulates the Development of Drosophila melanogaster and the Neural Function of Adult Flies under Oxidative Stress Conditions*. Antioxid, vol. 13, 2024, p. 102.
 17. Novasina A. *Operating Instructions LabMaster-Aw Neo*. 2021. <http://www.novasina.ch/en/water-activity> (access date: 29.03.2025).
 18. Oliveira, B.C.R., et al.: *An overview of the potential of select edible Amazonian fruits and their applications in dairy products*. Crit. Rev. Food Sci. Nutr., 2024, p. 1-15.
 19. Olugbuyiro, J.A.O., Oseh, J.E.: *Physico-chemical and sensory evaluation of market yoghurt in Nigeria*. PJN, vol. 10:10, 2011.
 20. Oprea, O.B., Gaceu, L. *Preliminary researches on using spices in traditional bakery product recipes*. JEAT, 2011, 15-18.
 21. Oprea, O.B., Gaceu, L. *Application of multiple criteria decision making (mcdm) in bakery industry. Study case: wastes and by-products*. BUT. Series II: Forestry• Wood Industry• Agricultural Food Engineering, 89-94. 2016.
 22. Pham, T.H., et al.: *Effect of transglutaminase on quality properties of fresh cheese*. Int. J. Adv. Appl. Sci., vol. 8(4), 2021, p. 44-53.
 23. Răducuță, I.: *Filiera laptelui*. Sibiu. Ed. Universității "Lucian Blaga", 2004.
 24. Santos, I.L., et al.: *Camu-camu [Myrciaria dubia (HBK) McVaugh]: A review of properties and proposals of products for integral valorization of raw material*. Food Chem., vol. 372 (2022), 2022, p. 131290.
 25. Sarmiento, R.C., et al.: *Estabilidade do ácido ascórbico em iogurte de leite de búfala adicionado de diferentes concentrações de polpa de camu-camu (Myrciaria dubia)*. Rev. Inst. Laticínios Cândido Tostes, vol. 74(3), 2019, p. 149-158.
 26. Shamilov, A.A., et al.: *Vaccinium vitis-idaea L.: Chemical Contents, Pharmacological Activities*. Pharm. Sci., vol. 26(4), 2020, p. 344-362.
 27. Song, J., Yang, J., Jeong, B.R.: *Characterization of Physiology, Photosynthesis, and Nutrition Based on Induced Deficiencies of Macro- and Micronutrients in Basil (Ocimum basilicum L.)*. Agronomy, vol. 14, 2024, p. 208.
 28. Spence, C.: *Sweet basil: An increasingly popular culinary herb*. Int. J. Gastron. Food Sci., vol. 36, 2024, p.1-9.
 29. Tița, M.A.: *Manual de analiză și controlul calității în industria laptelui*. Sibiu. Ed. Universității „Lucian Blaga” din Sibiu, 2002.
 30. Tița, O., Constantinescu, M.A., Tița, M.A., Bătușaru, C., Mironescu, I.: *Sensory, textural, physico-chemical and enzymatic characterization of melted cheese with added potato and carrot peels*. Frontiers in Nutrition, vol. 10, 2024, p. 1260076.
 31. Zielinska, M., Zielinska, D., Markowski, M.: *The Effect of Microwave-Vacuum Pretreatment on the Drying Kinetics, Color and the Content of Bioactive Compounds in Osmo-Microwave-Vacuum Dried Cranberries (Vaccinium macrocarpon)*. FABT, vol. 11, 2018, p. 585-602.
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SUSTAINABLE PLANT-BASED FORMULATIONS DEVELOPMENT

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Abstract: Driven by consumer interest in sustainable diets, plant-based food alternatives (PBFA) are gaining popularity with more products available on the market. This study investigated consumer understanding and interpretation of PBFA, using five plant-based recipes developed within the study: mayonnaise, pumpkin seeds cheese alternative, sunflower seeds and tomatoes pâté, nettle- and ramson-based pesto, nettle-based hummus. All developed plant-based products were evaluated for sensory attributes and nutritional value were calculated as well. As a result, developed recipes can contribute to new market, exploring the possibilities of completely plant-based formulations.

Keywords: plant-based food development, nutritional value, sensory study.

1. Introduction

The expansion and integration of plant-based foods into mainstream diets have profound implications for the United Nations Sustainable Development Goals (SDGs), offering a multifaceted approach to addressing some of the most pressing global challenges [1], [2], [3].

Contribution to SDG 12: The shift towards plant-based diets represents a paradigm shift in how people view food consumption and production [4], [5]. This transition is aligned with the principles of responsible consumption, as plant-based diets typically require fewer natural resources [6]. The adoption of these diets encourages a more sustainable food system that minimizes environmental degradation and promotes the efficient use of resources [7], [8].

The adoption of plant-based foods offers a holistic solution to environmental challenges, health issues, and food security concerns [9]. As the world seeks sustainable paths towards development, the role of plant-based diets becomes increasingly important [10], [11].

The plant-based meat market is experiencing significant global growth [12]. While the Asian market, valued at USD 1.37 billion in 2023, is currently smaller than those in other developed regions, it is expected to continue expanding [13], [14]. The European market, valued at USD 2.1 billion in 2023, is projected to grow at a compound annual growth rate (CAGR) of 20.4 % between 2024 and 2030 [15]. Similarly, the U.S. market, estimated at USD 3.21 billion in 2024, is

forecast to grow at a CAGR of 18.1 % from 2025 to 2030 [16].

The production of plant-based foods aims to bring these products closer to animal-based foods, providing similar flavor, texture, and nutritional composition [17], [18], [19], [20].

This study aims to research the impact of ingredients composition on the product characteristics and nutritional value of plant-based food products.

2. Materials and methods

2.1. Raw materials

Apple, dried plums, banana, avocado, lemon, dehydrated tomatoes, onion, garlic, walnuts, chickpeas, inactive yeast flakes, sunflower seeds, pumpkin seeds, sesame seed sauce olive oil, parsley, dill, nettle, ramson (wild garlic), salt were purchased from a retail store in Chisinau, Republic of Moldova.

2.2. Plant-based formulations development

The developed plant-based formulations included:

- plant-based mayonnaise,
- plant-based pumpkin seeds cheese alternative,
- plant-based sunflower seeds and dehydrated tomatoes pâté,
- plant-based nettle and ramson pesto
- plant-based nettle-based hummus.

All developed formulations are shown in Table 1.

Table 1. *Plant-based formulations developed within the study*

No	Plant-based formulations	Ingredients list	Ingredients amount, [%]
1.	Plant-based mayonnaise	Fresh lemon juice	10
		Fresh garlic paste	1
		Inactive yeast flakes	5
		Unshelled sunflower seeds	30
		Salt	1
		Water	53
		Total	100
2.	Plant-based pumpkin seeds cheese alternative	Pumpkin seeds	40
		Fresh lemon juice	7
		Fresh garlic paste	1
		Inactive yeast flakes	5
		Fresh dill	3
		Fresh onion paste	7
		Salt	1
		Water	36
		Total	100
3.	Plant-based sunflower seeds and dehydrated tomatoes pâté	Unshelled sunflower seeds	35
		Dehydrated tomatoes	19
		Walnut kernel	15
		Olive oil	5
		Salt	1
		Water	25
		Total	100
4.	Plant-based nettle and ramson pesto	Fresh nettle	20
		Avocado pulp	20
		Walnut kernel	5
		Fresh parsley	5
		Unshelled sunflower seeds	10
		Fresh ramson (wild garlic)	5
		Inactive yeast flakes	3
		Olive oil	1
		Salt	1
		Water	30
		Total	100
5.	Plant-based nettle hummus	Boiled chickpea paste	70
		Fresh nettle	20
		Sesame seed paste	8
		Fresh garlic paste	1
		Salt	1
		Total	100

2.3. Plant-based formulations evaluation

2.3.1. Nutritional Fact Panel

The nutritional content and fact panel of the plant-based formulations were developed using food chemical composition database.

2.3.2. Sensory Analysis

Plant-based formulations were developed and evaluated for their sensory attributes.

The sensory study was carried out with the academic group TMAP-202 of the Faculty of Food Technology, Technical University of Moldova. Fifteen students participated in the sensory analysis (Figure 2). Students were provided with a tasting sheet, a plate, a cup, a single-use spoon, still water, and slices of bread. The water and bread were served to minimize residual taste sensations from the previous product (Figure 1).



Fig. 1. Setup for the sensory analysis of the plant-based developed formulations



Fig. 2. Sample of students participating in the sensory study of the plant-based formulations

The tested attributes included: appearance and color, flavor, taste, consistency, and overall

sensory acceptability (OSA). A 5-point hedonic scale shown in Table 2.

Table 2. A 5 - Point Scale for Descriptive Attributes of plant-based formulations

Points	Rating	Description
5	Very good	Outstanding performance, perfect
4	Good	Relevant indicators
3	Satisfactory	Minor defects
2	Unsatisfactory	Obvious defects
1	Poor	Strongly marked defects

2.3.3. Statistical Analysis

The results variation analysis was carried out by the method with application of Microsoft Office Excel program. Differences were considered statistically significant if probability was greater than 95% ($q < 5\%$). Experimental results are expressed as average $\pm$ SD (standard deviation).

3. Results and discussions

3.1. Technological aspects

Technological aspects of plant-based formulations are described in Table 3.

3.2. Nutritional Value

The nutritional fact panel of all 5 plant-based developed formulations is presented in Table 4. A comparative nutritional evaluation of newly developed formulations revealed marked differences in macronutrient composition, total calories, and functional health ingredients. Therefore, plant-based developed formulations can be a nutritious choice for individuals seeking vegetarian or vegan diet.

Table 3. *Technological aspects of plant-based formulations*

No	Plant-based formulation	Pre-treatment operations	Processing method	Presentation and serving
1.	Plant-based mayonnaise	Sunflower seeds are thoroughly washed and placed in a container. They are covered with water by 2–3 cm and left in a warm place for 8 hours to hydrate. After the hydration period, the remaining water is drained from the seeds.	The hydrated sunflower seeds are placed in a blender together with all other ingredients and blended until a smooth paste is obtained. The taste can be adjusted with salt.	The mayonnaise can be added to any salad to enhance flavor.
2.	Plant-based pumpkin seeds cheese alternative	Pumpkin seeds are thoroughly washed and hydrated in a warm place for 8 hours. After the hydration period, the remaining water is drained from the seeds. The hydrated seeds are then rinsed with cold water.	The hydrated pumpkin seeds are placed in a blender together with all other ingredients and blended at maximum speed until a homogeneous paste is obtained. Salt is added to taste.	The paste is garnished with whole pumpkin seeds and served with slices of dark bread or another preferred type of bread.
3.	Plant-based sunflower seeds and dehydrated tomatoes pâté	Seeds and walnuts are soaked in cold water for 6 hours. After soaking, they are rinsed and drained with cold water, then homogenized using a blender.	The hydrated seeds and walnuts are placed in a blender together with nutritional yeast flakes, adding olive oil for taste and consistency. Salt is added to taste. Dried tomatoes are then incorporated.	The pâté is stored under refrigeration. It is served with raw vegetables (bell peppers, endives, cucumbers).
4.	Plant-based nettle and ramson pesto	Nettles are thoroughly washed under cold water and blanched for 1–2 minutes, then drained. Ramson leaves are washed and gently patted dry with a paper towel to remove excess water. Nettles and ramson are then finely chopped.	The chopped nettles and ramson leaves are added to a blender together with parsley, salt, and olive oil. The remaining ingredients are added according to the recipe. Water is incorporated depending on the desired consistency of the paste.	Nettle and ramson pesto can be served with pasta, potatoes, soups, crackers, fish, shellfish, meat, garlic bread, and other dishes.
5.	Plant-based nettle hummus	Nettles are thoroughly washed under cold water and blanched for 1–2 minutes, then drained.	The hummus is put into the blender at maximum speed. Then already blanched nettles are added with sesame seeds sauce, salt and garlic paste.	Nettle hummus can be decorated with sesame seeds and served with slices of bread.

Table 4. *Nutritional information for developed plant-based formulations (per 100 g of product)**

No	Nutritional information	Plant-based mayonnaise		Plant-based pumpkin seeds cheese alternative		Plant-based sunflower seeds and dehydrated tomatoes pâté		Plant-based nettle and ramson pesto		Plant-based nettle hummus	
		Amount	% of Daily Value	Amount	% of Daily Value	Amount	% of Daily Value	Amount	% of Daily Value	Amount	% of Daily Value
1.	Calorie	758.14		1013.41		1327.53		956.03		1161.88	
2.	Total fat	15.89 g	19.07	21.20 g	25.4 4	32.16 g	38.59	20.73 g	24.88	7.40 g	8.88
3.	Total carbohydrates	2.43 g	1.04	3.64 g	1.56	5.34 g	2.29	3.18 g	1.36	39.93 g	17.11
4.	Dietary fibers	0.01 g	0,04	0.16 g	0,56	0.21 g	0,74	0.45 g	1,58	2.90 g	10,15
5.	Proteins	6.96 g	13.92	9.21 g	18.42	10.95 g	21.90	8.21 g	16.42	16.43 g	32.86
6.	Calcium	117.80 mg	13.86	163.18 mg	19.20	189.22 mg	22.26	184.36 mg	21.69	307.77 mg	36.21
7.	Iron	18.58 mg	111.48	24.78 mg	148.68	22.49 mg	134.94	7.86 mg	47.16	9.60 mg	57.60
8.	Potassium	227.41 mg	6.69	313.64 mg	9.22	509.45 mg	14.98	376.81 mg	11.08	869.31 mg	25.57
9.	Sodium	426.24 mg	19.67	444.21 mg	20.50	468.82 mg	21.64	419.70 mg	19.37	447.57 mg	20.66

* The % daily value was calculated on a dily diet of 2000 calories based on general nutritional advice.

3.2. Sensory evaluation

Sensory study included tasting of all 5 formulations by panelists and evaluating the main sensory attributes of the products. Based on individual tasting sheets, an average score was

calculated for evaluated sensory attributes: appearance, color, flavor, taste, texture and overall sensory acceptability (OSA), presented in Table 5.

Table 5. *Sensory evaluation of freshly prepared plant-based formulations*

No	Plant-based formulation	Sensory attributes				
		Appearance and color	Flavor	Taste	Texture	OSA
1.	Plant-based mayonnaise 	4.73±0.31	4.77±0.21	4.71±0.28	4.73±0.23	4.69±0.31
2.	Plant-based pumpkin seeds cheese alternative 	4.78±0.22	4.66±0.32	4.73±0.23	4.63±0.27	4.71±0.25
3.	Plant-based sunflower seeds and dehydrated tomatoes pâté 	4.59±0.31	4.45±0.34	4.76±0.27	4.63±0.33	4.67±0.29
4.	Plant-based nettle and ramson pesto 	4.77±0.21	4.21±0.33	4.53±0.37	4.55±0.27	4.74±0.21
5.	Plant-based nettle hummus 	4.79±0.19	4.76±0.20	4.79±0.20	4.73±0.23	4.86±0.22

Following the sensory evaluation, the respondents recommended improving the taste of the plant-based mayonnaise. According to their feedback, the garlic flavor was perceived as predominant. It was suggested to improve the flavor of the plant-based pâté formulated with sunflower seeds and dehydrated tomatoes. The pumpkin seed-based plant cheese alternative showed favorable scores for aroma and appearance, while the taste was perceived as an aspect that could be further optimized by incorporating new components. The plant-based nettle and ramson pesto was appreciated for its appearance and aroma. The plant-based nettle hummus was liked by most participants for its taste, aroma, and appearance. The choice of serving vessel was noted to influence the overall sensory experience for this product.

4. Conclusions

A dietary pattern dominated by fresh or minimally processed plant-based foods, with low consumption of meat, eggs, and dairy products, provides the simplest and clearest definition of a plant-based diet. The perceived benefits of healthy eating and dietary modification include weight management, improved health status, enhanced quality of life, and disease prevention. Individuals often face barriers when attempting to modify their dietary intake.

In this study, five plant-based food products were developed: mayonnaise, pumpkin seeds cheese alternative, sunflower seeds and tomatoes pâté, nettle and ramson pesto, nettle-based hummus. For each product, technological aspects and process particularities were described, nutritional values were calculated.

Sensory analysis of the developed products showed that they possess pleasant sensory attributes and were positively perceived by potential consumers. Based on the sensory evaluation results, certain sensory attributes of the products were refined according to feedback received.

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References

1. Daverkosen, S., Mouritsen, O.G. *Effects of specially designed meal boxes on plant-forward dietary choice*, International Journal of Gastronomy and Food Science, vol. 39, p. 101079, 2025.
2. D.E.S.A. *UN The sustainable development Goals report 2023: Special edition*. [Online]. Available: <https://unstats.un.org/sdgs/report/2023/>
3. *World Health Organization. Sustainable healthy diets: Guiding principles*. Food & Agriculture Org., 2019. [Online]. Available: via Link
4. Van Asselt, E.D., Focker, M., Hobé, R.G., Banach, J.L. *Risk-ranking of chemical hazards in plant-based burgers: An exploratory case study on recipe formulations*, Food Control, vol. 160, p. 110365, 2024.
5. Kokkorou, M., et al., *Effects of the hedonic value of a starter dish on liking, emotional response, and intake of a plant-based main dish in an adolescent school setting*, Food Quality and Preference, vol. 135, p. 105725, 2026.
6. Melendrez-Ruiz, J., Dujourdy, L., Arvisenet, G., Chambaron, S. *Disentangling consumer perceptions regarding plant-based food processing and formulation: Insights from a French study*, Food Quality and Preference, vol. 134, p. 105654, 2025.
7. Kuosmanen, S., Korhonen, K., Pajari, A.M., Konttinen, H. *Enabled to eat more plant proteins? Capabilities, opportunities, and motivations related to increasing pulse and pulse-based product consumption across consumer groups*, Food Quality and Preference, vol. 126, p. 105388, 2025.
8. Lim, C.S., Wong, S.C., Yeo, C.M. *Plant-Based Meat consumption value: vegetarian and non-vegetarian*, Appetite, vol. 212, p. 108015, 2025.
9. Menezes, R. C. F. D., Gomes, Q. C. D. C., Almeida, B. S. D., Matos, M. F. R. D., Pinto, L. C. *Plant-based mayonnaise: Trending ingredients for innovative products*, International Journal of Gastronomy and Food Science, vol. 30, p. 100599, 2022.
10. Spencer, M., Rowe, S., Bonnell, C., Dalton, P. *Consumer acceptance of plant-forward recipes in a natural consumption setting*,

- Food Quality and Preference, vol. 88, p. 104080, 2021.
11. Yıkmaş S., *et al.*, *Culinary trends in future gastronomy: A review*, Journal of Agriculture and Food Research, vol. 18, p. 101363, 2024.
 12. Gansweith, E., Hoving, C. *Exploring perceived social norms when considering a plant-based diet - An interview study*, Food and Humanity, vol. 5, p. 100858, 2025.
 13. Creedon, A.C., Foyle, L., McCall, N., Arulpragasam, M.G., Gibson, R., Dimidi, E. *Characterising the diversity of plant-based food and beverage consumption in adults, and exploring associations with cardiometabolic health outcomes: A cross-sectional study*, Clinical Nutrition, vol. 52, pp. 47–61, 2025.
 14. Safdar, B., Zijia, Z., Cao, J., Zhang, T., Li, H., Liu, X. *Investigating the incorporation of plant-based meat alternative in Asian culinary practices*, International Journal of Gastronomy and Food Science, vol. 40, p. 101170, 2025.
 15. Popovici, C., Gaceu, L., Teng, X.M., Jadeja, R. *The application of response surface methodology for development of sensory acceptable walnut cheese-like alternatives*. JEAT, 2024, ISSN 1844-8577, Vol. 20, no. 2, 34-42 p.
 16. Popovici, C., Teng, X.M., Jadeja, R. *Walnut cheese-like alternatives as an innovation among dairy analogues*. JEAT, 2024, ISSN 1844-8577, Vol. 20, no. 2, 5-12 p.
 17. Maciel, J.B., De Oliveira Silva, Y., Santos, S.S., Dionísio, A.P., Machado De Sousa, P.H., Garruti, D.D.S. *Plant-based gastronomic products based on freeze-dried cashew fiber*, International Journal of Gastronomy and Food Science, vol. 30, p. 100603, 2022.
 18. Van Bergen, G., Neufingerl, N., Meijboom, S., De Rosa Spierings, K., Zandstra, E.H., Polet, I. *What's cooking, if not meat? Effects of repeated home-use, recipe inspiration and meal context on perception of plant-based meat analogues*, Appetite, vol. 193, p. 107135, 2024.
 19. Birke Rune, C.J., Song, Q., Clausen, M.P., Giacalone, D. *Consumer perception of plant-based burger recipes studied by projective mapping*, Future Foods, vol. 6, p. 100168, 2022.
 20. Sprengholz, P., Hammer, L., Scheelje, L. *The taste of change? Free vegan meal boxes do not change meat consumption, self-efficacy, or attitudes toward a plant-based diet among meat eaters*, Food Quality and Preference, vol. 128, p. 105471, 2025.
 21. Oprea OB, Gaceu L. *Consumer acceptance and sensorial analysis of bread with grape seed flour*. InE3S Web of Conferences 2020 (Vol. 215, p. 01005). EDP Sciences.
 22. Oprea OB, Gaceu L. *Preliminary research on consumer acceptance of 6% replacement degree protein fish powder in snacks*. Journal of EcoAgriTourism, Vol. 18 (1), 2022;
 23. Mnerie, D., Gaceu, L., Oprea, O.B., Mnerie, G.V. and Shamtsian, M., 2014, September. *Web based forms regarding consumer's opinion in food products labelling*. In *Resource and Energy Saving Technologies of Production and Packing of Food Products as the Main Fundamentals of Their Competitiveness: Proceedings of the 3rd International SpecializedScientific and Practical Conference* (p. 148).

MAINTAINING POTATO QUALITY UPON IMPACT WITH A SPECIFIC SURFACE BY USING A DIGITAL POTATO AND COMPUTER GRAPHICS FOR ASSESSING THE INFLUENCE OF THE POTATO CONVEYORS ANGLES ON IMPACT FORCES

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Abstract: The present paper presents a method for analyzing the impact between potatoes transported by belt conveyors at specific velocity of 30m/min and several impact surfaces. The study focuses on a specific area of the potato harvester. Following the experiments, values determined allow adjustments in order to maintain the quality of the potatoes in the handling chain. Overall results obtained with the help of the electronic potato are important in the harvest and post-harvest potato management for obtaining quality potato for people consumption.

Keywords: potato, quality, conveyers, impact forces.

1. Introduction

Depreciation of vegetables and fruits can be achieved mainly due to mechanical shocks or improper storage conditions. Potato travels a long way in the conditioning flow between harvest and storage or consumption. In this process, potato is subjected to the action of mechanical shocks produced by contact with the surfaces of the organs and components of the conditioning flow. Mechanical shocks subsequently cause mechanical injuries that lead to major economic losses [2,9]. In Great Britain, 64% of potatoes harvested annually are damaged. Of these, 23% suffer both surface and internal injuries, while 13% suffer only internal injuries.

Although the shocks to which the fruits and vegetables are subjected generate injuries to the internal tissues, these shocks are unavoidable and must be taken into account, especially in the transport processes and in the harvesting and calibrating/sorting machines. The researchers found that 18% of harvested potatoes are already mechanically damaged when they arrive in the harvester's hopper, while another 20% are damaged along the way from unloading from the harvester's hopper to storage [11].

Maintaining the quality of tubers in the conditioning flow is related to their resistance to mechanical damage. The notion of resistance to mechanical damage in potato tubers does not coincide with a simple and precisely outlined

character of the plant organism, but is in reality a complex character, the result of a complex of distinct properties. Like all resistance qualities, resistance to mechanical damage is the result of the combined action of very varied and often independent physiological, anatomical-morphological and biochemical manifestations and processes [3].

In order to create machines, tools and equipment for harvesting, transporting and handling tubers, which produce as low mechanical damage to the tubers as possible, it is necessary to know, qualitative and quantitative aspects of the process of tubers damage under the action of mechanical stresses. An important tool for achieving this goal is the electronic potato [1,11].

The electronic potato allows determining the size of the impact in specific areas. The purpose of this article is to analyze with the help of this device the magnitude of the impact forces developed when the potato passes from a conveyor on a surface that will be inclined at three different angles. Subsequently the intensity of the impacts to the produce during harvest and post-harvest will be correlate this with the probability of damage to the produce itself [6].

2. The working procedure

A better understanding of the areas that generate shocks on potatoes but also the particularization of the area that is the subject of

this article, can be achieved by studying the flow of mechanized harvesting of potatoes with the help of a harvesting machine presented in figure 1. The technological process of potato harvesting includes the following work operations: removal of stems (especially for early varieties); digging

and breaking up the soil layer where the tubers are found; separation of tubers from stolons; separation of tubers from soil, stones and other plant debris; cleaning and sorting tubers; collecting tubers for transport.

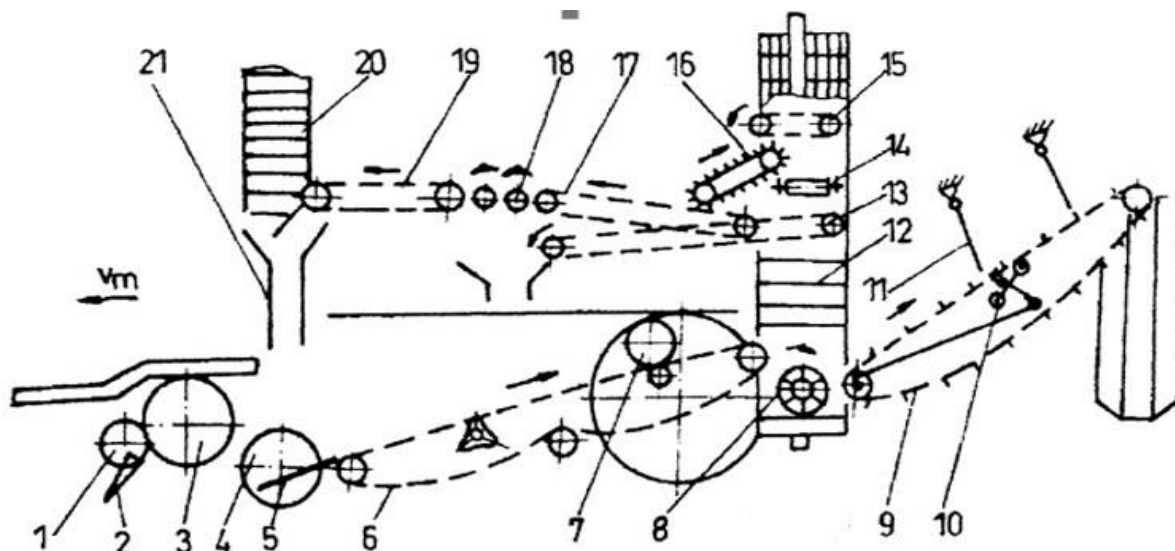


Fig. 1. Functional scheme of the potato harvester

1- discs; 2- spur; 3- drums; 4- disc knives; 5- displacement coulter; 6- rolling conveyor; 7- pneumatic roller; 8- thrower rotor; 9,10,11- pindle separator; 12- elevator drum; 13 conveyor for stones; 14, 15- conveyors with rods; 16- the separating conveyor with elastic fingers; 17, 19- conveyors with rods for manual separation; 18- sorting rollers; 20- elevator for loading the tubers in the trailer; 21- stone collector.

The table 1 shows some surfaces found in this stream above in different areas. For example, the Sieve band N 40 can be found at the rolling

conveyor 6 and the EB Pindle band (55 and 70) at the conveyor with rubber fingers 9 [5].

Table 1. Material characteristics

Material	Characteristics of the materials		
	Thickness (mm)	Length x width (mm)	Components
Sieve band N 40	18	3560x800	Rubber, steel hearth (platband)
EB Pindle band (rubber fingers)	44	2000x800	Rubber

The conveyer was first installed on the specific angle (5°, 10°, 15°) using the hydraulic crane, then the impact surface was put in front of the

conveyer, and the angle of the surface was modified by forklift. (55 cm, 70 cm) as shown in Fig. 2.

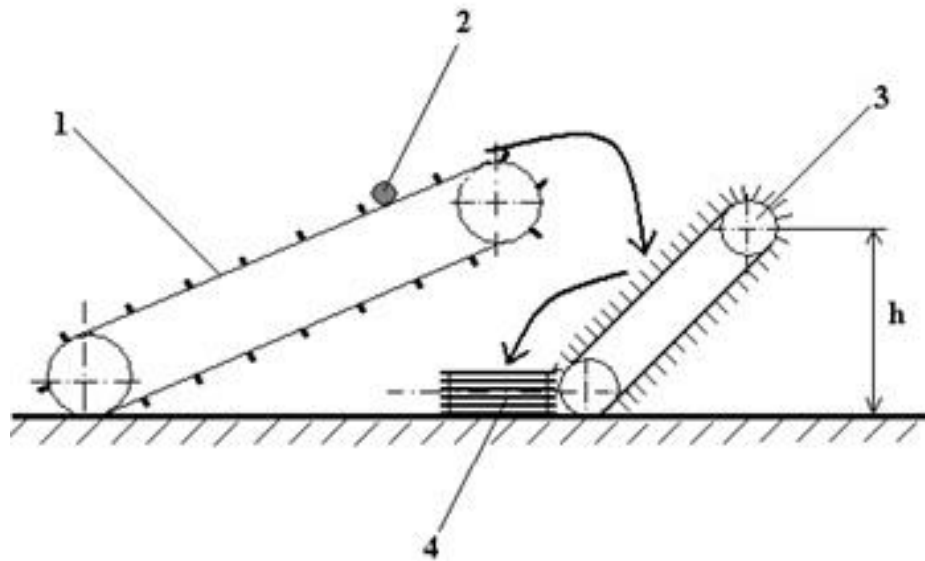


Fig. 2. *The modification of h [4]*

1 – transporting band; 2 – the digital potato; 3 – pindle band; 4 – Transporting band 230 B

The speed of the belt 1 was fixed at the specific value 30 m/min adjusting the frequency at the central command panel. The electronic potato 2 is activated put on the belt and the moment of impact is marked on the Receiver.

After 30 recorded impacts a run is completed. All the data were unloaded from the receiver in the computer, and the data were represented as graphics. In the figure 3 is represented a drawing of the pindle band with the components.

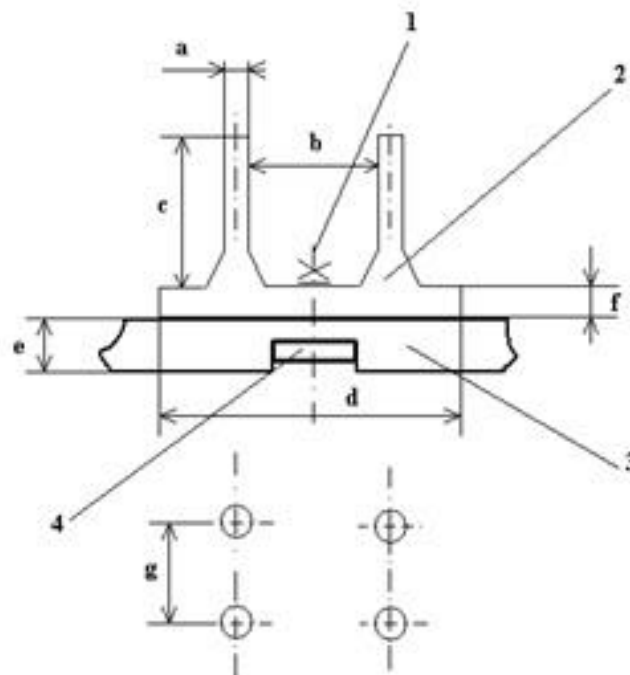


Fig.3. *The pindle band drawing*

1 Rivet from steel, 2 - Rubber finger from rubber, 3- Support band from rubber, 4- Steel plate from carbon steel

3. Results and data interpretation

When the potato hits the surfaces, the energy of

impact was absorbed by a condenser placed inside the potato [6]. Due to constructive defects, the entire energy was not always discharged at

once. So there were different delays between several shocks. In the dynamic situation, when the delay between two peaks was less than 0,4 s the shocks were added. After the data impacts data were downloaded from the receiver in the computer, there are exported by the PTR200 program as text files [8].

The text files were converted into Excel files. The impact forces value are calculated by Excel with Eq. (1) (Van Canneyt, 2001):

$$F = e^{\frac{\ln(x)+7.8877}{2.048}} \quad (1)$$

where F is the impact force and x the maximum impact value showed by receiver.

Table 2. *T test*

velocity = 30							
degree	5	10	15		5d-10d	5d-15d	10d-15d
material	mean						
c	121.6567	147.75	98.59119	T tests	2.01812	2.275937	3.670621
sieve	212.4063	204.201	213.75	T tests	0.489472	0.085189	0.63043
EB 55	243.8807	241.5986	234.733	T tests	0.125112	0.478331	0.394583
EB 70	289.2391	256.2964	221.2753	T tests	1.578473	2.806978	1.594897

In figure 4, the data from the table 2 are graphically represented. Even though the object of this article is to highlight the impacts between the electronic potato and the EB pinddle band surface, the results obtained on the C-profile

surface are also shown in the table. The resulting values also appear as a result of the statistical interpretation with the T test [7].

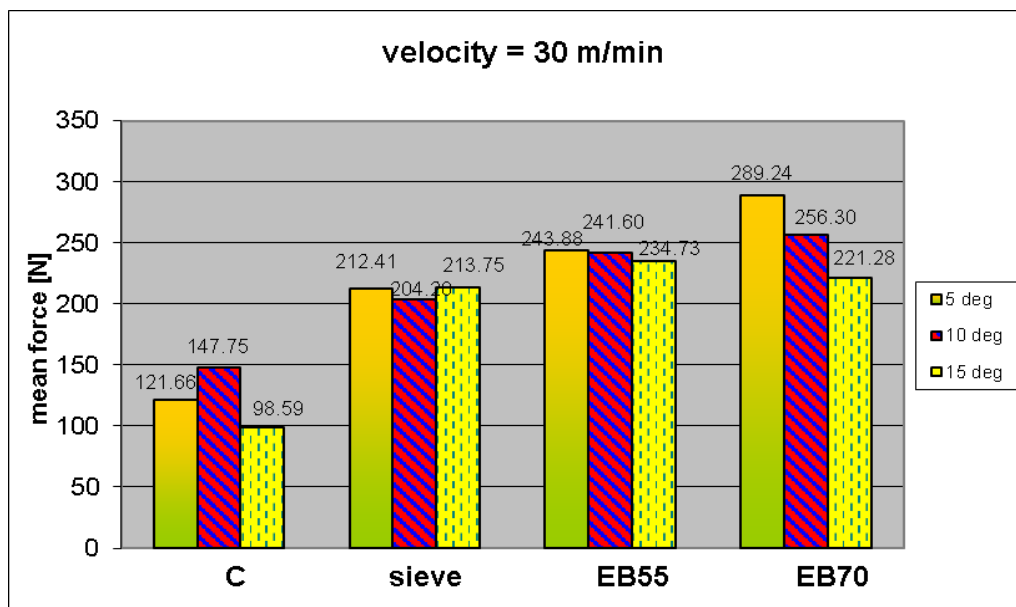


Fig.4. The mean force for the velocity of 30m/min

4. Conclusions and future work

From the analysis of the impact forces presented in the graph in figure 5, for the impact on the EB55 surface, the impact force decreases

with the increase of the inclination angle of the conveyor from 5 to 10 and to 15 degrees. The same trend is preserved in the case of the EB70 surface with the difference that for angles of 5 and 10 degrees the values of the impact forces are

higher than in the case of the EB55 surface for the same angles. The conclusion is that increasing the height h in figure 3 from 50 to 70 cm results in an increase in the impact force for the inclination of conveyor 1 to 5 and 10 degrees, respectively. It is very interesting that at the value of 15 degrees of the angle of conveyor 1 and the height of 70 cm of the EB surface, the lowest value of the impact force on the EB surface is obtained.

This conclusion is important because by adjusting the angles of the conveyors 6 and 9 in figure 1 to the experimentally determined values, the impacts for the area of interest are modified.

Also, following the impact force on the Sieve surface, it is observed that the values of all the impact forces are lower compared to the EB surface. For the Sieve surface, it is observed that the highest value of the impact force is obtained for an inclination of conveyor 1 of 15 degrees.

The data obtained are important for agricultural producers because it helps them to adjust the equipment so that the impact forces are minimal and implicitly to improve the quality of the tubers for consumption by reducing the shocks to which they are exposed [6].

References

1. Aldred W.H., Burch J.J.: *Telemetry and microcomputer system aids investigation of forces on peaches during mechanical harvesting*. ASAE paper no. 77-1527 (1977).
2. Blandini G., Cerruto E., Manetto G.: *Evaluation of the bruising of citrus fruits during post-harvest processing through the use of computerized equipment*, presented at AGENG '96, Madrid, Spain (1996).
3. Cerruto E., Manetto G., Schillaci G.: *Damage to potatoes during mechanized operations*, Institute of Farm Mechanization University of Catania, Italy paper 96F-004.
4. Danila D.M., Baciuc G., Aldea G., *Assesing the impact forces on falling potato using a digital device*, Bulletin of the Transilvania University of Brasov, Vol 10(45), 2003.
5. D.M. Dănilă, L. Găceu, W.W. Thierheimer, D. Ola, N. Țane, M. Hodirnau: *Management of the potato crops for minimizing environmental and human health impacts environmental*, Engineering and Management Journal 2010 pag 1685.
6. D.M. Danila: *Maintaining potato quality by using the digital potato and computer graphics for assessing relation between potato conveyors velocity and impact forces resulted*, J. of EcoAgriTourism, Vol. 18, 2022.
7. G.K. Hall Medical Publishers: *Statistics for Food and Agricultural Scientist*. Boston, Massachusetts, 1980.
8. Instruction manual, *The digital potato-PTR200*, distributed worldwide by Martin Lishman Ltd. Unit 2B Roman Bank, Bourne, Lincs PE10 9LA, U.K., 2000.
9. Mohsenin, N. N., *Physical Properties of Plant and Animal Materials*. Gordon and Breach, New York (1970).
10. Ola, D.C., Manescu, M., Găceu L., *“Software technique for Performance evaluation of a volumetric screw dosing system for agro-food bulk solids”*, in *Inovative Techniques in Instruction Technology, E-learning, E-assesment and Education*, pag. 392-395, Springer Science+Business Media B.V. 2008.
11. Specht A., *Potato harvesting without mechanical damages*, Landtechnik Heft 1,2/1966

THE INFLUENCE OF ARONIA POWDER ON THE TECHNOLOGICAL, NUTRITIONAL AND SENSORY QUALITY OF BREAD

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Abstract: The study analyses the use of *Aronia melanocarpa* powder as a functional ingredient in bakery and its impact on bread quality. *Aronia* is appreciated for its high content of bioactive compounds, especially polyphenols and anthocyanins, which confer a high antioxidant capacity and significant nutritional potential. The research aims to obtain aronia powder from dehydrated pomace and its integration into classic bread recipes, in proportions of 3%, 6% and 9%, compared to a control sample without addition. Technological changes in the dough (hydration, stability, gluten development) are evaluated, as well as the sensory characteristics of the final product: colour, texture, taste, aroma and general acceptability. The results show that the addition of aronia progressively intensifies the colour of the skin and core and increases the intake of fibre and antioxidants. However, high concentrations cause a more compact structure, an increase in friability and an accentuation of the bitter taste. Sensory analysis indicates that the 3% level represents an optimal compromise between improving the nutritional value and maintaining consumer acceptability, while higher additions reduce the overall preference. The study confirms the potential of aronia as a functional ingredient, with optimal use at moderate concentrations.

Keywords: aronia powder; functional bread; sensory analysis; antioxidants

1. Paper sections and font styles

Aronia melanocarpa, known as the "black chokeberry", is a shrub native to North America, where it grows spontaneously in swampy areas and forest clearings. In recent decades, the plant has been introduced and widely cultivated in Europe, including Romania, due to its high resistance to variable climatic conditions and good productivity. This has contributed to the increased availability of the fruit and its expanded use in the food industry [1]. *Aronia* berries are valued for their high content of bioactive compounds, especially polyphenols, anthocyanins, procyanidins and flavonoids, which are essential elements for the high antioxidant capacity of the fruit. Recent studies show that both fresh fruits and derived products (juices, purees, extracts or pomace) retain a significant amount of phytochemical compounds, which explains the growing interest of the food industry in this ingredient [2]. At the same time, aronia is distinguished by a good stability of phenolic compounds to moderate thermal

processing, an aspect that makes it suitable for use in products such as bakery products. Also, the intense purple colour and the specific astringency of the fruit contribute to the distinct sensory profile of the ingredients obtained from chokeberry, which offers the possibility of developing food products with their own visual and gustatory identity. In the context of the current trend towards natural ingredients and functional foods, chokeberry has become one of the most studied and valued fruit species, being used more and more frequently in modern formulations aimed at improving the nutritional value and antioxidant capacity of food products.

Aronia melanocarpa fruit can be harvested either manually or mechanically, the method chosen depending on the size of the plantation and the destination of the final product. In small and medium plantations, manual harvesting is preferred because it allows for careful selection of the fruit, reduces mechanical damage and maintains a high level of bioactive compounds, an important aspect in the case of raw materials intended for extracts, powders or products with

high functional value [3]. In contrast, large-scale plantations use mechanized harvesting, using specialized small-fruit equipment based on vibration and collection systems, which can provide high yields and higher work speeds, with an accuracy of up to 98% when the crops are properly arranged [4]. Although this method is much more efficient, it can lead to a higher degree of fruit crushing and moderate losses during harvesting, which is why rapid post-processing is essential to maintain quality [5]. Thus, both methods are used in practice, but for products where the phytochemical integrity is desired (such as chokeberry powder), manual harvesting remains the preferred method. In addition, chokeberry is distinguished by good processing stability, its compounds resisting temperature relatively well, which makes it suitable for products involving heat treatment, such as baking. In the food industry, chokeberry is used in a wide range of products: functional beverages, syrups, dairy products, desserts, nutritional supplements and, more recently, bakery products. This versatility is due to the fact that aronia-based ingredients (whether in the form of pulp, extract or powder) can improve the nutritional profile by providing fibre, vitamins and phenolic compounds, while imparting colour, flavour and antioxidant properties to the final products [5]. The transformation of fruit into powder is one of the most efficient methods of industrial valorisation, since the powder is stable, easy to transport and easy to integrate into different recipes. Obtaining the powder involves dehydrating the pomace (consisting of peels, pulp and seeds) by convective drying at 50°C or by lyophilization at -55°C, followed by fine grinding of the material. The finished product is characterized by a very high content of fibre (55-58%), polyphenols, anthocyanins and minerals such as potassium, calcium, magnesium, iron and zinc, which transforms it into a functional ingredient with high nutritional value [6].

From a sensory point of view, aronia powder has an intense red-violet colour due to anthocyanins, a slightly acidic fruity aroma and a specific astringent taste, influenced by the high content of polyphenols and tannins. The texture of the powder varies depending on the drying method: freeze-drying produces a fine and porous texture, while convective drying generates more compact granules. These elements determine how the powder influences the colour, taste and structure of the products in which it is introduced [6].



Fig. 1. *Chokeberry fruits*



Fig. 2. *Chokeberry powder*

Due to its nutritional, physicochemical and sensory characteristics, aronia powder is increasingly used in the development of value-added food products. In bakery, it contributes to increasing the fibre and antioxidant content, enriching the nutritional profile and obtaining products with a distinct and attractive chromaticity. The increased interest in natural ingredients with a functional role supports the use of aronia powder as a technological and nutritional adjuvant in products such as bread, biscuits, cakes, cereals or functional drinks.

2. Purpose, objectives and analysis of results in the context of specialized literature

The aim of the work is to analyse the impact of aronia powder on the technological, nutritional and sensory qualities of bread obtained by classic bakery recipes. Breads with additions of 3%, 6% and 9% are compared with a control bread, without aronia, to evaluate the changes generated by this functional ingredient. The study examines the influence of aronia powder on dough behaviour (gluten development, hydration, elasticity and stability), as well as on the internal structure, volume, colour, texture and aromatic profile of bread. The nutritional benefits of aronia are also analysed, in particular the intake of fibre, polyphenols, anthocyanins and compounds with antioxidant activity, aiming to maintain technological and organoleptic qualities.

The study examines the influence of aronia powder on dough behaviour (gluten development, hydration, elasticity and stability), as well as on the internal structure, volume, colour, texture and aromatic profile of bread. The nutritional benefits of aronia are also analysed, in particular the intake of fibre, polyphenols, anthocyanins and compounds with antioxidant activity, aiming to maintain technological and organoleptic qualities. The study by Cacak-Pietrzak et al. [7] on wheat bread enriched with freeze-dried aronia pomace shows that the addition of 3% causes consistent increases in the content of fibres, minerals and polyphenols, accompanied by a moderate reduction in volume and a slightly firmer texture, without compromising sensory acceptability. The authors conclude that the 3% level represents the optimal limit for maintaining a pleasant sensory profile, a fact confirmed by the study by Yoon et al. [8], where the samples with 3% obtained the best scores in appearance, colour and overall appreciation, even surpassing the control.

Research shows that bakery products with 3% aronia addition were evaluated most favourably, while increasing the concentration resulted in a denser core and a reduction in organoleptic scores. As the addition level increases towards 6%, the literature confirms the amplification of functional effects, but also the accentuation of undesirable changes in bakery properties. Studies in Applied Sciences show that at concentrations of 4-6%, the dough exhibits higher water absorption and reduced stability, which leads to breads with reduced volume, a more compact texture and a visible decrease in the brightness of the core, which acquires an intense reddish hue. In parallel, the intake of fibre, phenolic compounds and antioxidants is maximum at these levels, but sensory evaluations are significantly lower, with the authors strongly recommending not to exceed the 3% threshold for products intended for general consumption [5]. Similar

studies on breads enriched with chokeberry fibre also reported an increase in crumb hardness and an enhancement of astringency at concentrations of 6% [6]. Another study, confirms that bread with high addition of chokeberry powder have the highest values for fibre content, phenolics and antioxidant activity, but also the most pronounced negative changes in texture and structure. Therefore, comparison of data from the literature shows a clear convergence: the addition of 3% ensures the best compromise between nutritional value and sensory quality, the 6% level maximizes the intake of bioactive compounds, but causes significant losses in baking quality, and concentrations close to 9-10% lead to major changes in the structure and texture of the bread, offering nutritional advantages, but limiting the acceptability of the final product. This analysis contextualizes the experimental results and allows their interpretation within a validated scientific framework.

3. Materials and methodology

For the experiment, four bread samples were prepared, designed to highlight how the addition of chokeberry powder influences the behaviour of the dough and the quality of the final product. The control batch was made without the addition, while the three experimental samples included chokeberry powder in proportions of 3%, 6% and 9%, related to the total mass of flour. The choice of these concentrations allowed the observation of the differences between a low, medium and high addition, so that the optimal limit of use of the functional ingredient in baking could be established. The recipe used to make the four bread samples is presented in the table below, where the exact quantities of ingredients used for the control sample and for the variants enriched with aronia powder are indicated.

Table 1. *The exact quantities of ingredients used for the 4 batches of bread*

Ingredients	Test sample	P1 - 3% addition	P2 - 6% addition	P3 - 9% addition
Wheat flour	500 g	485 g	470 g	455 g
Chokeberry flour	0	15 g	30 g	45 g
Yeast	7 g	7 g	7 g	7 g
Sugar	25 g	25 g	25 g	25 g
Salt	10 g	10 g	10 g	10 g
Oil	25 ml	25 ml	25 ml	25 ml
Water	300 ml	300 ml	300 ml	300 ml

The control sample was prepared to represent the reference point in the evaluation of the changes generated by the additions of chokeberry powder. The required ingredients were weighed individually using an analytical balance, to ensure the exact and repeatable dosage of the recipe. Experimental samples P1 (3%), P2 (6%) and P3 (9%) were prepared following the same direct preparation method, the difference between the batches being represented exclusively by the amount of chokeberry powder introduced into the recipe. The required ingredients for each sample were weighed individually using an analytical balance, to ensure the precision of the formulation and the comparability of the results obtained between the samples.

After weighing, the dry ingredients — flour, chokeberry powder, sugar, and dry yeast — were homogenized in a bowl to ensure an even distribution of the chokeberry powder in the mixture. The salt was dissolved in lukewarm water to avoid direct contact with the yeast before hydration and to prevent inhibition of the fermentative activity. Subsequently, the saline solution was added to the solid mixture, along with the oil.

The kneading of all samples with addition was done manually, for 10 minutes. This type of kneading allowed the direct observation of the dough consistency and how the aronia powder affects the texture, elasticity and homogeneity of the mass. The higher the percentage of addition, the more compact the dough had a texture and a more intense colour. After kneading, the dough of each sample was shaped into a round shape and introduced into the proofer. Proving took place for 45 minutes, at a constant temperature of 30-35°C. At this stage, it was observed that the volume of the dough increased differently depending on the percentage of aronia powder: samples with higher additions had a more moderate volumetric development, because fibres and polyphenolic pigments can affect the retention of gases formed during fermentation.

After proofing, the samples were transferred to the oven and baked for 40 minutes at 200°C. Baking caused the crust to form, the internal structure to stabilize, and the characteristic colour of each sample to develop, which was more intense in the case of those enriched with aronia, due to the natural pigments in the fruit. Finally, the breads were allowed to cool to room temperature and were subsequently visually and sensorially evaluated.

4. Sensory analysis

Sensory analysis is a widely used method for evaluating the characteristics of food products, with the objective of examining various sensory attributes to determine consumer acceptability and to improve the food product based on the results obtained from the evaluation.

Sensory analysis methods play a key role in assessing quality and understanding consumer expectations and reactions to new food products at different stages of the development cycle. Thus, sensory analysis is fundamental to the success of the development of new meat products, significantly influencing the entire production process, from research and development to quality control and marketing strategies. To assess the acceptability of the addition of aronia powder to bread, a sensory analysis was performed using a questionnaire applied to a sample of 15 trained evaluators. Four samples were analysed: the control sample (P0) and three samples with progressive additions of aronia powder — P1 (3%), P2 (6%) and P3 (9%). The sensory parameters evaluated included the colour of the peel, the colour of the core, the intensity of the tastes (bitter, salty, sour), the texture of the core (uniformity of the pores, softness, crumbliness), as well as the aroma and its persistence. A scale from 1 to 5 was used for these characteristics, where a score of 1 indicated a very weak intensity and a score of 5 a very pronounced intensity. In the case of overall acceptability, the assessment was based on a hedonic scale from 1 to 9, where a score of 1 represented a very low level of pleasure and a score of 9 a maximum level of satisfaction. This approach allowed for a detailed analysis of how the addition of aronia influences the overall perception of the product and the identification of the optimal concentration to achieve a balance between quality and acceptability.

5. Results

Analysing the evolution of the bread crust colour, a clear intensification is observed as the percentage of added chokeberry powder increases. The control sample P0, without addition, presents the lowest colour intensity, having significantly lower values compared to the samples enriched with chokeberry. In samples P1 (3% chokeberry) and P2 (6% chokeberry), the colour of the crust becomes progressively more pronounced, which shows a directly proportional

influence between the level of addition and the chromatic intensity. The most intense shade of the crust is recorded in sample P3, with 9% addition of chokeberry powder, confirming that a higher chokeberry content gives the crust a stronger and more obvious coloration. The same upward trend is observed in the colour of the core, which follows a similar evolution. The control sample P0 has the weakest coloration of the core, but with the transition to P1 and P2, the shade becomes increasingly intense and more

uniform. It is worth noting that, at the maximum concentration of aronia powder (P3), the core even shows a slightly higher intensity than the crust, indicating a very efficient absorption and distribution of the pigment in the internal structure of the bread. Overall, the graph highlights a direct and consistent relationship between the percentage of aronia powder and the colour intensification both at the crust and core level.

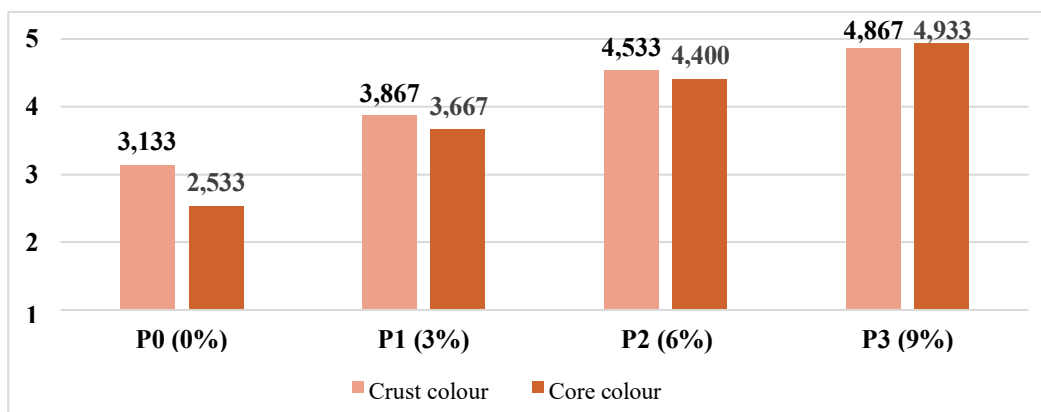


Fig. 3. Results obtained from the evaluation of the colour of the crust and core.

The evaluation of the crumb texture highlights that the addition of chokeberry powder directly influences the structural quality of the bread. The control sample P0 presents the most balanced texture, characterized by good pore uniformity, high softness to the touch and a moderate level of crumbliness, which suggests a well-formed structure, with an elastic and aerated gluten network. With the addition of 3% chokeberry (P1), the texture remains similar to that of the control sample, although a slight decrease in softness is noted, possibly due to the different

water absorption by the chokeberry fibres, which compete with the flour for hydration.

Sample P2 (6%) shows good maintenance of the core structure, but with the first visible signs of diminishing pore uniformity, which may suggest that higher additions are starting to interfere with optimal gluten development. However, softness is maintained at an acceptable level and friability increases only slightly, which shows that up to this percentage, the impact on texture is not drastic.

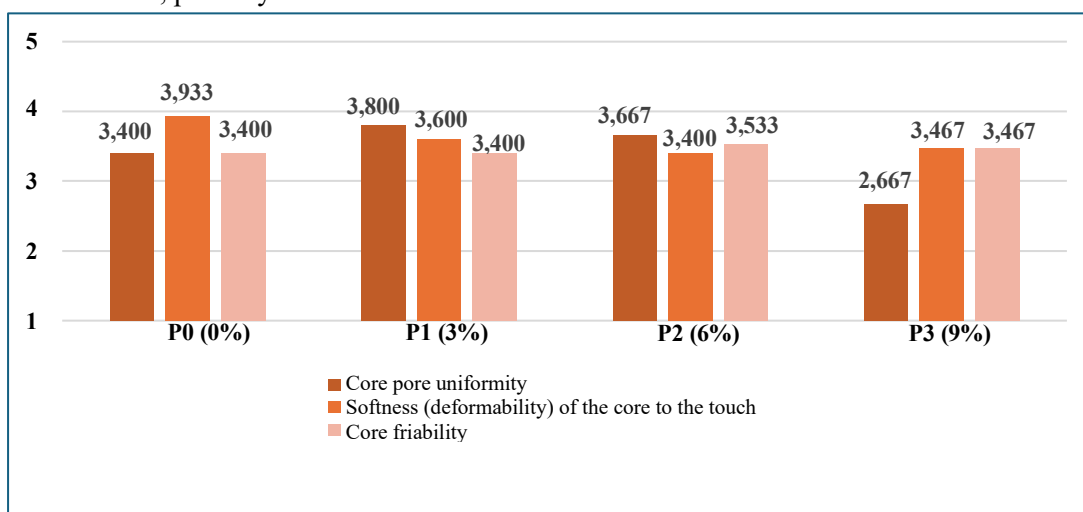


Fig. 4. Results obtained from the evaluation of core uniformity, deformability and friability.

In contrast, in sample P3 (9%), the effects become much more pronounced: the pore uniformity decreases the most, indicating that the internal structure becomes more compact and less aerated. This change can be attributed to the interference between aronia polyphenols and gluten proteins, which results in a weaker network with reduced gas retention capacity. Friability also increases, suggesting a greater fragility of the crumb. Softness, although still

present, is below the values recorded in the previous samples. Overall, as the percentage of aronia increases, the texture of the crumb goes from a uniform and elastic structure (P0) to a less aerated, denser and more prone to crumbling (P3), indicating the limit at which the addition begins to negatively affect the quality of the bread.

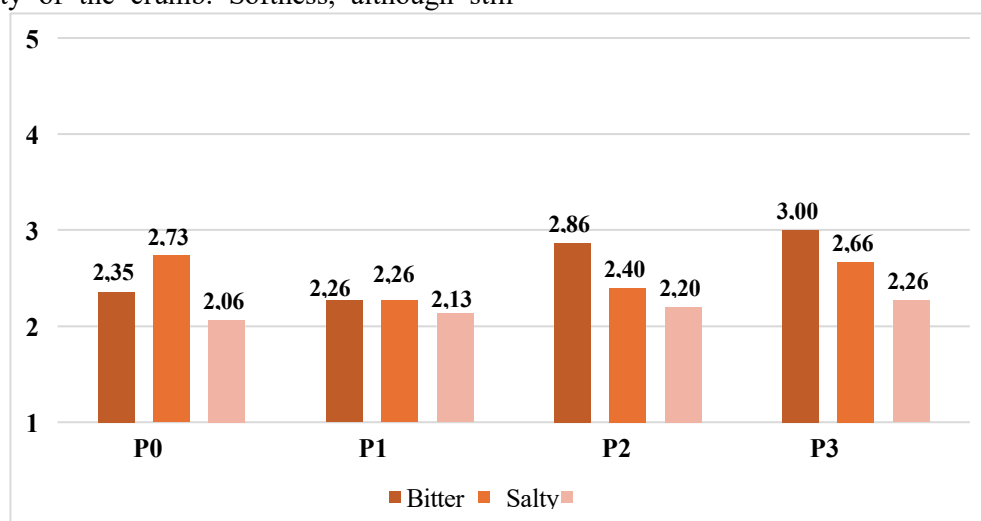


Fig. 5. Results obtained from analysing basic tastes

The analysis of the taste characteristics indicates that the addition of aronia powder progressively modifies the sensory profile of the bread. In the control sample P0, the bitter, salty and sour taste are maintained at moderate levels, representing the standard taste of a bread without additional ingredients. With the introduction of aronia powder at a proportion of 3% (P1), the bitter taste remains close to the control, but the salty and sour notes do not show significant differences, suggesting that this level of addition does not significantly influence the taste balance. At P2 (6% addition), the increase in the bitter taste becomes more evident, reflecting the higher concentration of phenolic compounds characterized by a natural bitter tinge. The same sample shows a slight intensification of the salty taste, possibly due to interactions between the aronia powder and the components of the dough, which can modify the perception of saltiness.

Sample P3, with the highest addition of aronia (9%), highlights the strongest intensity of the

bitter taste and, to a lesser extent, of the salty taste. This demonstrates that at high concentrations, aronia becomes a determining factor in shaping the taste profile, which can influence the acceptability of the product for consumers sensitive to bitter tastes. Regarding the sour taste, the variations between P0-P3 are reduced, which shows that aronia does not contribute significantly to the perception of acidity in the final product. Overall, the data show that the bitter taste is most influenced by the addition level, followed by the salty taste, while the sour taste remains relatively constant.

In figure 6 the analysis of the aromatic characteristics shows that the addition of chokeberry powder positively influences both the intensity of the specific aroma and the persistence of the aroma after chewing and swallowing. The control sample P0 presents moderate levels for both characteristics, corresponding to a simple bread, without added aromas.

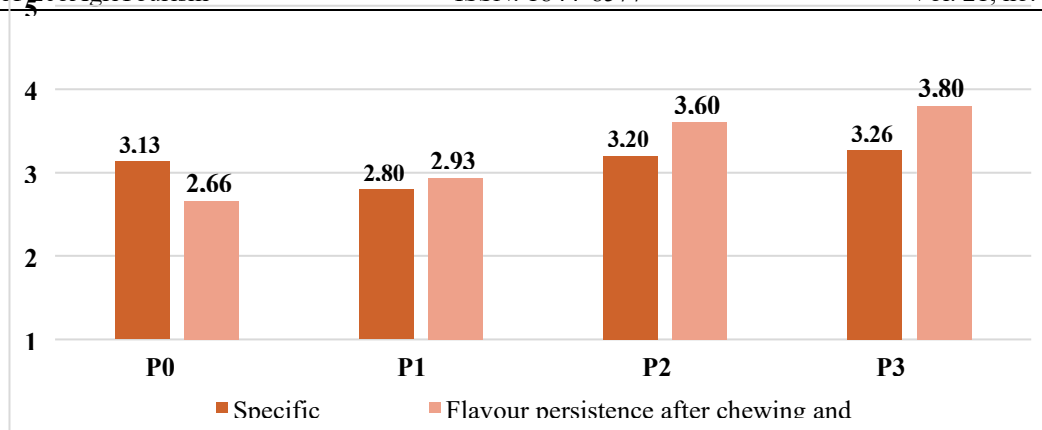


Fig. 6. Results obtained from the evaluation of the specific aroma and the persistence of the aroma after chewing and swallowing

With the introduction of chokeberry powder in a proportion of 3% (P1), a slight increase in aromatic persistence is observed, while the specific aroma remains close to that of the control – an indication that the moderate addition does not significantly modify the basic aromatic profile. A more obvious increase occurs in sample P2 (6%), where both the specific aroma and its persistence increase considerably. This result suggests that a medium level of chokeberry intensifies the aromatic perception in a pleasant and balanced way, without dominating the taste and smell of the product. Sample P3 (9%)

reaches the highest values for aroma persistence, which indicates that a high addition of aronia gives the bread an intense note, which remains long after consumption. The specific aroma also becomes more evident, but the increase is more moderate compared to the persistence. Overall, the graphs show that aronia has a pronounced aromatic effect, especially on persistence, and this intensification increases progressively with the percentage of addition.

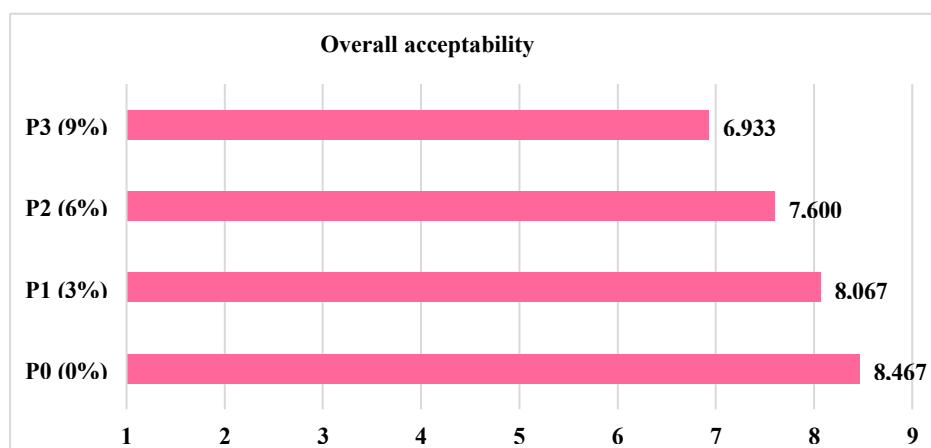


Fig. 7. The results obtained in terms of overall acceptability

The overall acceptability graph highlights how the addition of chokeberry powder influences the overall consumer preferences. The control sample P0, without chokeberry addition, obtains the highest score (8.467), which shows that the traditional bread variant is the best accepted. As the percentage of chokeberry increases, acceptability starts to gradually decrease: P1 (3%) remains well appreciated, however, with a high score of 8.067, which suggests that small additions do not negatively affect consumer satisfaction. At P2 (6%), acceptability decreases

noticeably to 7,600, a sign that the enhancement of taste and textural characteristics begins to be perceived as less pleasant by some of the evaluators. The lowest acceptability occurs in sample P3 (9%), with a score of 6,933. This result indicates that a high percentage of chokeberry, although improving the flavour and contributing to beneficial functional properties, can negatively affect the overall sensory experience, probably due to the intensification of the bitter taste, textural changes and the appearance of a very persistent flavour.

Therefore, the overall acceptability decreases progressively with the increase in the percentage of chokeberry, and the optimal level, which maintains a balance between the improvement of sensory properties and consumer preferences, seems to be around 3–6% addition.

6. Conclusions

Sensory evaluation of bread samples enriched with aronia powder (P1-P3), compared to the control P0, highlights clear influences on all analysed parameters — colour, taste, aroma, texture and overall acceptability. Regarding the colour of the crust and core, the addition of aronia causes a progressive intensification of the shades, culminating in the maximum values in P3. This behaviour is characteristic of the anthocyanin pigments in aronia, which confer an increasingly pronounced coloration to both the external and internal parts of the bread.

At the taste level, it was observed that the perception of bitter and salty taste increases with the percentage of addition, while the sour taste remains relatively constant. This trend is associated with the phenolic compounds present in aronia, whose bitter notes become increasingly evident at high concentrations. On the flavour side, the addition of aronia enriches the aromatic profile of the bread, increasing both the intensity of the specific flavour and the persistence of the flavour after consumption, characteristics that reach the highest values in the samples with 6% and 9% addition (P2 and P3). Regarding the texture of the crumb, the results show that low additions (P1 and P2) maintain a structure close to that of the control, while high addition (P3) negatively influences the pore uniformity and increases the friability, indicating a more compact and less elastic structure. This suggests that at high concentrations, aronia interferes with the gluten network, reducing its ability to form an aerated structure. All these sensory changes are reflected in the total acceptability, which progressively decreases with increasing aronia percentage. The control bread (P0) is the most appreciated, closely followed by P1, which shows that low additions are well tolerated and even appreciated. Acceptability decreases visibly at P2 and more pronouncedly at P3, signalling that the intensification of the bitter taste, persistent aroma and textural changes may reduce consumer preference. As an overall conclusion, the addition of aronia powder has a significant

sensory impact, improving colour and aromatic contribution, but influencing taste and texture at high addition levels. From the perspective of the balance between functional qualities and sensory acceptability, the optimal incorporation percentage seems to be between 3% and 6%, where benefits such as natural colouring and increased nutritional value can be obtained without compromising the overall sensory experience.

References

1. Xu, J., et al. (2024). A Comprehensive Review of the Functional Potential and Sustainable Applications of *Aronia melanocarpa* in the Food Industry. *Plants*, 13(24), 3557.
2. Lazar M.A., et al. 2020, Valorisation of *Aronia Melanocarpa* Pomace for Development of Functional Ingredients with High Nutritional Value and Antioxidant Capacity. Scientific Papers. Series B, Horticulture, Vol. LXIV, Issue 2, Print ISSN 2285-5653, 403-410.
3. Jurendić, T., & Ščetar, M. (2021). *Aronia melanocarpa* Products and By-Products for Health and Nutrition: A Review. *Antioxidants*, 10(7), 1052.
4. Buda, V.; et al. Cardioprotective Effects of Cultivated Black Chokeberries (*Aronia* spp.): Traditional Uses, Phytochemistry and Therapeutic Effects. In *Natural Products-From Bioactive Molecules to Human Health*; IntechOpen: London, UK, 2020.
5. Borowska, S.; Brzóska, M.M. Chokeberries (*Aronia Melanocarpa*) and Their Products as a Possible Means for the Prevention and Treatment of Noncommunicable Diseases and Unfavourable Health Effects Due to Exposure to Xenobiotics. *Compr. Rev. Food Sci. Food Saf.* 2016, 15, 982–1017.
6. Kokotkiewicz, A.; et al. *Aronia* Plants: A Review of Traditional Use, Biological Activities, and Perspectives for Modern Medicine. *J. Med. Food* 2010, 13, 255–269.
7. Cacak-Pietrzak, G., Dziki, D., Gawlik-Dziki, U., Parol-Nadłonek, N., Kalisz, S., Krajewska, A., & Stępniewska, S. (2023). Wheat Bread Enriched with Black Chokeberry (*Aronia melanocarpa* L.) Pomace: Physicochemical Properties and Sensory Evaluation. *Applied Sciences*, 13(12), 6936.
8. Yoon H.S., et al. Quality Characteristics of Bread added with Aronia Powder (*Aronia melanocarpa*). *J Korean Soc Food Sci Nutr* 2014, 43:273-280.

ECOLOGICAL AND EFFICIENT COMBUSTION OF WOOD BIOMASS

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Abstract: The biomass of solid fuel is a necessary activity for human life, regardless of whether the beautiful one direct or through the industries they support. The most important thing about biomass combustion is that it produces carbon dioxide neutral. The use of wood biomass also eliminates the danger of disposing of it in natural, thereby polluting the natural environment, especially surface waters. Harmful emissions from combustion systems that use wood pellets are significantly lower than those from systems that use petroleum derivatives. Using wood biomass in the form of pellets releases fewer pollutions into the atmosphere than burning firewood. The environmental impact of burning wood also includes the impact of cutting down an impressive amount of food material. Wood biomass is a renewable source of energy. Burning of wood will have negative effect on indoor and outdoor air quality.

Keywords: energy density, biomass, briquettes

1. Paper sections and font styles

Smoke is the main cause of pollution from wood combustion.

The amount of smoke coming out of the chimney can be reduced in several ways:

- replacing the old combustion system with a new one, if possible, at least the burner;
- selecting a heating system tailored to you needs and placing it in a central location relative to all household utilities;
- use a chimney that is suitable in size and position for the chosen heating system;
- use only well-dried wood that is split to the correct size for the combustion systems;
- all measures must be taken to improve the efficiency of the combustion systems, because using a reduced amount of fuel will significantly reduce the impact on the environment.

Wood differs from other forms of fossil fuel, due to its carbon neutrality. Wood biomass is renewable because it recycles carbon dioxide.

As plants grow, the use carbon dioxide from the atmosphere as a source of carbon for then physiological growth needs.

This carbon accounts for approximately 50% of the weight of wood, when wood biomass burns, the wood decomposes quickly and the carbon dioxide returns to the atmosphere. Thus burning wood doesn't contribute to climate change, as fossil fuels do.

There are two groups of polluting sources that generate dust, ash and smoke in the atmosphere: artificial sources and natural sources.

Artificial sources can be grouped into two broad categories: sources based on industrial fuel combustion and sources based on domestic fuel combustion,

In table 1 is presented industrial source of dust, smoke and ash pollution.

Table 1. Industrial sources of dust, smoke and ash pollution [18]

Industry	Source of pollution	Poluting product
Steelworkers	Blast furnaces	Iron oxides, iron, smoke
Cast iron foundries	Blast furnaces	Iron oxides, dust, smoke, oil furnaces
No-ferrous metalurgy	Blast furnaces at smelters	Smoke, oil furnaces and metals

In table 2 is presented the values for smoke and dust emissions in industries.

Table 2. *Smoke and dust emissions in industries [18].*

Industry	Smoke and dust emissions
Siderurgy	10 kg/ ton of metal
Foundries	15-25 kg/ton of metal
Aluminium processing	450 kg/ ton of metal
Bronze and brass smelters	12 kg/ton of metal

An important industrial source, especially dust in the construction materials industry, which is based on the procentage of natural rocks (silicates). The dust resulting from cement manufacturing can be observed up to 3 km among from the source.

Smoke is the invisible part of the substances that are eliminated through company chimneys and is made up of water vapor, gases and incompletely burned products (tars, hydrocarbons, coal).

The black color indicates incomplete combustion, due to the lack of air, as well as the presence of large amounts of carbon and soot.

The color of the smoke can rarely be reddish, grey or brown, as fossil coal contains iron, aluminum or manganese.

2. Materials and method

The determination of the calorific value is almost similar to that of coal (as a solid fuel) and with few differences compared to liquid (gasoline, diesel) or gaseous (methane gas, biogas) fuels.

The number of tests required by the regulations is 10 tested samples (ASTM D 3286-96, DIN 51900-1, 2000, Dihoiu, 1995).

The installation used to determine the calorific value of woody biomass was the XRY-1C explosive combustion calorimeter, produced by Shanghai Changji Geological Instrument Co.

Before performing the actual test, the calorimeter bomb is calibrated with benzoic acid (benzoic acid with a known calorific value of 26463 kJ/kg is used).

Figure 1 shows the sketch for calorimeter bomb.

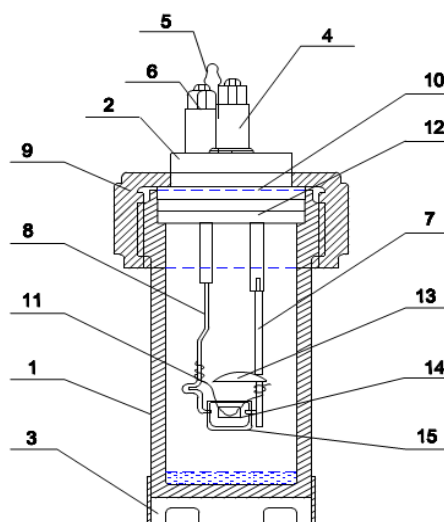


Fig.1. *Sketch for calorimeter bomb*

The process of determining the calorific value of wood material refers first to the preparation of the raw material and the installation, then to the actual determination and finally to obtaining the fuel results.

Preparing the wood material for testing consists of taking a small portion of briquettes spruce or briquettes beech (0.6-0.8 grams of the whole material). The weighed sample must have an accuracy of 0.0002 grams.

The sample must be clean, made from freshly cut wood because old wood doesn't have all the volatile and flammable substances.

This sample is placed in a porcelain crucible and placed in a laboratory oven, in order to dry at 103 ± 2 °C.

It is checked by successive weighings until the difference between two successive weighings is less than twice the processing precision. The test sample 1 is tied to the cotton thread 2 and placed in the bomb crucible 3. Tie the nickel wire 4 to the sample and the cotton thread, then position the protective cap 5 correctly.

The crucible is connected to the calorimetric bomb lid 6 through 2 electrodes 7 and 8. By screwing on the cap of the cylinder 11 is converted to the oxygen cylinder through calorimeter bomb 12, registering 30 atmospheres.

The test contains three different periods, respectively:

- The initial period (fore), which aims to determine the temperature variations, of

the water in the calorimeter, due to the exchange of heat with the outside before burning. During this period, usually 5 minutes, the precision thermocouple temperature is displayed and read minute by minute.

- The main period ("main") begins with the ignition of the sample and has as a consequence the increase of the water temperature in the calorimetric vessel, due to the burning of the wood particle and the emission of heat.
- The final period ("after") aims to determine the average temperature variation of the water in the calorimeter due to the heat exchange with the outside, after combustion.

In figure 2 is presented the soft interface for determining the calorific power for spruce briquettes.

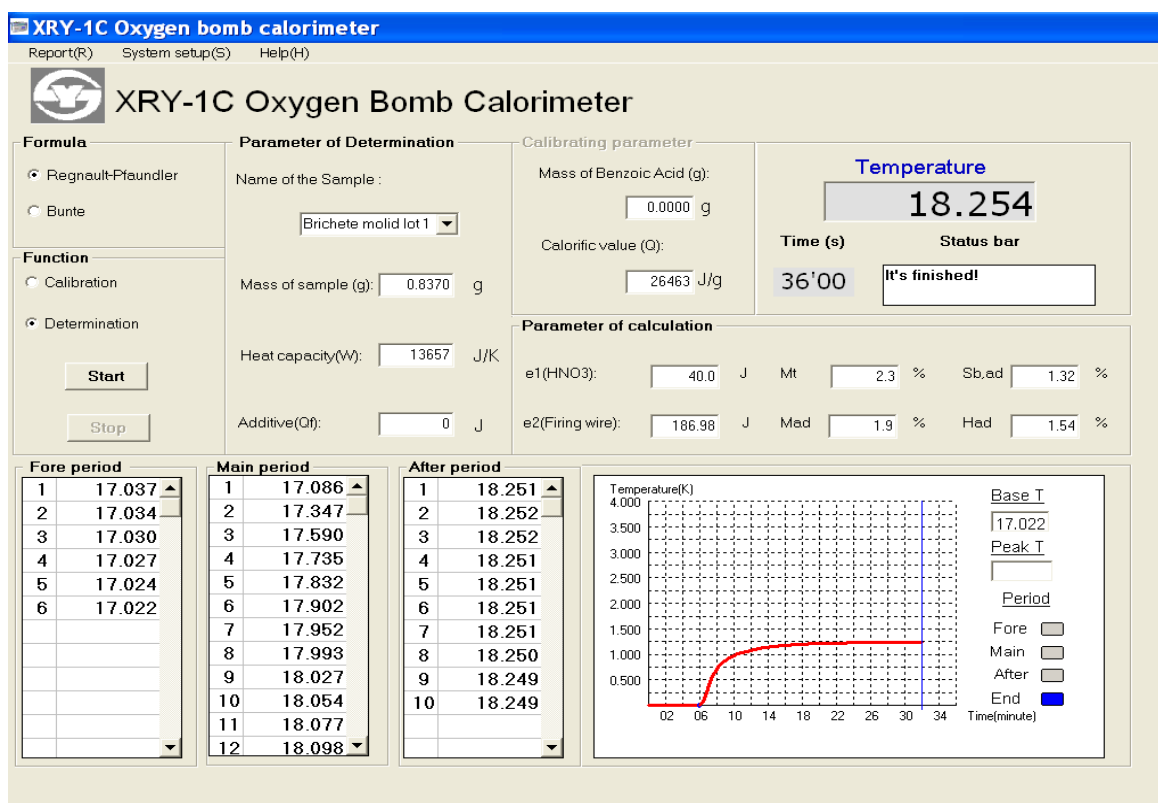


Fig. 2. The soft interface for determining the calorific power for spruce briquettes

In figure 3 is presented the soft interface for determining the calorific power for beech briquettes.

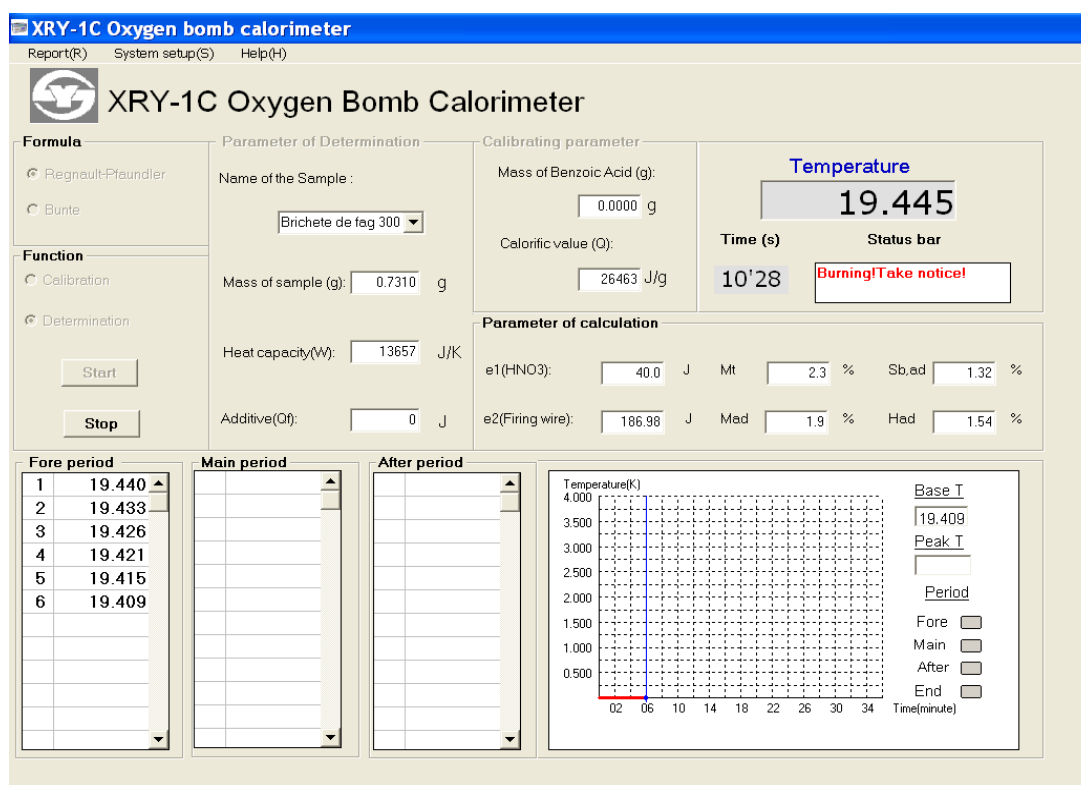


Fig. 3. The soft interface for determining the calorific power for beech briquettes

For the spruce briquettes $U = 0\%$, $m = 0.8345$ g, higher caloric power = 20209 kJ/kg, lower caloric power = 19709 kJ/kg, energy density = 15.07 kJ/cm³, burning speed = 518 kJ/min, $U = 10\%$, $m = 0.9870$ g, higher caloric power = 16950 kJ/kg, lower caloric power = 16301, energy density = 15.45 kJ/cm³, burning speed = 527 kJ/min, $U = 20\%$, $m = 0.7810$ g, higher caloric power = 13609 kJ/kg, lower caloric power =

12310 kJ/kg, energy density = 11.69 kJ/cm³, burning speed = 368 kJ/min, $U = 50\%$, $m = 0.8580$ g, higher caloric power = 9481 kJ/kg, lower caloric power = 5801 kJ/kg, energy density = 5.89 kJ/cm³, burning speed = 120 kJ/min.

The variation of the energy density for spruce pellets is presented in figure 3.

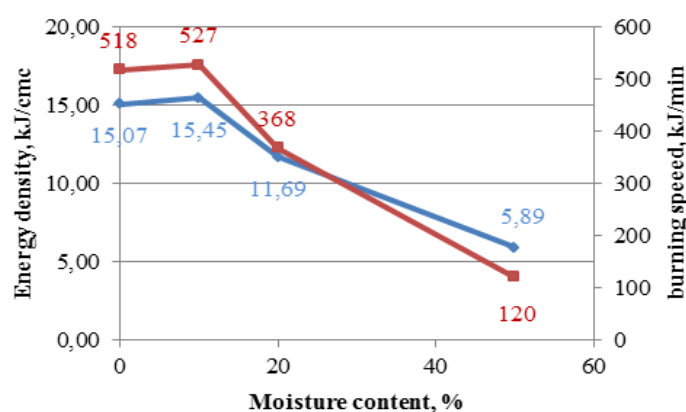


Fig. 3. The variation of the energy density for spruce briquettes

For the beech briquettes $U = 0\%$, $m = 0.6890$ g, higher caloric power = 18879 kJ/kg, lower caloric power = 18221 kJ/kg, energy density = 13.67 kJ/cm³, burning speed = 470 kJ/min, $U = 10\%$, $m = 0.7530$ g, higher caloric power = 17208

kJ/kg, lower caloric power = 16384, energy density = 14.01 kJ/cm³, burning speed = 555 kJ/min, $U = 20\%$, $m = 0.7320$ g, higher caloric power = 15431 kJ/kg, lower caloric power =

13201 kJ/kg, energy density = 11.94 kJ/cm³, burning speed = 389 kJ/min, U= 50%, m = 0.7327 g, higher caloric power = 10218 kJ/kg, lower caloric power = 6218kJ/kg, energy

density = 4.61 kJ/cm³, burning speed = 87 kJ/min.

The variation of the energy density for beech briquettes is presented in figure 4.

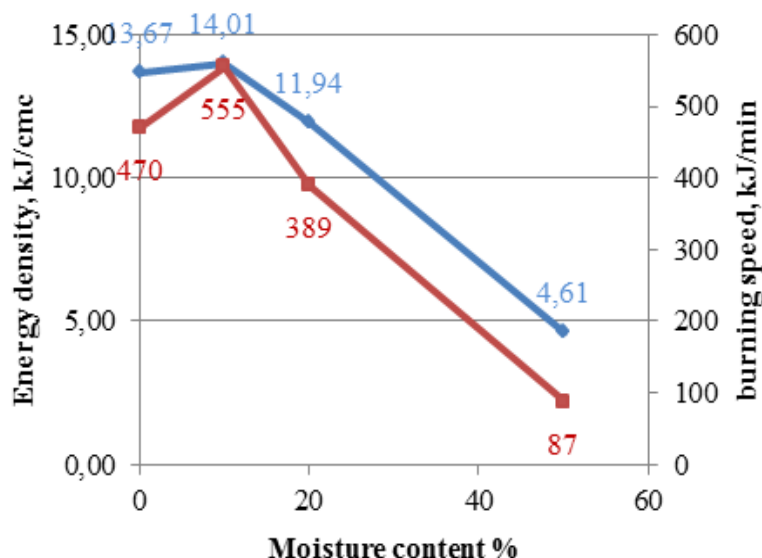


Fig.4. The variation of the energy density for beech briquettes

3. Conclusions

Burning wood biomass is an environmentally unfriendly process, but it is indispensable to human activity due to the thermal energy it produces obtaining wood gas through controlled combustion is an efficient method of obtaining energy, used especially in internal combustion engines, but it is not the best solution for the efficient use of biomass.

The use of wood biomass, as fuel as based on its favorable properties, such as low price, the fact that it is a renewable material, has good energy power comparable to fossil fuels can be easily stored due to its natural solid state, and doesn't require complicated conservation and storage measures.

References

1. Abassi, S.A, Nipanay, P.C., Schaumberg, G.D. *Bioenergy potential of eight common aquatic weeds*, Biological Wastes, vol.34, No.4, pag.359-366, 1990;
2. Doniță, N., Ceianu, I., Purcelan, S, Beldie, A. *Ecologie forestieră*, Ed. Ceres București, 1977;
3. Feng, S., Cheng, S., Yuan, Z., Leitch, M., Xu, C. *Valorization of bark for chemicals and materials: A review*. Renewable and Sustainable Energy Reviews, vol.26, pag.560-578, 2013;
4. Fernandez, L. M.J., Carrasco G.J.E. *Suitability of thermo-chemical corrections for determining gross calorific value in biomass*, Thermochimica Acta, vol.468, pag.101-107, 2008;
5. Filipovici, J. *Studiul lemnului*, Ed. didactică și pedagogică, București, 1984;
6. Friedl, A., Padouvas, E., Rotter, H., Varmuza, K. *Prediction of heating values of biomass fuel from elemental composition*, Anal Chim ACTA, vol.554, pag.191-198, 2005;
7. Gavrilescu, D *Energy from biomass in pulp and paper mills*, Environmental Engineering and Management Journal, pag.537-546, 2009;
8. Grîu, T., Lunguleasa, A. *Factors of influence combustion*. Proceedings Advances in Environment Technologies, Agriculture, Food and Animal Science, International Conference WSEAS, pag.143-147, 2013;
9. Grotheim, K. *Toorefaction and densification of biomass fuels for generating electricity*, Milestone 9 Report. Minneapolis: Bepex International LLC, 2011;
10. Haugland, N. *Guideline for classification of ash from solid biofuels and peat utilised for recycling and fertilizing in forestry and agriculture*, NT Technical Report, TR 613, 2013;

11. Hu, X.Y., Dong, C.Q., Yang, Y.P., Zhang, J.J. *The effect of biomass pyrolysis gas reburning on N₂O emission in a coa-fired fluidized bed boiler*. Chinese Science Bulletin, Vol.56, Nr.14, pag.1429-1433;
12. Isabel, M., Jorge, G., Ines, M. Pereira, H. *Fractioning and chemical characterization of barks of Betula pendula and Eucalyptus globules*. Industrial Crops and Products, vol.41, pag.299-305, 2013;
13. Ionescu. M.F. *Biomasa forestieră lemnoasă, un potential energetic nefolosit încă pe deplin de România, anul XX*, Nr.36, pag. 86-89, 2015;
14. Juran, M. *Calitatea produselor*, Ed. Tehnică, București, 1973;
15. Lako J., Hanesok J, Yuzhakova T. *Biomass-A source of chemicals and energy for sustainable development*, Environmental Engineering and Management Journal, vol. 7(5), pp. 499-509, 2009;
16. Larsson, S.H., Rudolfsson, M., Nordwaeger, M., Olofsson, L., Samuelsson, R. *Effects of moisture content, torrefaction temperature and the temperature in pilot scale pelletizing of torrefied Norway spruce*, Appl. Energy, vol.102, pag.827-832;
17. Lăzăroiu G, Mihăescu L. *Combustion of pitcoal-wood biomass briquettes a boiler test-facility*, Environmental Engineering and Management Journal, pp 595-601, 2008;
18. Lunguleasa A. *The calorific power of wooden biomass*, Bulletin of the Transilvania University of Brasov-Series II, vol.2(51), pp.65-70, 2010;
19. Mărăscu-Klein, V. *Aspects regarding the implemntation of waste products management in Romania*, Revista de inginerie industrială-Recent. Ed. Universității Transilvania din Brașov, vol.7, Nr.1(16), 2006;
20. Moya R., Tenorio C. *Fuelwood characteristics and its relation with extractives and chemical properties of ten fast-growth species in Costa Rica*, Biomass and Bioenergy, vol.56, pp.14-21, 2011;
21. Nielsen NPK, Gardner D. *Importance of temperature, moisture content a species for the conversion process of wood residues to fuel pellets*, Wood Fiber vol.41, pp 414-425;
22. Pawlicka, A., Waliszewska, B. *Chemical composition of selected species of exptoc wood derived from the region of Africa*. Acta Scientiarum Polonorum-Silvarum Calendarum Ratio et Industria Lignaria, vol.10, Nr.1, pag.37-41, 2011;
23. Petrovici, V.Gh., Agache, C. *Chimia și prelucrarea chimică a lemnului*, Universitatea Transilvania din Brașov, 1999;
24. Prasertsan S., Sajjakulnukit B. *Biomass and bioenergy in Thailand: Potential, opportunity and barriers*, Renewable energy, vol. 31, Nr.5, 2006;
25. Rahmann A, Masood, M.A. *Influence of size and shape in the strength by briquettes*, Fuel Process Technology, vol.22, pp125-145,2013;
26. Roser D., Asikainen A. *Sustainable use for Forest Biomass for Energy*, Springer Series in Wood Science, 2006;
27. Swithenbank, J, Chen, Q, Zhang, X, Sherif, V., Poukashamiani, M, *Wood would burn*, Biomass and bioenrgy, nr.3, 2011.
28. Tani, Y., Sawai, T., Sakay, Y. *Energy from wood*, USA. Forest Product Labortory, 2004,
29. Teuch O, Hofeanuer A, Troger F, From J. *Basic properties of specific wood-based materials carbonised in a nitrogen atmosphere*, Wood Science and Technology, Springer, vol.38, nr.3, 2004;
30. Uslu A, Faaji A.P.C, Bergman P.C.A *Pre-treatment technologies, and their effect on international bioenergy supply chain logistics. Techno-economic evaluation of torrefaction, fast pyrolysis and pelletisation*, Energy, vol. 33(8), pp. 1206-1223.

IDENTIFICATION OF ANTIBIOTIC RESIDUES IN RAW COW'S MILK FOR THE PRODUCTION OF HIGH-QUALITY DAIRY PRODUCTS

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Abstract: The subject of milk safety is currently attracting increased public attention due to high global consumption and the harmful effects that veterinary drug residues can have on human health. The objective of this study is to ascertain the presence of veterinary drug residues by examining the quality of raw milk intended for processing from a farm in Alba County. The analysis of raw milk samples is conducted in a laboratory setting using a Varian 320-MS LC/MS spectrophotometer, an instrument that employs liquid chromatography with mass spectrometry to determine the quantity of antibiotics present. Antibiotics from the beta-lactam and cephalosporin groups are considered. The analysis revealed that 10 out of the 14 antibiotics exhibited concentrations that fell below the stipulated maximum permissible limit. This method is considered suitable for screening purposes, as all the validation parameters tested fell within the accepted ranges at the requisite concentration levels.

Keywords: antibiotics, liquid chromatography, beta-lactam, cephalosporin, cow's milk

1. Introduction

Milk is defined as the fluid secreted by the mammary glands of female mammals following parturition. The substance under scrutiny is a complex, opaque white fluid with a sweet taste and a pH close to neutral. The subject is a valuable source of calcium, protein, and vitamins, which contribute to the maintenance of healthy bones and teeth, as well as proper bodily function (Răducuță, 2004).

Presently, the European Union is the world's foremost producer of cow's milk, with 155.7 million tons produced in 2021, followed by the US (102.6 million tons), India (96.0 million tons), and China (34.6 million tons). The successful execution of this production is only made possible by the utilisation of various classes of pharmaceuticals in livestock, which are employed for the purpose of disease management and enhancement of animal well-being. Certain diseases, such as mastitis, are treated with antibiotics, which can generate residues above the recommended limit. This can have a detrimental effect on the quality of the final product, especially when the recommended milk withdrawal period is not respected (Ribeiro et al., 2022).

The subject of milk safety is currently attracting increased public attention due to high global consumption and the harmful effects that veterinary drug residues can have on human health. The European Union has established maximum residue limits in milk for certain antibiotics through Regulation 2377/90, the latest amendment of which is reflected in Regulation 37/2010 (Cañadas et al., 2022).

It is estimated that approximately 63,151 tons of antibiotics are utilised in the context of animal production on a global scale on an annual basis (Song et al., 2019). In the European Union, the annual human and animal consumption of this substance is approximately 5,460 tons (Hu et al., 2018). The utilisation of medicated milk, comprising antibiotics, primarily through intramammary administration for the treatment of mastitis, has resulted in substantial milk wastage and significant economic losses within the agricultural sector (Liu et al., 2023).

Beta-lactams are defined as antibiotic drugs that are active against certain bacteria, including penicillins and cephalosporins. Ampicillin is a semisynthetic antibiotic belonging to the penicillin group. It is a type of β -lactam antibiotic that functions by inhibiting bacterial

transpeptidase, thereby preventing cell wall synthesis (Bagheri and Ghaedi, 2020).

From a human and veterinary medicine perspective, it is notable for its strong bactericidal activity and wide range of applications. However, it should be noted that ampicillin cannot be fully absorbed and metabolised by the body, with a proportion of the antibiotic remaining in the animal. Subsequently, it can enter the human body via the food chain, which is detrimental to human health. The European Union has established maximum residue limits for ampicillin in milk and meat at 4 µg/L and 50 µg/L, respectively. In contrast, the Food and Drug Administration (FDA) has stipulated a maximum limit of 10 µg/L (Song et al., 2012; Chen et al., 2022).

Amoxicillin, a semisynthetic antibiotic of the aminopenicillin class, is sensitive to β-lactam penicillinase and has activity against a wide range of bacteria (Abgueguen et al., 2007). It is one of the most commonly prescribed antibiotics for the treatment or prevention of neonatal sepsis. Antibiotics are designed to target specific pathogenic bacteria; however, many antibiotics, including amoxicillin, have been reported to have adverse side effects on neonatal and infant microbiota and immunity. These side effects may contribute to the development of dysbiosis, microbiota disruption, and impaired immunity to pathogens (Shekhar et al., 2023).

Oxacillin has been detected in raw milk, where it is present as a residue. This has significant implications for public health, as it can lead to allergic reactions, the development of antibiotic-resistant bacteria, and other potential toxicities. This phenomenon arises when animals are not subjected to a withdrawal period following antibiotic treatment. The presence of these residues constitutes a public health concern that necessitates rigorous monitoring and quality control measures within the food supply chain (Bystrón et al., 2010; McKay, 2008).

Dicloxacillin is a penicillin-based antibiotic used to treat bacterial infections. The utilisation of antibiotics in dairy cattle may result in the presence of residual antibiotics in raw milk, which has the potential to induce significant health complications in consumers (Costa et al., 2024).

The objective of this study is to assess the quality of raw milk, a critical component in the production of premium dairy products, sourced from a farm in Alba County. The analysis of raw milk samples is conducted in a laboratory setting,

employing liquid chromatography with mass spectrometry as a method to ascertain the quantity of antibiotics present. Antibiotics from the beta-lactams and cephalosporins groups are considered.

The quantity of antibiotics will be reported in accordance with the maximum permissible limit, by comparison with a standard, respectively with a fortified sample (with a blank), in order to highlight the difference between a sample that is within the parameters and a contaminated sample.

2. Materials and methods

Materials

The cow's milk is sourced from a licensed farm in Alba County, which possesses a milk processing capacity of 10 tons of milk per day. The farm utilises two breeds of cows, namely Simmental and Fleckvieh, which are categorised as mixed milk-meat breeds.

Methods

1. Description of the extraction scheme for beta-lactams and cephalosporins

For the analysis of beta-lactams and cephalosporins, 3 g of the 50 mL sample that was previously stored in a frozen environment will be utilised. Each sample is processed in duplicate, and one of the samples is designated as a matrix blank. Subsequently, the PG-D7 Internal Standard, the antibiotic mixture, and the phosphate must be added, with these elements being present in the presence of water. Stirring is a pivotal step in the process, as it ensures the uniformity of the composition. The milk samples are then subjected to a centrifugation process in a Nuve NF 800R cooling centrifuge for a duration of 15 minutes at a speed of 400 revolutions per minute. Following a 15-minute centrifugation process, the milk samples are removed and filtered using filter paper. The resulting extract is then transferred to an additional, clean, dry polyethylene tube.

Colony activation is represented by passing through the appropriate colonies to retain the beta-lactams and cephalosporins antibiotic group, 2 mL of methanol, 2 mL of ultrapure H₂O and 2 mL of NaH₂PO₄ 0.1M. The subsequent addition of 2 mL of methanol is performed after the application of a vacuum for a period of 2 minutes on the colonies. These are then transferred into test tubes and the entire composition is permitted to pass drop by drop into the test tube.

The process of evaporation in a nitrogen stream is conducted at a temperature of 40°C for a duration of 30 minutes, or until the presence of residue on the walls of the test tube is no longer perceptible. The dry residue is then reconstituted with 500 µL H₂O, transferred to 2 mL tubes, and subjected to a centrifugation process at 14,000 rpm for a duration of 15 minutes. The transfer of the solution from the tubes to the injection vials is meticulously executed through the utilisation of syringes.

The application of the special cap is a critical step in this process, and the injection of the standards and reagent blank is conducted concurrently to ensure the efficacy of the method and the veracity of the results. The vials are then inserted into the injection device in accordance with the injection list.

2. LC-MS/MS analysis

The calibration curve is plotted, and 30 µL of each standard solution is injected into the LC-MS/MS device (Varian 320-MS LC/MS). The matrix curve is then plotted. The amount of analyte in the sample solution portion for analysis injected into the LC-MS/MS should be read from the calibration curve on the matrix in ng/gram. The samples are then processed in duplicate, and the readings are averaged.

The recovery percentage is calculated using formula 1.

$$R = (C_{p \text{ fort}})/(C_{\text{fort T}} \cdot 100) [\%] \quad (1)$$

Where:

R - recovery percentage, %

C_{p fort} - amount of analyte in the fortified sample read on the curve, ng/g

C_{fort T} - amount of analyte in the fortified sample, theoretical, ng/g

The concentration of the analyte in the sample is calculated using formula 2.

$$Ca = C_p/R \quad [\text{ng/g}] \quad (2)$$

Where:

Ca - concentration of the analyte in the analyzed sample corrected by the obtained recovery/analyte, ng/g

C_p - concentration of the analyte in the sample obtained from the calibration curve, ng/g

R – recovery obtained for the respective analyte, %

The compound of interest is then identified by comparing the retention time of the respective peak in the sample with the peak of the standard substance in the chromatogram. The ratio between the retention time of the analyte in question and the internal standard is such that it matches those in the standard solutions and fortified samples with a tolerance of +2.5% (Alija et al., 2020; Cristina et al., 2017).

3. Results and discussions

Reporting results using the LC-MS/MS technique for detecting beta-lactams and cephalosporins is done in two steps, namely: 1. by identifying the chromatographic peak at the specific retention time, which varies depending on the antibiotic, and then overlaying the chromatograms for an overview of the specific peak variation; and by numerical reporting, 2. by identifying the screening for each injection sequence, with the results reported in µg/kg; this will be compared with the maximum limit allowed by current food safety legislation, such as European Commission Regulation 37/2010, European Commission Regulation 2017/880, European Commission Regulation 2017/12.

Comparison of chromatograms

Ampicillin

As illustrated in Figure 1, the signal manifests as a chromatographic peak following the injection of the 1 MRL standard. According to the internal validation of the method, this peak is detected at 12.169 minutes and attains its maximum intensity at 350 kConts, as reported. The standard is injected for the purpose of verifying both the method and the apparatus. The 100 MRL (maximum residue limit) working solution is constituted of a mixture of penicillin and cephalosporin standards derived from individual solutions.

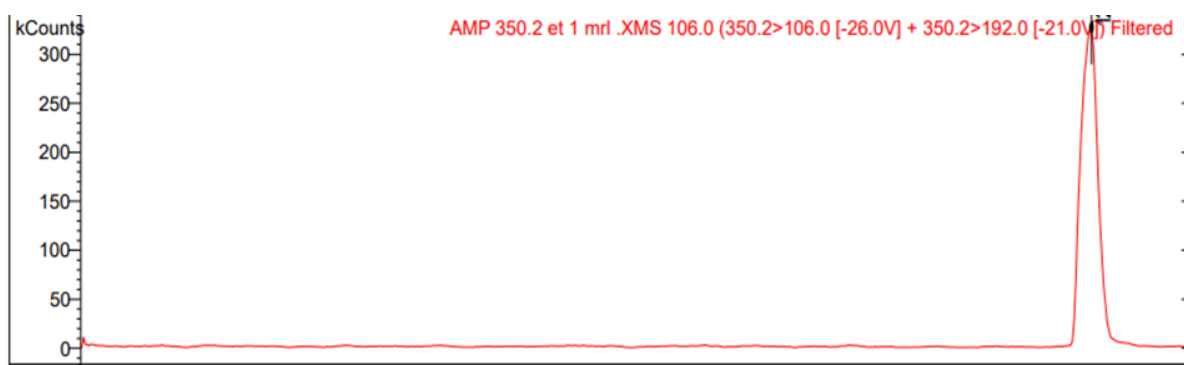


Fig. 1. Identification of the signal for the 1 MRL standard, ampicillin, in an injection sequence

As demonstrated in Figure 2, the chromatographic peak was identified at 12.169 minutes, with an intensity of up to 3 kCounts, thus indicating the presence of ampicillin. Despite the presence of other interferences being detected in

the sample, the device did not integrate any additional peaks. This finding suggests the presence of traces of ampicillin.

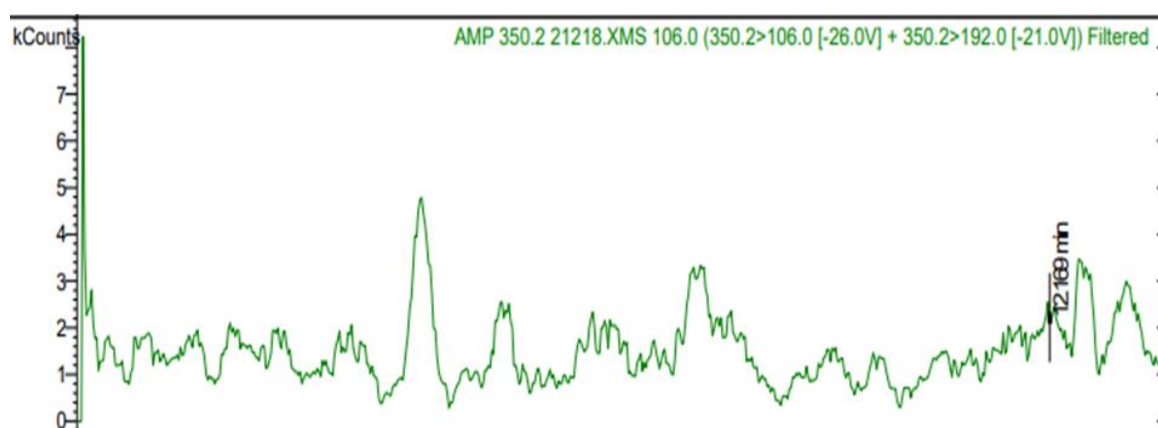


Fig. 2. Identification of the specific signal for ampicillin in an injection sequence in cow's milk samples

For the sample that was considered negative and fortified at 1 MRL (see Figure 3), the device identified a chromatographic peak at 12.169 minutes with an intensity of 130 kCounts. This

peak was specific to the presence of ampicillin in the fortified sample (Fig.3).

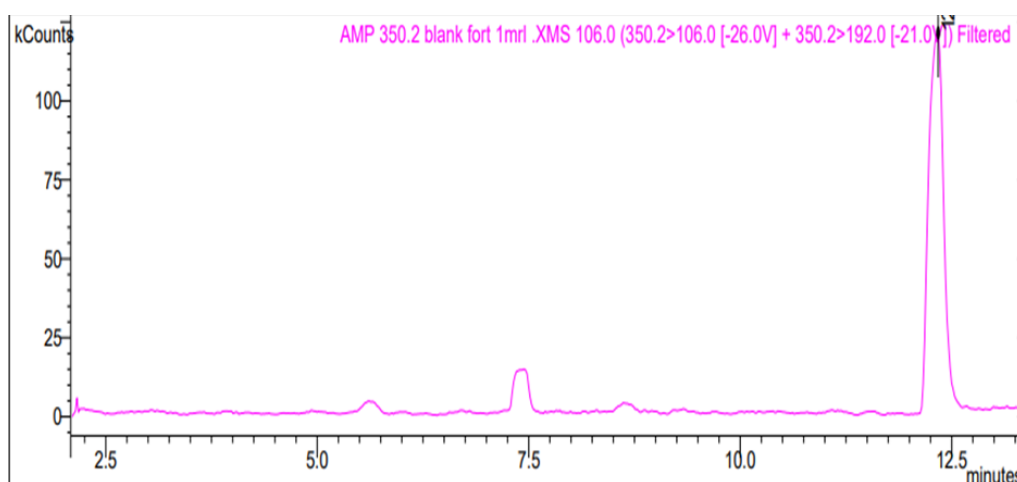


Fig. 3. Identification of the ampicillin-specific signal in an injection sequence in the matrix blank fortified at 1 MRL

Amoxicillin

As demonstrated in Figure 4, the chromatographic peak was detected at 8.124 minutes, with an intensity of 16.2 kCounts. The

retention time was found to be specific for the presence of amoxicillin residues, thus necessitating the injection of the standard to verify both the method and the apparatus.

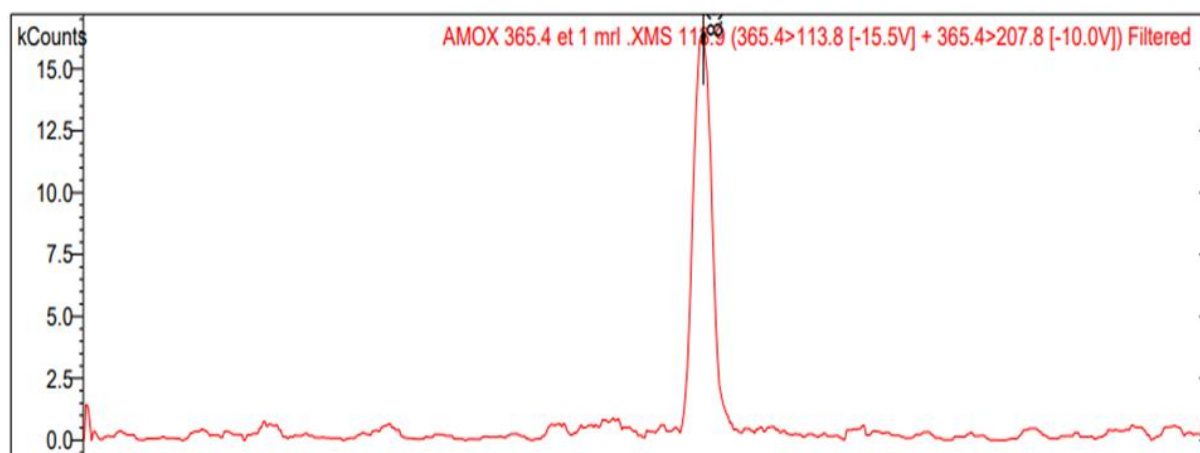


Fig. 4. Identification of the amoxicillin-specific signal in an injection sequence in the 1 MRL Standard

The chromatographic peak that is specific to the presence of amoxicillin residues in milk is reported at 8.084 minutes, with an intensity of

0.2 kCounts, as demonstrated in the chromatogram in Figure 5.

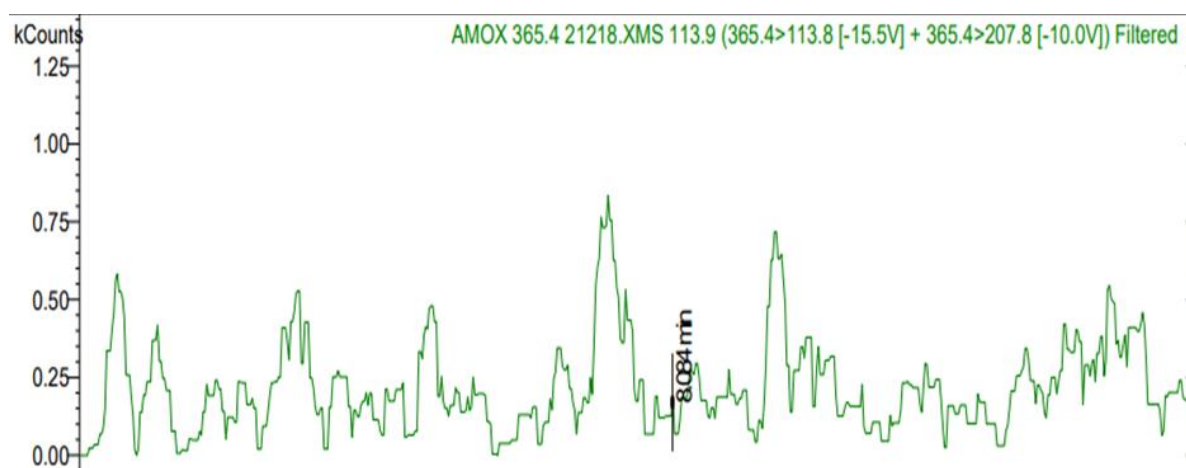


Fig. 5. The present study aims to identify the signal specific to amoxicillin in an injection sequence in raw cow's milk samples

In addition to the interference detected by the device, as illustrated in Figure 6, the signal for the peak formed at the retention time for the

fortified sample was at 7.48 minutes, with an intensity of over 8.5 kCounts.

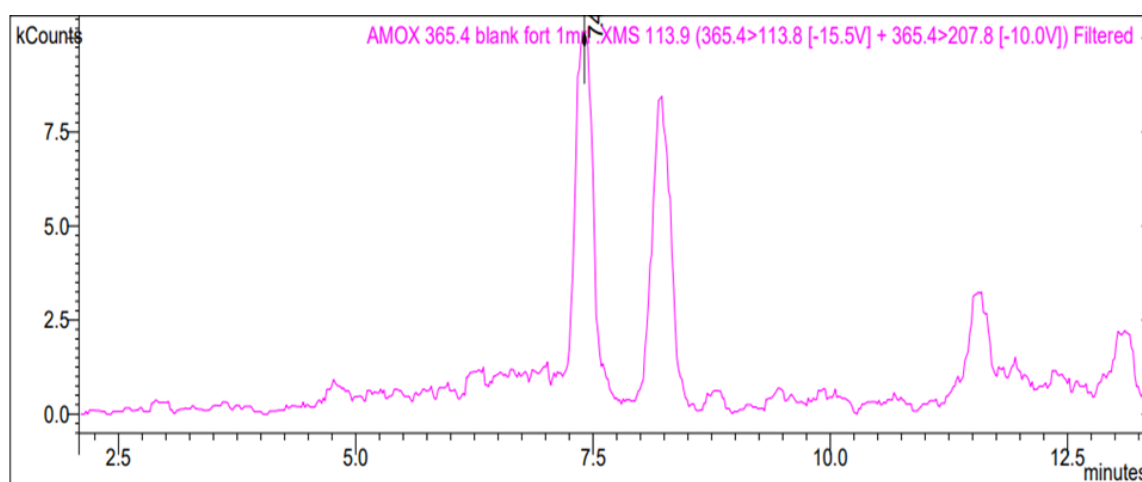


Fig. 6. Identification of the specific signal for amoxicillin in an injection sequence in milk fortified to 1 MRL

Oxacillin

The time at which the signal specific to oxacillin was recorded was 20.9 minutes, and the

recorded intensity was 35 kCounts, as represented in the chromatogram in Figure 7.

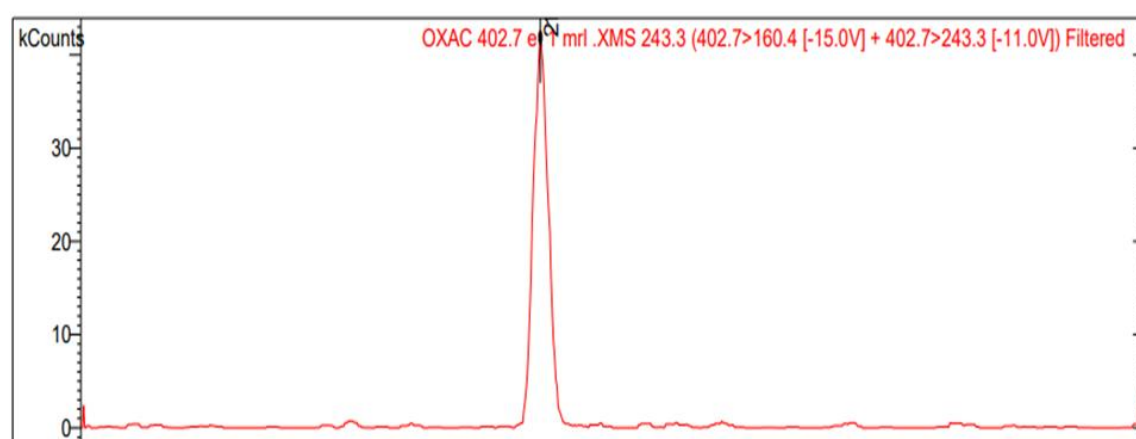


Fig. 7. Identification of the oxacillin-specific signal in an injection sequence for a 1 MRL standard

As demonstrated in Figure 8, the cow's milk sample exhibited a peak at 20.967 minutes, with an intensity of approximately 0.075 kCounts.

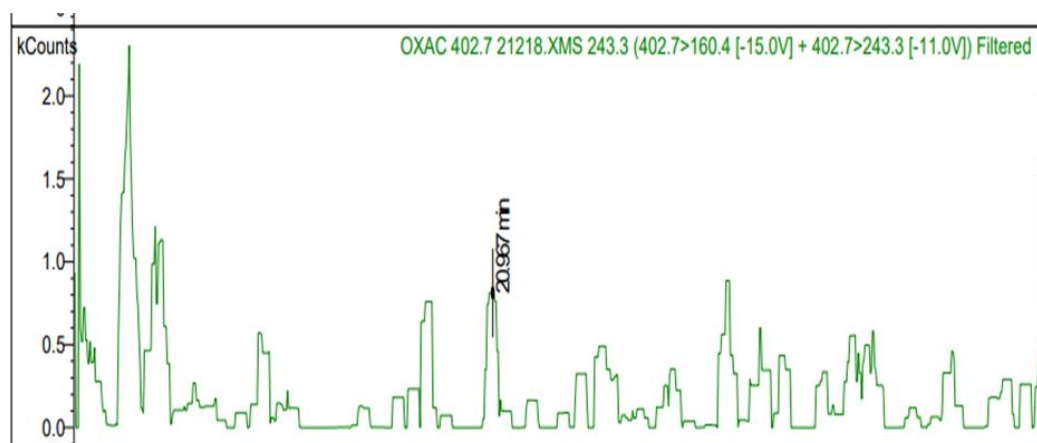


Fig. 8. Identification of the signal specific to oxacillin in an injection sequence for raw cow's milk samples

The signal at which oxacillin residues were identified at a retention time of 20.98 minutes with an intensity of 21.7 kCounts is shown in Figure 9.

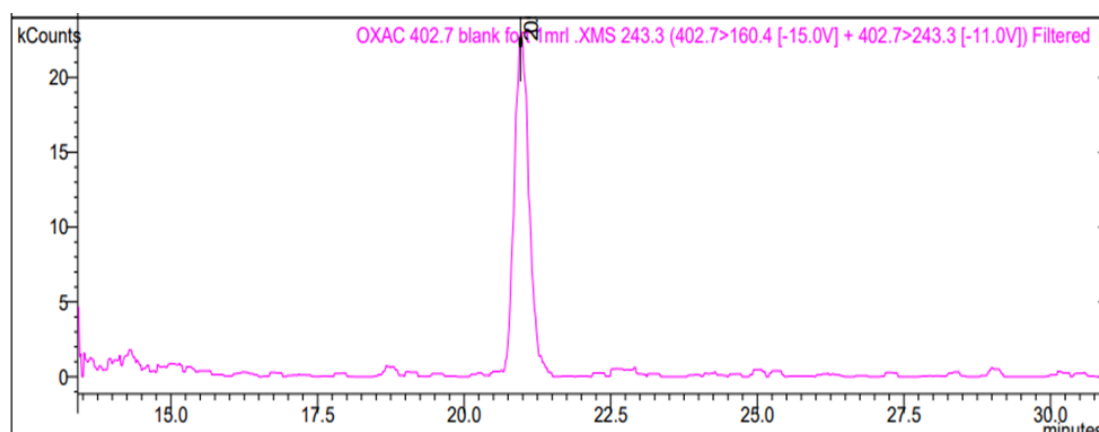


Fig. 9. Identification of the oxacillin-specific signal in an injection sequence for the matrix blank fortified at 1 MRL

Dicloxacillin

The chromatographic peak was detected at 23.46 minutes, with an intensity of 129 kCounts, as illustrated in Figure 10.

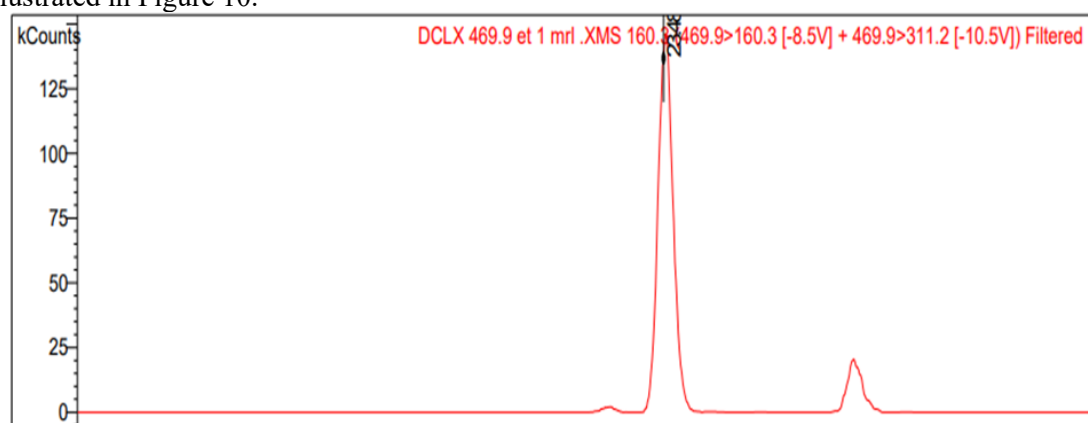


Fig. 10. Identification of the specific signal for dicloxacillin in an injection sequence for a standard at 1 MRL

The retention time of the peak formation was recorded at 23.45 minutes, with an intensity of 213 kCounts, specific for the presence of dicloxacillin, according to the chromatogram in Figure 11.

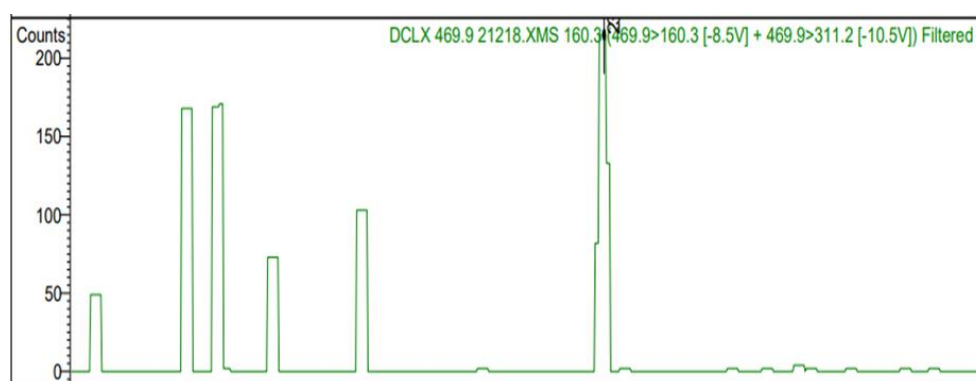


Fig. 11. Identification of the specific signal for dicloxacillin in an injection sequence for raw cow's milk samples

As demonstrated in Figure 12, the time of 23.45, with an intensity of over 98 kCounts.

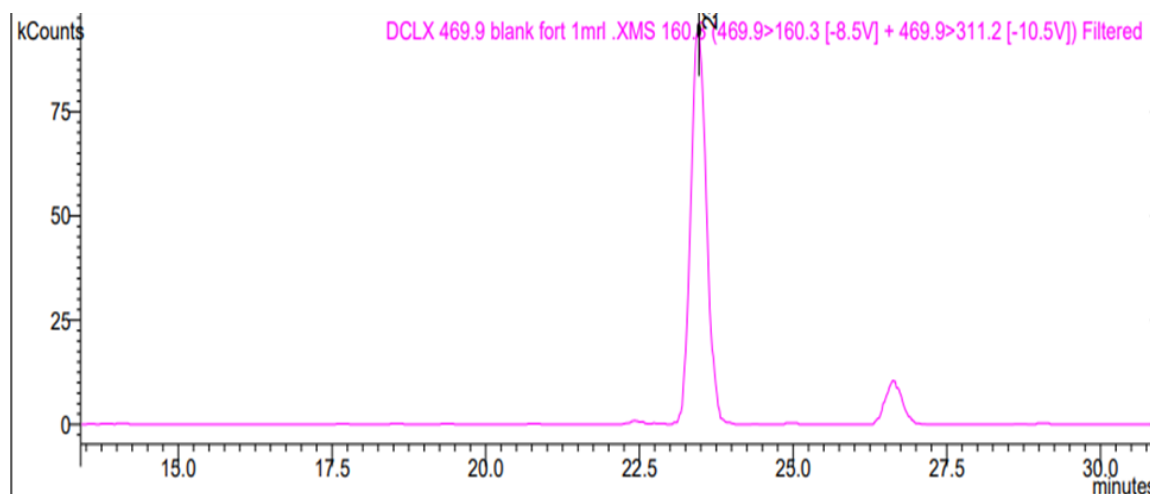


Fig. 12. Identification of the dicloxacillin-specific signal in an injection sequence for the matrix blank fortified at 1 MRL

For the other substances analysed from the beta-lactams and cephalosporins groups, the same procedure was followed, by superimposing the chromatograms, thus generating the final results in numerical form, reported in $\mu\text{g/kg}$. The four antibiotic substances displayed below are representative of the beta-lactam group, as they have the widest range of use in the treatment of sick animals.

Screening identification

As illustrated in Figure 13, the analysis encompassed 14 distinct antibiotic types, alongside their respective retention and quantification times, peak area formation, and the

values obtained in the final column, expressed in ng/g . According to the prevailing legislation, these values are required to be less than the stipulated maximum permissible limit ($< \text{cc}\alpha$).

The cow's milk sample was analysed and the following results were identified according to the screening, reported to the maximum permissible limit of residues according to European Commission Regulation 37/2010 $\mu\text{g/kg}$. As illustrated in Table 1, 10 out of the 14 antibiotics exhibited values that are below the critical limit ($\text{cc}\alpha$), thereby indicating that the cow's milk sample is within the acceptable range and is labelled as "NEGATIVE."

Table 1. Reporting results for cow's milk

Analytical	Maximum permitted limit According to EC Regulation 37/2010 ng/g - milk	Test results COW'S MILK
Amoxicillin	4 ng/g	0.000 ng/g
Ampicillin	4 ng/g	0.000 ng/g
Penicillin G	4 ng/g	0.000 ng/g
Oxacillin	30 ng/g	21.706 ng/g
Cloxacillin	30 ng/g	4.939 ng/g
Nafcillin	30 ng/g	8.501 ng/g
Dicloxacillin	30 ng/g	9.900 ng/g
Cefapirin	60 ng/g	10.985 ng/g
Cefquinone	20 ng/g	0.000 ng/g
Cephalonium	20 ng/g	6.061 ng/g
Cefazolin	50 ng/g	27.688 ng/g
Cefalexin	100 ng/g	5.457 ng/g
Ceftiofur	100 ng/g	4.638 ng/g
Cefoperazone	50 ng/g	0.000 ng/g

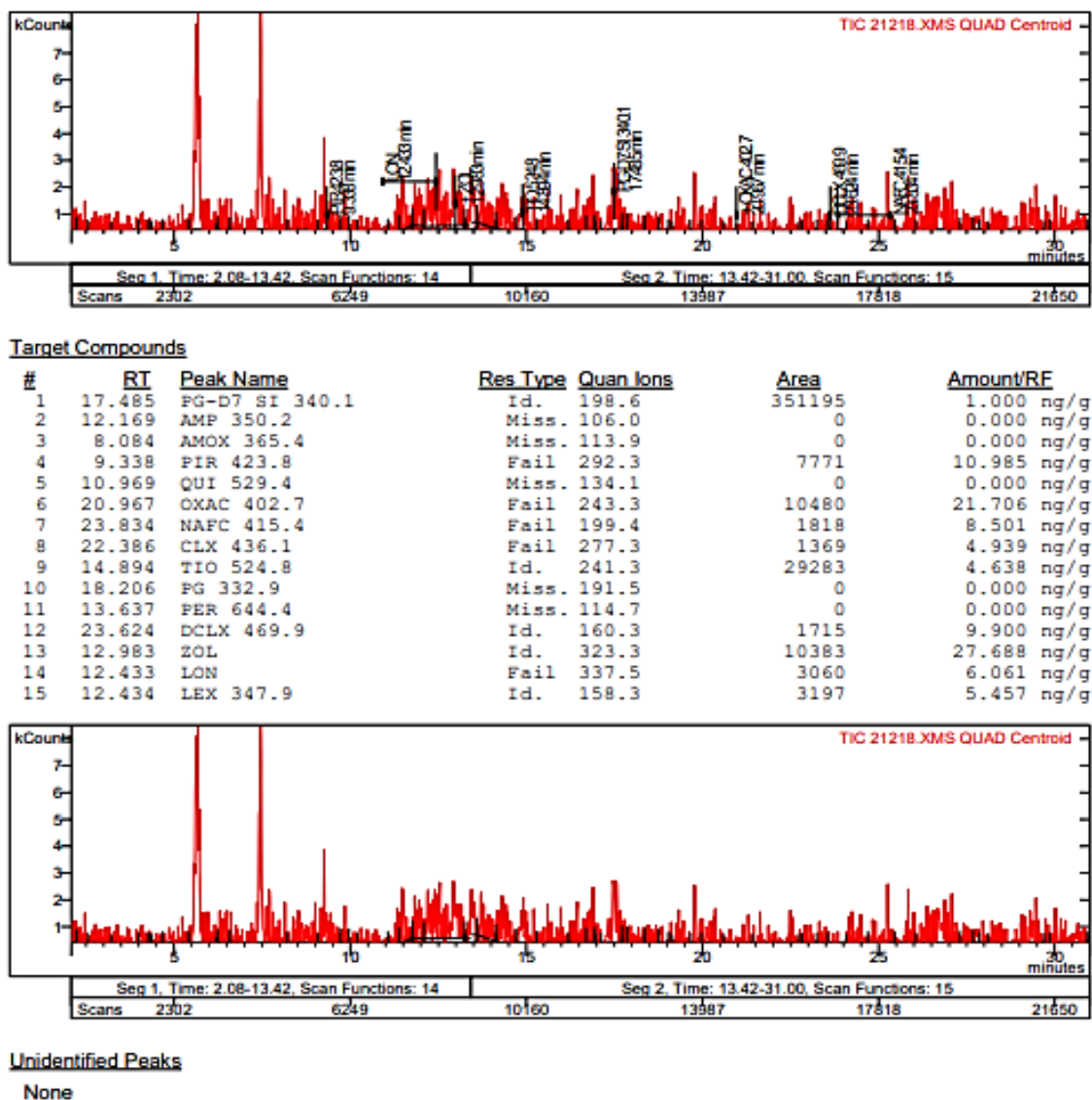


Fig. 13. Reporting results for raw cow's milk sample

Conclusions

The present study examined the quality of raw cow's milk intended for processing, sourced from a farm in Alba County. The antibiotic concentrations in the beta-lactam and cephalosporin groups were determined by means of liquid chromatography with mass spectrometry. The quantity of antibiotics was reported in accordance with the maximum permissible limit, by comparison with a standard, respectively with a fortified sample (with a blank), in order to highlight the difference between a sample that is within the parameters and a contaminated sample. The analyses indicated that 10 of the 14 antibiotics had concentrations below the maximum permissible limit, thereby rendering the cow's milk sample compliant. This method facilitates the qualitative determination of all antibiotics targeted at the concentration levels stipulated by the European

Commission. The substance has been demonstrated to be effective in screening applications, with all validation parameters tested falling within the accepted range at the requisite concentration levels.

References

1. Abgueguen, P., Azoulay-Dupuis, E., Noel, V., Moine, P., Rieux, V., Fantin, B., Bedos, J.P.: *Amoxicillin is effective against penicillin-resistant Streptococcus pneumoniae strains in a mouse pneumonia model simulating human pharmacokinetics. Antimicrob. In: Agents Chemother.*, vol. 51, 2007, p. 208-214.
2. Alija, G., Hajrulai-Musliu, Z., Uzunov, R.: *Development and validation of confirmatory LC-MS/MS method for multi-residue analysis of antibiotic drugs in bovine milk.*

- In: SN Applied Sciences, vol. 2(9), 2020, p. 1563.
3. Bagheri, A.R., Ghaedi, M.: *Magnetic metal organic framework for pre-concentration of ampicillin from cow milk samples*. In: Journal of Pharmaceutical Analysis, vol. 10(4), 2020, p. 365-375.
 4. Bystroń, J., Podkowik, M., Korzekwa, K., Lis, E., Molenda, J., Bania, J.: *Characterization of Borderline Oxacillin-Resistant Staphylococcus aureus Isolated from Food of Animal Origin*. In: J. of Food Protection, vol. 73(7), 2010, p. 1325-1327.
 5. Cañadas, R., Garcinuño Martínez, R.M., Paniagua González, G., Fernández Hernando, P.: *Development of a molecularly imprinted polymeric membrane for determination of macrolide antibiotics from cow milk*. In: Polymer, vol. 249, 2022, p. 124843.
 6. Chen, C., Lei, H., Liu, N., Yan, H.: *An aptasensor for ampicillin detection in milk by fluorescence resonance energy transfer between upconversion nanoparticles and Au nanoparticles*. In: Food Chemistry: X, vol. 15, 2022, p. 100439.
 7. Costa, L.V., Gebara, C., Zaccaroni, O.d.F., Freitas, N.E., Silva, A.N.d., Prado, C.S., Nunes, I.A., Cavicchioli, V.Q., Duarte, F.O.S., Lage, M.E., et al.: *Antibiotic Residues in Raw Cow's Milk: A Systematic Review of the Last Decade*. In: Foods, vol. 13, 2024, p. 3758.
 8. Cristina, R.T., Ungureanu, F., Romeu, L., Constantin, A., Tulcan, C., Morar, D., Stef, S., Hutu, I.: *Prevalence of steroid hormone residues by GC-MS/MS screening in animal matrices in Romania*. In: ROMANIAN BIOTECHNOLOGICAL LETTERS, vol. 22(1), 2017, p. 12155-12162.
 9. Dobрева, K., et al. *Chemical Composition and Antioxidant Activities of Three Bulgarian Garden Thyme Essential Oils*. Appl. Sci. 2024, 14(22).
 10. Hu, J., Zhou, J., Zhou, S., Wu, P., Tsang, Y.F.: *Occurrence and fate of antibiotics in a wastewater treatment plant and their biological effects on receiving waters in Guizhou*. In: Process Safety and Environmental Protection, vol. 113, 2018, p. 483-490.
 11. Liu, P., Wu, Z., Fang, Z., Cravotto, G.: *Sonolytic degradation kinetics and mechanisms of antibiotics in water and cow milk*. In: Ultrasonics Sonochemistry, vol. 99, 2023, p. 106518.
 12. McKay, A.M.: *Antimicrobial resistance and heat sensitivity of oxacillin-resistant, mecA-positive Staphylococcus spp. from unpasteurized milk*. In: Journal of Food Protection, vol. 71(1), 2008, p. 186-190.
 13. Oprea, O.B., Gaceu, L. *Application of multiple criteria decision making (mcdm) in bakery industry. Study case: wastes and by-products*. BUT. Series II: Forestry• Wood Industry• Agricultural Food Engineering, 89-94. 2016.
 14. Răducuță, I.: *Filiera laptelui*. Sibiu. Ed. Universității "Lucian Blaga", 2004.
 15. Ribeiro, B.V., Ferreira, L.F., Franco, D.L.: *Advances in biosensor development for the determination of antibiotics in cow's milk - A review*. In: Talanta Open, vol. 6, 2022, p. 100145.
 16. Shekhar, S., Brar, N.K., Håkansson, A.P., Petersen, F.C.: *Treatment of Mouse Infants with Amoxicillin, but Not the Human Milk-Derived Antimicrobial HAMLET, Impairs Lung Th17 Responses*. In: Antibiotics, vol. 12, 2023, p. 423.
 17. Song, Z., Zhang, X., Ngo, H.H., Guo, W., Wen, H., Li, C.: *Occurrence, fate and health risk assessment of 10 common antibiotics in two drinking water plants with different treatment processes*. In: Science of The Total Environment, vol. 674, 2019, p. 316-326.

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HYGIENIC DESIGN OF PROFESSIONAL KITCHENS IN THE HORECA INDUSTRY. GREASE SEPARATORS IN PROFESSIONAL KITCHENS: CONCEPTS, TECHNOLOGIES AND PRACTICAL APPLICATIONS

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Abstract: Hygienic design is an integrated approach to the design and use of spaces, installations and equipment, with the aim of preventing the build-up of dirt, organic matter and residual moisture, as well as simplifying cleaning and disinfection processes. In contrast to a strictly operational, procedure-focused perspective, hygienic design places infrastructure in the essential role of the food safety system. In this sense, hygiene is no longer just the result of behavior and routine, but becomes a structural feature of the built environment.

Keywords: hygienic design, solutions, sanitation, clean in place

1. Operational and environmental benefits of hygienic design

An easily sanitized space reduces downtime for food establishments. For restaurants with extended hours or fast turnover, these savings translate into additional production capacity or more generous maintenance windows, which prolongs the life of equipment. At the same time, the consumption profile flattens: less water, less fuel or electricity for heating, fewer chemical agents discharged into the network. In the long term, the carbon footprint decreases and utility costs become more controllable (Oprea, 2017).

On the social side, a hygienic and well-ventilated environment reduces operator discomfort, slip risks, exposure to irritants and the physical strain associated with prolonged washing. A culture of hygiene, when supported by infrastructure, becomes a plausible routine, not a disproportionate burden. Many kitchens operate in historic buildings or spaces with construction limitations. Here too, substantial gains can be achieved through targeted interventions: closing critical joints, replacing difficult-to-clean siphons, reconfiguring work routes to separate incompatible flows, installing additional gutters, changes in ventilation to control condensation.

In parallel, lower-impact sanitation solutions can be adopted: washing at optimized temperatures, agents with high cleaning power and reduced contact time, automatic dosing systems, intelligently programmed cleaning to avoid overlapping consumption.

Each relatively small adjustment can produce, over time, compound effects on consumption, microbiological stability and operational comfort.

Hygienic design of professional kitchens is the critical infrastructure of a safe, efficient and environmentally responsible culinary operation. It transforms hygiene from a succession of obligations into a structural property of the space, which prevents accumulations, facilitates cleaning and substantially reduces resource dependence. The benefits are convergent: fewer sanitary incidents, less food waste, fewer discharged substances, reduced water and energy consumption, extended equipment life and a healthier work culture (Oprea et al, 2018).

2. The importance of grease separators

The HoReCa industry generates large quantities of wastewater loaded with food scraps, oils and fats. If these substances were discharged directly into the sewage system, they would cause deposits, clogging of pipes, strong odors and, in the long term, major failures (EHEDG Guideline

Doc. 37, 2025), (EHEDG Guideline Doc. 20, 2024). Grease separators are the essential technical solution to prevent these problems. They operate on a simple principle – the difference in density between water, solid particles and grease – but offer major benefits: protecting installations, complying with regulations, reducing costs and protecting the environment. ACO, a global leader in the field, produces a complete range of separators that meet the specific needs of HoReCa.

ACO grease separators offer a number of significant advantages for the HoReCa sector, where hygiene, safety and efficiency are critical factors for the success of a business. These benefits can be analyzed on several levels: hygiene, protection of facilities, compliance with legislation, adaptability, durability and environmental impact.

Hygiene and food safety

In professional kitchens, HACCP standards and sanitary regulations impose strict conditions on waste management. ACO separators prevent the accumulation of grease in the networks and eliminate potential sources of contamination. This prevents the appearance of bacteria, mold and unpleasant odors. In addition, ACO equipment is designed to be easy to clean and sanitize.

Plant Protection

A well-sized grease separator significantly reduces the risk of clogging of internal and external pipes. Blockages and failures are costly and can interrupt the operation of the unit. By retaining grease and oil, ACO ensures continuous operation and protects investments in plant infrastructure.

Compliance with legislation

National and European legislation obliges HoReCa units to use grease separators. ACO supplies equipment certified according to SR EN 1825, which guarantees their acceptance by the authorities. Operators thus avoid fines and sanctions, but also the risk of being forced to suspend their activity.

Adaptability

The diversity of the ACO range allows finding a solution for any type of unit. From small cafes with a few dozen menus daily, to hotels and industrial canteens, there is a suitable model. Compact models such as Grease Capture are

ideal for confined spaces, while Lipumax G or Lipumax C can handle high flows for units with hundreds or thousands of customers.

Durability

The materials used (concrete, stainless steel, polyethylene, GRP) are chosen for their strength and longevity. ACO separators have a lifespan of over 25 years if properly maintained. This makes the investment safe and profitable in the long term.

Environmental impact

Fats and oils discharged into sewage networks often end up in natural waters, where they create films that prevent oxygenation and affect ecosystems. By retaining these substances, ACO separators directly contribute to environmental protection. In addition, the collected fats can be used for energy recovery through recycling or biogas production processes.

Economic efficiency

Maintenance and repair costs are significantly reduced. A separator prevents frequent unclogging interventions and reduces wear on the networks. In addition, ACO equipment is designed to minimize the time required for cleaning and emptying, which reduces operational costs.

Image and compliance

For any HoReCa establishment, the image in front of customers and authorities is crucial. The use of professional equipment such as those produced by ACO sends a message of responsibility and respect for hygiene and the environment. In addition, compliance with European standards brings a competitive advantage.

Therefore, the advantages of ACO separators for HoReCa are not only technical, but also economic, legal and image. They represent an investment that protects the business in the long term and contributes to sustainability.

3. Principiul de funcționare al separatoarelor de grăsimi ACO

Grease separators are essential equipment for any HoReCa unit, and their operating principle is based on the difference in density between water, oils and fats, respectively solid particles. This difference causes a natural separation when the

waste water has enough time to stay in an appropriate retention volume.

The process can be divided into several distinct stages:

- wastewater inlet: water from sinks, dishwashers or cooking areas enters the separator through an inlet connection. The flow rate and speed are controlled by appropriately sizing the inlet diameters.
- flow deceleration: inside the tank, the water reduces its speed, which allows gravity to act. This stage is crucial, as turbulence can prevent the correct separation of the fractions.
- solids settling: particles heavier than water (sand, food scraps, sediment) accumulate at the bottom, forming a layer of sludge. This area is known as the 'sludge trap'.
- rise of fats and oils: lipophilic substances, lighter than water, rise to the surface. As they accumulate, they form a compact film, isolated from the rest of the water.
- discharge of partially purified water: the intermediate zone, located between the sludge and the fat layer, contains relatively clear water. This is discharged through the outlet connection, respecting the quality conditions imposed by the sanitary norms.

The European standard SR EN 1825 requires that separators be sized according to the wastewater flow rate, expressed by NS (Nominal Size). For example, NS 1 indicates a flow rate of 1 l/s, NS 10 a flow rate of 10 l/s, and so on. Depending on this value, the minimum volumes for the sludge and grease compartments are established, as well as the constructive dimensions of the tank.

From a constructive point of view, separators include:

- Main tank, cylindrical or rectangular;
- Inlet and outlet with standard diameters (DN 100, DN 150, DN 200, etc.);
- Sludge trap, positioned at the bottom;
- Grease accumulation area, at the top;
- Access covers, usually Ø600 mm, for inspection and cleaning;
- Odour seals;
- Optional accessories: level sensors, control units, viewing windows.

The correct operation of the separator depends on compliance with the installation rules: horizontal positioning, sealing of connections, protection against rainwater infiltration, adaptation of the covers to the load of the installation area (pedestrian, road, heavy traffic).

Improper installation may lead to shortened service life or inefficiency.

It is also important to emphasize the role of complementary physicochemical processes. Although the principle is gravitational, the water temperature and the chemical nature of the detergents influence the behaviour of the fats. At high temperatures, the oils remain in suspension for longer, and sudden cooling causes solidification. Therefore, the standards provide for a minimum retention volume, so that the water has time to cool and the separation is effective.

4. ACO range of grease separators

The range of grease separators produced by ACO is one of the most varied on the market and is aimed at all types of HoReCa units, from small cafes and urban restaurants, to large hotels, school canteens, hospitals and industrial catering units. The diversity does not only refer to the dimensions, but also to the construction materials, types of installation, optional accessories and the degree of automation.

ACO separators can be grouped into three main categories: buried installation, free-standing and compact/mobile. In each of these categories there are models with specific characteristics, adapted to precise operating conditions.

Buried-mounted separators

a) ACO Lipumax G – made of GRP (glass-fibre reinforced plastic), a material that offers an optimal combination of mechanical strength and low weight. Lipumax G is available in a wide range of sizes, from NS 1–2 (capacity 580 l) to NS 25 (capacity over 8000 l). It is equipped with a sludge trap, anti-odour gasket and a sampling connector. The covers are available in classes A15, B125 and D400, which allows it to be installed in pedestrian, road or heavy traffic areas.

b) ACO Lipumax C – made of reinforced concrete, with a protective inner layer. This model is extremely robust and durable, ideal for situations where the separator must withstand heavy loads. Concrete has the advantage of excellent stability and a long service life. On the other hand, installation requires heavy equipment and careful site planning.

c) ACO Lipumax P-X – made of high-density polyethylene, easy to install, without the need for an additional concrete structure. It is especially recommended for areas with difficult access or

high-water table. Polyethylene is chemically resistant and allows safe operation even in demanding conditions.

Self-supporting separators

a) LipuJet P-O and P-S – made of polyethylene, in oval-shaped or separate-chamber versions. They are intended for installation inside the building, in frost-free technical rooms. The declared service life is over 25 years, and maintenance is simple. They are ideal for urban restaurants that do not have outdoor space.

b) LipuJet S-O and S-R – made of stainless steel, available in oval or round shapes. The advantages of stainless steel are perfect hygiene, corrosion resistance and professional appearance. These separators are frequently used in hotel kitchens, hospitals or facilities where hygiene must be impeccable.

Compact and mobile solutions

a) ACO Grease Capture (AGC 50, 100, 150, 220) – compact stainless-steel equipment, which is mounted directly under the sink. They have electrical systems for capturing and filtering grease. They are ideal for cafes, fast-food restaurants and other small units. Their small dimensions make them extremely easy to integrate.

b) ACO Grease Trap – simple, self-supporting separators made of stainless steel. They are robust, but also compact, being suitable for units with limited space.

c) ACO LipuMobil-P and LipuMobil-S – portable separators, made of polyethylene or stainless steel. They are equipped with wheels and can be easily transported, being recommended for food trucks, temporary events or seasonal units.

In addition to standard products, ACO also offers numerous accessories that can be integrated: lift-off covers, sampling devices, inspection windows, level sensors and remote-control units. This modularity allows solutions to be customized according to the specifics of each HoReCa unit. Thus, the ACO range is not limited to a few products, but represents a complete portfolio, adaptable to any requirement. Whether it is a neighborhood café or a luxury hotel complex, there is an appropriate ACO separator. Diversity, combined with compliance with European standards, makes these solutions among the most appreciated on the market.

Grease separator model ACO Lipumax G

The ACO Lipumax G model is one of the most representative grease separators with buried installation. Built from GRP (glass fiber reinforced plastic), this equipment combines high mechanical resistance with low weight compared to concrete solutions, which makes it easier to transport and install. Lipumax G was specially designed to meet the strict requirements of the HoReCa sector, complying with the SR EN 1825 standard and ensuring superior separation performance (fig.1.).

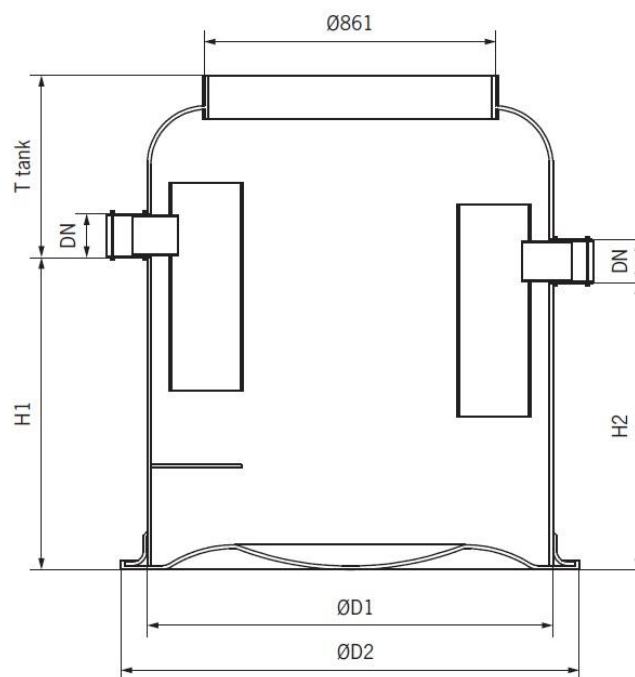


Fig. 1. ACO Lipumax G separator (www.aco.ro)

Structurally, the separator consists of:

- Cylindrical main tank, made of GRP, with thick walls and resistance to soil pressure;
- Integrated sludge trap, which collects heavy sediments and ensures uniform flow distribution;
- Grease accumulation space, dimensioned according to regulatory requirements;
- Rubber gasket for protection against odors;
- Connector for sampling device, required in sanitary controls;
- Ø600 mm covers, with adjustable riser tubes, available in classes A15 (pedestrian), B125 (light traffic) and D400 (heavy traffic).

From a technical point of view, Lipumax G is available in several sizes (NS), of which some are shown here:

- NS 1–2: inlet/outlet DN 110, sludge trap capacity 200 l, grease storage 190 l, total capacity 580 l.
- NS 10: inlet/outlet DN 160, sludge trap capacity 1000–2000 l, grease storage 400 l, total capacity 2225–3224 l.
- NS 25: inlet/outlet DN 250, sludge trap capacity 2500–5000 l, grease storage 1120 l, total capacity 5820–8481 l.

These values highlight the versatility of the product, which can be used both in small restaurants and in large industrial kitchens. The flexibility of assembly is one of the major advantages of Lipumax G.

The main advantages are the following:

- Quick installation due to its lower weight than concrete;
- High resistance to corrosion and the action of chemical agents;
- Easy maintenance, thanks to the wide access covers;
- Possibility of adapting to any type of terrain and mechanical load;
- Full compliance with European standards and the requirements of health authorities.

The maintenance operations and accessories available for ACO grease separators play a crucial role in maintaining the performance and lifespan of the equipment. Unlike other installations, separators work constantly under difficult conditions, being exposed to organic substances, detergents and temperature variations. Therefore, regular maintenance is not only recommended, but mandatory.

Emptying and cleaning

Separators gradually accumulate grease and sludge. If these deposits are not removed in time, the efficiency of the separator decreases and the

risk of clogging and odors increases. ACO recommends establishing a regular emptying schedule, adapted to the workload of the unit.

As a rule, for small restaurants, the interval is 2–4 weeks, and for large kitchens it can even be weekly.

Covers and risers

Access to the separator is via Ø600 mm covers. ACO offers covers in different load classes: A15 for pedestrian areas, B125 for light traffic and D400 for heavy traffic. Risers allow adaptation to the ground level and protect against infiltration. The covers are fitted with rubber seals for sealing, preventing the spread of odours.

Inspection windows and viewing devices

To monitor the grease layer without fully opening the cover, special windows can be installed, equipped with wipers. They allow for quick level checks and reduce the risk of contamination.

Filling and flushing devices

Separators can be equipped with flushing systems connected to the drinking water network. These facilitate cleaning of the inner walls and prevent excessive solidification of grease. Filling with clean water after emptying is mandatory to restore operating conditions.

Level sensors and control units

ACO provides special sensors with a heated electrode that measure the thickness of the grease layer. They transmit signals at 50% and 80% of the nominal capacity, warning the operator that emptying is necessary. The control units can be connected to building management systems, allowing centralized monitoring.

Preventive maintenance

In addition to cleaning operations, periodic inspections are recommended to check the seals, tightness of connections and the general condition of the tank. Early identification of potential problems reduces costs and avoids downtime.

Documentation and traceability

For HoReCa establishments, health authorities often request proof of maintenance. ACO recommends keeping a log of emptying and cleaning operations, including the date, the volume extracted and the company responsible.

This practice ensures transparency and legal compliance.

Additional accessories

Depending on the model, you can add: ventilation tubes for pressure equalization, sampling devices, additional connections for inspection or automatic washing. All these options increase safety and make operation easier. The maintenance of ACO grease separators should not be seen as an additional task, but as an integral part of the management of a professional kitchen. By using the available accessories and following the maintenance schedule, the equipment can operate for decades, ensuring hygiene, efficiency and protection.

5. Good practices for ACO grease separators

Best practice examples are the most convincing way to understand the usefulness of ACO grease separators in the HoReCa sector. Experience gained in restaurants, hotels, canteens and mobile units demonstrates the versatility of this equipment and its positive impact on daily operations.

Small urban restaurant

A restaurant with 40–50 seats, located in a central area, is faced with space limitations. The owner opted to install an ACO Grease Capture AGC 50 under the sink. The compact solution allowed compliance with sanitary regulations without sacrificing usable space. The separator retains the daily quantities of grease generated, and maintenance is done quickly, by periodically emptying the container. The result: reduced costs, increased hygiene and the elimination of odors.

School canteen

A canteen serving 400 students daily installed an ACO Lipumax P-X NS 4, buried in the inner courtyard. This polyethylene model was chosen because it did not require additional concreting and could be installed quickly, even during a short school holiday. The benefits were immediate: the internal network no longer clogged, and the maintenance staff noted the ease of emptying.

4-star hotel with its own restaurant

A seaside hotel with 150 rooms and a 200-seat restaurant opted for a free-standing ACO LipuJet S-O stainless steel unit installed in the technical room. The choice of stainless steel was motivated by the strict hygiene requirements and the possibility of integration with the building's monitoring systems. The level sensors transmit automatic alarms to the hotel reception, thus

ensuring permanent control. The management reported savings of over 30% on the maintenance costs of the installations.

Fast-food establishments

A local fast-food chain implemented ACO Grease Trap stainless steel units in all locations. These compact separators ensure grease retention and can be quickly cleaned by their own staff. Standardization of the equipment allowed for a reduction in training and maintenance costs. In addition, the uniformity of the solutions was appreciated by the health authorities during inspections.

Food trucks and mobile units

For a food truck serving burgers at festivals, an ACO LipuMobil-S was used. The portable separator, mounted on wheels, can be easily transported and sanitized daily. This solution allowed compliance with HACCP regulations even in temporary and mobile operation conditions. Good practices identified: correct sizing according to the actual flow of the kitchen; choosing the right material: stainless steel for hygiene, concrete for heavy loads, polyethylene for flexibility; establishing a clear maintenance and emptying schedule; integrating sensors and control units for efficient monitoring; maintaining maintenance documentation for authority inspections. These examples show that ACO separators are not simple auxiliary equipment, but strategic solutions that contribute to the sustainability and success of HoReCa businesses. Correct implementation brings immediate and long-term benefits: cost reduction, protection of facilities, legal compliance and, last but not least, customer safety.

6. Discussions

This paper has analysed in detail the role of hygienic design and grease traps in professional kitchens in the HoReCa industry, highlighting the multiple implications that these elements have on food safety, operational efficiency and environmental sustainability. The conclusions formulated can be summarized as follows:

The concept of hygienic design goes beyond the simple application of cleaning procedures and becomes the foundation on which the entire activity of professional kitchens is built. Infrastructure, equipment and spaces are designed to prevent dirt accumulation, to reduce sanitation time and to transform hygiene into a structural property. This not only ensures

compliance with the norms, but also offers a competitive advantage to HoReCa units.

The hygienic design and integration of grease separators bring direct benefits to the operation of the units. Reducing cleaning times, saving water, reducing energy and detergent consumption, protecting equipment and extending their lifespan are major gains. In addition, these solutions contribute to reducing the carbon footprint and to a more responsible management of resources.

The analysis has shown that grease separators are indispensable for any professional kitchen. Through the simple principle of the difference in density between water, solid particles and grease, these devices prevent clogging of pipes, reduce the risks of odors and contamination, protect the infrastructure and ensure the continuous operation of the units. They are not an optional accessory, but a structural element, as important as ventilation or drainage systems.

National and European legislation requires the use of grease separators, and ACO equipment, certified according to the SR EN 1825 standard, meets these requirements. Compliance with the rules ensures the avoidance of fines and sanctions, but above all sends a message of responsibility and seriousness to customers and authorities. Compliance is not only an obligation, but also a guarantee of sustainability and long-term viability.

The wide range of ACO separators – flush-mounted, free-standing, compact or mobile – demonstrates that there is a suitable solution for any type of establishment, from small cafes to luxury hotels. The materials used (concrete, stainless steel, GRP, polyethylene) ensure strength and durability, and accessories such as sensors, control units or special covers increase safety and ease of maintenance. Flexibility and modularity turn this equipment into safe and adaptable investments.

The case studies presented – urban restaurants, school canteens, hotels, fast-food outlets and food trucks – confirmed that ACO grease separators bring real and measurable benefits. Among them: reducing maintenance costs, eliminating network blockages, improving environmental hygiene, increasing the lifespan of installations and, last but not least, ensuring a positive image in front of customers and authorities. These good practices demonstrate the universal applicability of ACO solutions.

Grease separators directly contribute to environmental protection by preventing fats and oils from entering water systems and

subsequently ecosystems. In this way, they support sustainable development goals and promote a responsible food industry. At the same time, increased hygiene and the elimination of sources of contamination protect public health, reducing the risk of foodborne illness.

Recommendations for the HoReCa industry

- Integrating grease separators from the design phase of professional kitchens;
- Choosing certified equipment that complies with European standards;
- Adapting the type of separator to the specifics of the unit (dimensions, workload, type of menu);
- Implementing a regular maintenance, emptying and cleaning program;
- Using modern accessories (sensors, control units) for efficient monitoring and management;
- Maintaining documentation and traceability of operations for legal compliance and transparency.

7. Conclusions

The paper demonstrates that hygienic design and grease separators are not just technical components, but strategic pillars of food safety and sustainability in the HoReCa industry. By implementing these solutions, establishments not only comply with legislation, but also optimize their operation, reduce costs and strengthen their image. Investing in hygienic infrastructure and quality equipment is an investment in the future of the business and in the health of consumers.

Thus, ACO grease separators and the principles of hygienic design must be seen as essential elements for the success of any modern HoReCa establishment, contributing to a cleaner, safer and more sustainable environment.

References

1. EHEDG Guideline Doc. 6. (2018). Continuous UHT sterilization of liquid food; Available at: <https://www.ehedg.org/guidelines/>;
2. EHEDG Guideline Doc. 8. (2020). Hygienic equipment design criteria; Available at: <https://www.ehedg.org/guidelines/>;
3. EHEDG Guideline Doc. 14. (2022). Hygienic design of valves for food processing; Available at: <https://www.ehedg.org/guidelines/>;
4. EHEDG Guideline Doc. 16. (2023). Hygienic pipe couplings; Available at: <https://www.ehedg.org/guidelines/>;
5. EHEDG Guideline Doc. 17. (2023). Hygienic design of pumps, homogenisers and

- dampening devices; Available at: <https://www.ehedg.org/guidelines/>;
6. EHEDG Guideline Doc. 20. (2024). Hygienic design and safe use of double-seat mixproof valves; Available at: <https://www.ehedg.org/guidelines/>;
 7. EHEDG Guideline Doc. 32. (2024). Materials of construction for equipment in contact with food; Available at: <https://www.ehedg.org/guidelines/>;
 8. EHEDG Guideline Doc. 35. (2025). Welding of stainless-steel tubing in the food industry; Available at: <https://www.ehedg.org/guidelines/>;
 9. EHEDG Guideline Doc. 37. (2025). Hygienic design and application of sensors; Available at: <https://www.ehedg.org/guidelines/>;
 10. Gaceu, L. (2016). *Hygienic engineering and design in Romania*. J. of EcoAgriTourism, 12(2), 154-159;
 11. Gaceu, L. (2017). *Assessment method for hygienic design in food industry. Water drainage and water saving study case*. J. of EcoAgriTourism, 13(2), 53-56;
 12. Gaceu, L. (2018). *Comparative study on European legislation about hygienic engineering and design*. Journal of EcoAgriTourism, 14(2), 42-47;
 13. Gaceu, L. (2020a). *Design principles for assuring food safety in Romanian mountain dairy farms*. J. of EcoAgriTourism, 16(2), 21-25;
 14. Gaceu, L. (2020b). *Food safety in pasteurization of liquid food-basic elements for mountain farmers*. J. of EcoAgriTourism, 16(2), 51-55;
 15. Gaceu, L., Samoilă, N.R., Gruia, R. Oprea, O.B. (2021). *Use of Essential Oils from Aromatic and Medicinal Plants to Increase the Shelf Life of Mountain Dairy Products in Romania*, J. of Montology, 15, 7-20;
 16. Gruia, R., Gaceu, L., Oprea, O. B. (2025). *The Pillars of Societal Bioharmonism a Conceptualist Contribution to the Evolution of the Contemporary Society*. Challenges, 16(1), 16.
 17. Gruia, R., Florescu, G.I., Gaceu, L., Oprea, O.B., Țane, N. (2021). *Reducing environmental risk by applying a polyvalent model of waste management in the restaurant industry*. Sustainability, 13(11), 5852.
 18. Lelieveld, H., Holah, J., Domago, G. (2016) *Handbook of Hygiene Control in the Food Industry*, ISBN:978-0-08-100155-4, Elsevier;
 19. Lelieveld, H. & Holah, J. (2016). *Specific Requirements for Equipment for Aseptic Processing*. Woodhead Publishing Series in Food Science, Technology and Nutrition, ISBN: 9780081001554.
 20. Oprea, O.B. (2017). *Operational management of sanogeneous nutrition. Case study Covasna County*. J.of EcoAgriTourism, 13(2), 39-47.
 21. Oprea, O.B.; Samoilă, N.R.; Spirchez, Gh.C. (2018). *A Review of the Antimicrobial Activity of Thymus Vulgaris, Malaleuca and Ocimum Basilicum*. J. of EcoAgriTourism, 14(1), 135-140;
 22. www.ehedg.org
 23. www.aco.ro

CONTRIBUTIONS ON THE BASIC UNDERSTANDING OF HOW TO IDENTIFY LOW QUALITY FRUITS AND VEGETABLES IN THE SORTING PROCESS USING ARTIFICIAL INTELLIGENCE

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Abstract: This paper presents an artificial intelligence-based model provided by Google and called Google teachable machine applied to the sorting process of fruits and vegetables. The goal is to explain at a simple level the process of identifying fruits and vegetables with low quality using artificial intelligence.

Keywords: fruits, vegetables, potatoes, artificial intelligence, quality, neural networks

1. Introduction

Artificial intelligence (AI) is the ability of various systems to "learn" from data and do tasks that usually require human intelligence. Neural networks and deep learning are currently two key concepts of artificial intelligence. The most recent developments in the world of artificial intelligence can be attributed to these concepts and have played a significant role in its improvement. A neural network can mean either a "real", biological neural network, such as the one in the brain, or an artificial neural network, simulated on a computer.

We can say that artificial neural networks are packages of simple, interconnected processing elements that work in parallel in a way like biological brains and that exhibit the ability to learn. The neural network is similar with the human brain but composed of artificial neurons, which work by recognizing patterns. Sensory data is interpreted using machine perception, labeling, etc. The recognized patterns are numerical, enclosed in vectors, into which data, sound, text, etc. are translated.

Deep learning is the research field of "machine learning" and "artificial intelligence" that is based on different levels of representation, corresponding to hierarchies of the characteristics of factors or concepts, where the higher-level concepts are defined based on the lower-level ones. In other words, according to the definition of the Artificial Intelligence Observatory of the Politecnico di Milano, by deep learning we refer to a set of techniques based on artificial neural networks organized in different layers, where

each layer calculates the values for the next, so that the information is elaborated in a way that is as close to the final model.

In the field of agriculture, deep learning-based models have emerged as state-of-the-art techniques for image segmentation and classification, outperforming classical methods where data variability is higher. In the field of fruit and vegetable packaging, accurate detection and recognition of different types of fruits and vegetables using artificial intelligence is always a challenge due to the similarity between different types of products and variations in background, brightness, etc. In the history of fruit recognition system for shopping malls, researchers invented a simple fruit recognition system that includes a convolutional ladder and an image. Convolutional neural network (CNN) is a neural network that can be used to allow machines to visualize things and perform tasks such as image classification and image recognition. It can take input images, process them, and classify them. Image processing uses CNNs as one of the most common deep learning techniques.

2. Methods for identifying fruits and vegetables using the artificial intelligence

The studies from this field demonstrate that the use of artificial neural networks in classifying and sorting agricultural products brings significant improvements in terms of accuracy and efficiency of the process, contributing to the final obtaining of higher quality products.

One method used by artificial intelligence to achieve these goals is the processing of product

images based on artificial intelligence. This method can classify images into different categories, which is extremely useful for detecting and classifying products.

Technology allows the automation of many tasks that are currently performed predominantly manually, such as identifying defects, sorting objects on conveyor belts and quality control checks. In particular, the ability of artificial intelligence to recognize complex patterns and structures in images makes it an essential tool for quality assurance, since many of these details are difficult to observe with the human eye.

Over time, the integration of artificial intelligence into the food industry has marked a turning point in the processing, sorting and distribution of products. While initially the technology was used only to automate simple processes, today, advanced machine learning algorithms and deep neural networks have radically transformed the entire food production chain. These systems not only identify subtle defects but also manage the natural variability of raw materials and adjust production processes in real time. Thus, they contribute to reducing food safety risks and minimizing losses, while optimizing the resources used. Neural networks and decision trees are two methods used in modern automated classification and sorting processes for agricultural products, including potatoes. Each of these techniques has distinct advantages in terms of accuracy, processing speed, and interpretability of results.

Numerous studies have explored the use of artificial neural networks in this field. For example, Bennedsen used principal component analysis and artificial neural networks to detect surface defects in apples in near-infrared images, achieving an accuracy rate of 79% [1]. Unay and Gosselin developed a defect detection system based on neural networks, which achieved an accuracy of 89.9% in their classification [6]. Motaveli compared traditional mathematical models and artificial neural networks for predicting the drying process of pomegranates, demonstrating the superiority of neural networks [3,9,10]. Llobet proposed a classification model based on electronic sensors to determine the ripeness of bananas, using and comparing three different classification methods: Fuzzy ARTMAP, LVQ and artificial neural networks [2]. In another study, Rasekhi and Raoufat analyzed the performance of three neural network

models for orange classification, concluding that the MLP-RP and MLP-SCG models provided better results than the classical back-gradient propagation algorithm. Researcher Song proposed an automated method that takes multiple images for recognition, counting fruits of different colors and complex shapes. Yamamoto et al. developed a method using a conventional RGB digital camera together with machine learning to correctly detect the ripeness of tomatoes [5]. Wang et al. created a computer system for accurately identifying and registering apples based on input images. To reduce the variation of natural lighting, it operates with controlled artificial lighting at night [8]. Some previous works have discussed the problems and challenges in fruit recognition systems and proposed deep learning-based algorithms for fruit recognition.

3. Using Google Teachable as an artificial intelligence tool for fruits and vegetables identification

Google Teachable Machine is an online application developed by Google that allows users to create artificial intelligence models in a simple and intuitive way, without the need for advanced programming knowledge. The platform works directly from the browser and can be used to more easily understand how a machine "learns" to recognize objects, sounds or movements. This platform allows machine learning models to classify and recognize objects based on images, sound or movement. To identify fruits and vegetables using Google Teachable machine, the following steps are taken:

First, the platform is accessed (<https://teachablemachine.withgoogle.com/train>) which is accessible directly from the browser. After accessing the platform, the user selects the type of project they want to create. For the current study, the "Image Project" option was selected, as the main goal is to classify agricultural products (potatoes) based on visual characteristics, such as surface defects or other quality variations [11,12].

The next step is a crucial one in using Teachable Machine and involves creating a dataset for training the model. The user must collect relevant images for each category that he wants the model to recognize (Fig 1).



Fig.1. Sample of good quality potatoes for training artificial intelligence algorithms [12]

In the present study, images of potatoes from two categories were collected: good quality potatoes – with proper physical appearance, without obvious defects and low-quality potatoes – with spots, imperfections or other signs of damage.

Each category of images is uploaded to the platform and labeled accordingly, so that the Teachable Machine can learn the characteristics of each class (Fig.2).

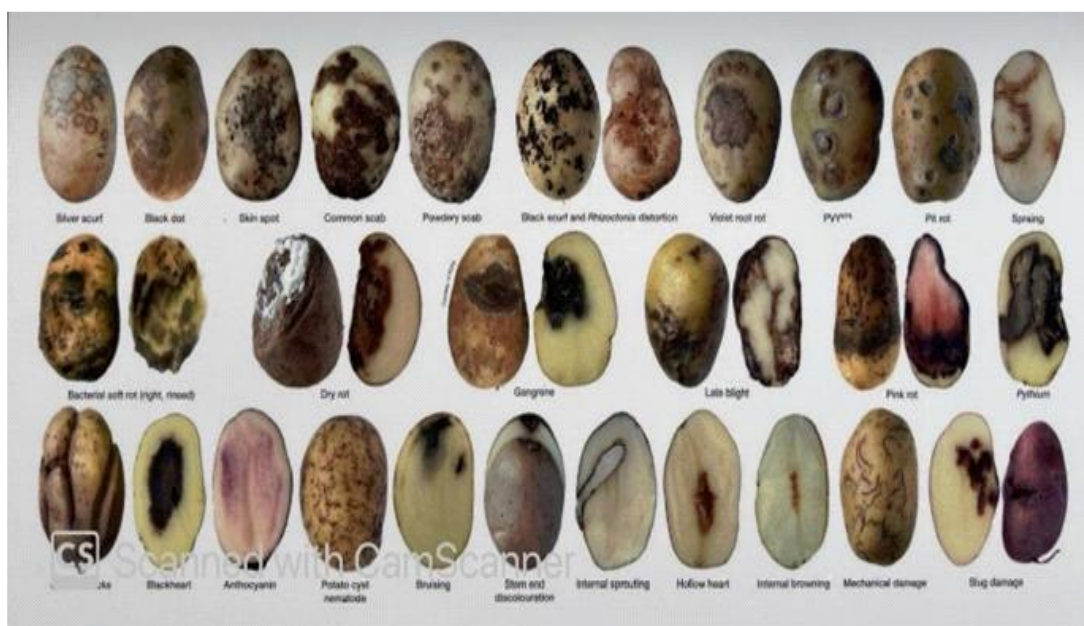


Fig.2. Sample of low quality potatoes for training artificial intelligence algorithms [12]

Once the image set has been loaded and labeled, the training of the model begins (Fig 3). Teachable Machine uses machine learning algorithms to analyze images and learn class-

specific models. This is the process in which the platform learns to recognize the differences between good and low-quality potatoes based on visual characteristics [12].

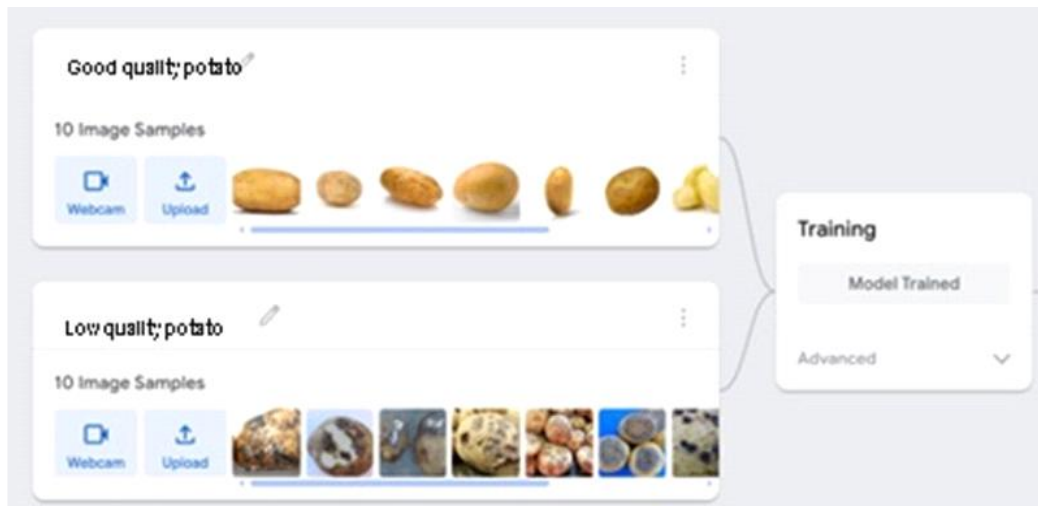


Fig.3. Training artificial intelligence algorithms [12]

After training is complete, users can test the model on new sets of images. The platform allows you to upload additional images or capture them in real time via a device's webcam. The trained model will automatically classify potatoes, determining whether they are compliant or defective, based on previous learning [12].

The model has an accuracy of 92%, indicating very good performance in the context of visual recognition (Fig.4). The following errors were identified: 5 classification errors for compliant potatoes being misidentified as defective and 3 errors for defective potatoes being misclassified

as low-quality potato. This graph shows how confidently the model classified each image. Most scores are in the range of 0.60–1.00, so the model is relatively confident in its predictions.

After the model has been successfully trained and tested, users can export the results. Teachable Machine allows you to save the trained model in an easy-to-use format for implementation in various applications. For example, you can export the model to be integrated into a JavaScript application for use on a website or mobile app [12].

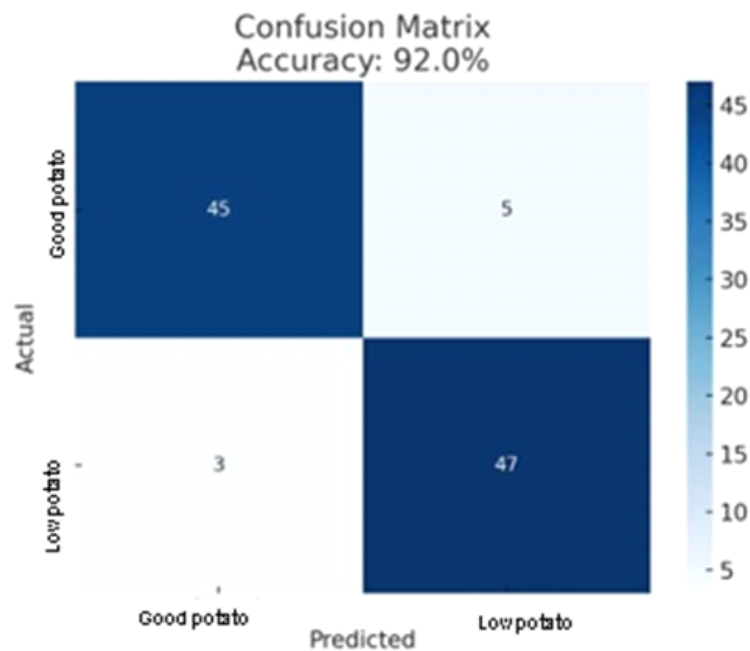


Fig.4. Testing and evaluating the trained model [12]

4. Conclusions

Sorting vegetables and fruits with artificial intelligence brings numerous advantages to both producers and consumers. First, automated systems ensure much greater efficiency compared to manual sorting, as they can process large volumes of products in a short time, thus reducing dependence on labor and increasing productivity. In addition, accuracy is much higher, as smart sensors and cameras can identify subtle differences in color, size, shape or defects that the human eye might miss.

Products that have minor imperfections, but are still edible, can be redirected to industrial processing, avoiding their disposal. Thus, the entire harvest is better utilized. At the same time, smart sorting contributes to the standardization of batches, ensuring uniformity in appearance and degree of ripeness, which is essential for meeting market requirements and for the attractiveness of products on the shelf.

The use of artificial intelligence also offers the possibility of collecting data on the quality and quantity of products, information that can later be used to optimize agricultural, storage and distribution processes. In the long term, these advantages lead to cost reductions by minimizing losses and increasing overall efficiency, compensating for the initial investment in technology. Finally, automated sorting with AI helps to increase food safety and consumer satisfaction, as fruit and vegetables of consistent quality reach the market, without major defects or risks of contamination. In this way, artificial intelligence not only modernizes the sorting process, but also supports the development of more sustainable and profitable agriculture. The artificial intelligence-based method offers a similar advantage in terms of efficiency and accuracy, with a higher processing speed. However, it also has its limitations: in the event of a minor defect, the entire potato is discarded, and the non-compliant parts cannot be recovered, thus leading to additional losses. This technology also involves high initial costs and requires constant maintenance and recalibration of equipment. However, the adoption of AI in this sector also raises several challenges, including issues related to ethics, data security, system interoperability and technology accessibility. Thus, responsible implementation of AI in the food industry must find a balance between innovation and concerns

about safety, sustainability and the long-term impact on food systems.

References

1. Bennedsen, B. S., et al. (2007). *Detection of apple surface defects using principal component analysis and artificial neural networks in near-infrared images*. Biosyst. Eng., 90 (4), 419-431;
2. Llobet, E., et al. (1999). *Electronic sensor-based classification model for determining banana ripeness using Fuzzy ARTMAP, LVQ, and artificial neural networks*. Meas. Sci. Technol. 10, 538–548
3. Motevali, A., et al. *Drying of Pomegranate Arils: Comparison of Predictions from Mathematical Models and Neural Networks*. Int. J. Food Eng, 6 (3);
4. Hameed A, Ali TM, Hermanto. *Machine-Learning-Based Approach to Orange Quality Detection and Classification*. Eng. Proceedings. 2025; 107(1):92.
5. Song, Y., et al. (2014). *Automatic fruit recognition and counting from multiple images*. Biosyst. Eng., 118, 203-215.
6. Ünay, D., & Gosselin, B. (2005). *Artificial neural network-based segmentation and apple grading by machine vision*. IEEE International Conf. on Image Processing 2005, 2, II-630;
7. Yamamoto, K., et al. (2014). *On plant detection of intact tomato fruits using image analysis and machine learning methods*. Sensors, 14(7), 12191-12206;
8. Wang, Q., et al. (2012). *Automated crop yield estimation for apple orchards*. Proceedings of the 13th International Symposium on Experimental Robotics. Québec City, Canada;
9. D.M. Dănilă, L. Gaceu, W. W. Thierheimer, et al. (2010). *Management of the potato crops for minimizing environmental and human health impact*. EEMJ., 1685.
10. Gaceu L., Lepadatescu B., (2013). *Monitoring of the Vegetables Drying Process using Infrared Images*, Advances in Envir. Tech., Agri., Food and Animal Sci., 267-272;
11. L. Gaceu, D. Tucu, D. Mnerie, *Labview tool for infrared monitoring the quality of vegetables drying process*, 43rd Inter. Symp. on Agri. Eng., „Actual Task on Agricultural Engineering”, 311 – 320, Opatija, 2016, ISSN 1848-4425;
12. G.V. Șerban (2024). Master's thesis: *Contributions on the quality assessment of agricultural products of plant origin through the use of artificial intelligence*.

THE ADMINISTRATIVE-TERRITORIAL REORGANIZATION MODEL BASED ON THE BIOHARMONISM OF ECOANTHROPOSYSTEMS

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Abstract: The study addresses the pressing issue of Romania's administrative-territorial reorganization through a model that brings as a novelty the application of the bioharmony paradigm to an integrated territorial landscape represented by zonal ecoanthroposystems. The paper defines this complex unit, which is analyzed structurally and functionally, highlighting the emergence and systemic resilience. A framework model of territorial reorganization through administrative re-settlement into 9 departments resulting from the calculations of the proposed methodology is presented. The principles and regulations necessary for the functionality of the new model are specified, showing what the criteria for restructuring and delimitation into bioharmonious departments are. The process diagram is established, which involves laborious calculations and comparisons, so as to highlight the metric indicators taken into account in the diagnosis of ecoanthroposystems. A calculation methodology is applied, from which specific indicators result that indicate the new organization on the 9 departments from the balanced and harmonized re-arrangement of the current counties. The resulting map and the framework elements regarding the functionality of the departments in relation to both the national center and the component localities and local communities are presented.

Keywords: bioharmony, eco-anthroposystem, systemic effectiveness, territorial departments.

1. Introduction

The feasibility of the study is based on the current administrative-territorial structure of Romania, which is artificial and political, unchanged for over half a century. It no longer reflects the realities of current development and, especially, does NOT reflect real ecosystems and resources. It is not adapted to the current geopolitics of European integration and globalization, to the current systems of high-performance development and financing, but also to adaptation to overlapping crises, especially climate change and environmental protection. It is worth noting the importance of adapting eco-anthroposystems to all of this and to supporting food security, in short, to ensuring food for the Romanian population. In this context, both in our country and worldwide, negative effects related to the "climate - food" relationship are being recorded, where international statistics show that global warming leads to 500,000 victims

annually and to damages of 1000 billion dollars. In our country, desertification and pedological drought are leaving their increasingly visible and damaging mark in southern Romania and in Dobrogea. That is why there is an urgent need for reforms, starting with territorial reorganization because Romania's current administrative model is counterproductive. It ignores major ecosystem differences (plain, hill, mountain), does not capitalize on local bioeconomic potential and is not built on the principle of the natural flow of resources, but on political criteria and historical conventions.

1.1. Literature review

We specify that numerous international academic and theoretical sources are intensely concerned with modernization and territorial resilience regarding globalization, regional development, regionalization, decentralization, etc. [2-5, 8, 14, 23, 24]. Special attention is observed in relation to regionalization and

integrated governance [6, 7, 11]. The issue of territorial reorganizations is also analyzed in relation to the quality of life, the food, education and health system, the rural-urban relationship and aspects regarding the relationship between centralization and decentralization [1, 9, 10, 12]. It is necessary to mention the technical and legislative concerns of this issue on an international level [15, 21], but also on a national level [13, 16, 19]. Romanian concerns are eloquent, addressing various points of view in this complex, but politically delayed issue [17, 18, 20, 22]. In this direction, the novelty of this study is also distinguished, which refers to the idea that the territory is NOT a map, it is a LIVING SYSTEM. The new model brings to the fore the idea that the current administrative structure fractionates ecosystems, while through the paradigm of bioharmony (dynamic equilibrium and multiple integrations with emergent effect) it reintegrates them and adapts them convergently with anthroposystems.

In this way, the integrated structural components of eco-anthroposystems are taken into account, namely the harmonization between: ecosystems (Nature), anthroposystems (man, community) and resource flows (energy, information, matter). All of this is based on the idea of BIOHARMONY with all its semantic nuances: "bioharmonic" (respectively an adjective, indicating a manifestation, which shows the quality or state of a thing or a system of being in harmony with life), "bioharmony" (as a noun, which shows the process of living balance and harmonization of a phenomenon and/or system) and, of course "bioharmony" (as a noun describing the theory / paradigm / doctrine that proposes how to obtain the process of bioharmony and reach a bioharmonious state, that is, how the thing, phenomenon or system can function as a methodology and paradigm at the individual, societal and global levels).

2. Working Methodology

A comparative analysis between ecosystems and anthroposystems and their harmonized integration is carried out, with an applied study on the territorial resources of the given area (including with reference to the agri-food field of activity), highlighting a comparison of flows of physical and biological environments. Structures of block diagrams, statistical aspects, principles, systemic flows and defining and conceptual elements, as well as methods of eco-energetic

analysis are compared. The methodology refers to the BIOHARMONY paradigm supported by the bioharmonic principle of reorganization, as a phenomenological state and manifestation, a principle based on the processes of bioharmony. Methodologically, bioharmony essentially proposes how to obtain and how the state of bioharmony can function at all systemic levels ("eco-", "anthropo-", "eco-anthropo" in integronic dynamics with emergent effect).

3. Results and Discussion

The conceptual premises of the work are based on an ideological novelty. Thus, BIOHARMONY, in its theoretical meaning, proposes a paradigm of societal reorganization based on the harmonization between the natural environment (eco-system), human communities (anthropo-system) and the flows of biological, material and informational resources. In this framework, the "ECO-ANTHROPOSYSTEM" represents an integrated ensemble in which man, community, economy and natural environment form a "living organism", interdependent, self-regulating, in which balance is not a static result, but a dynamic process of bioharmonization, resulting in systemic emergence (see box below).

Bioharmonism = harmonization between ecosystem + anthroposystem + resources, and Romania approached as a living organism, not just as an administrative map.

Key concept: Ecoanthroposystem (EAS) = natural functional unit, based on the emergent integration: Nature – Community – Resources.

3.1. Model of Administrative-Territorial Reorganization of Romania

Model based on ecoanthroposystems and bioharmonism criteria with reorganization into bioharmonious departments

Contemporary civilization is facing a systemic crisis derived from the increasingly accentuated rupture between nature and society — between ecosystems and anthroposystems. In this context, the Theory of Bioharmony (Gruia, R., 2019) proposes a unifying vision, based on the principle that life, matter, energy and consciousness are expressions of the same fundamental informational flow, and societal balance derives from the harmonization of these flows on the 7 existential levels in integronic dynamics (multiple integrations):

Information – Energy – Matter – Ecology –

Society – Culture – Consciousness

The structure of a bioharmonious unit of the ecoanthroposystem type can be analyzed in summary in Table 1.

Table 1. *Structure of an Ecoanthroposystemic Bioharmony Unit*

Flow Level	Bioharmony Integration Level	Component Specification of the Eco-Anthroposystem
Level 1	Information	• geospatial data, sustainability indicators
Level 2	Energy	• renewable resources, local energy autonomy
Level 3	Matter	• material resources, agriculture, local industry
Level 4	Ecology	• biodiversity, ecosystems, resource management
Level 5	Society	• local administration, public services
Level 6	Culture	• traditions, creativity, heritage
Level 7	Consciousness	• community, values, local identity

This general model allows the definition of territorialized bioharmonic indicators, which creates a new metric for development, analysis and interpretation. In this sense, territorial reorganization, based on the integrated approach of eco-anthroposystems, starts from a series of fundamental questions: (1) What is the natural functional unit? (geographic ecosystem); (2) What is the human community that co-evolves with that ecosystem? (anthroposystem) and (3) What are the resource flows that unite the two

system types? (emergent convergence). The bioharmonist principal results in which reorganization also starts from a series of questions, but of a pragmatic nature: What is the natural unit? / Which community co-evolves with it? / What resources circulate between them?

Starting from these considerations, the reorganization method addressed in this study takes into account the fact that the administrative-territorial unit is not a county, but an ECOANTHROPOSISTEM (acronym: EAS), pragmatically found in a group of counties interconnected harmoniously in balanced and viable departments.

This structure with a better efficiency of territorial landscape management is defined by a series of elements that can be quantified. We refer briefly to: bioecological identity (relief, climate, biodiversity), economic identity (local resources, agri-food chains, renewable energy) and socio-cultural identity (history, traditions, functional communities).

From this perspective, the relationship between the ecosystem and the anthroposystem is no longer just a matter of applied ecology, but a problem of ontological convergence between two forms of life organization: the natural and the built.

Bioharmonism thus offers a framework for systemic reconnection between these two domains of reality (the ecosystem and the anthroposystem) through their convergence in the harmonized form of the ecoanthroposystem (table 2).

Table 2. *The Theoretical Relationship Between the Three Forms of Bioharmony*

Type of bioharmonism	Prevailing levels	Type of balance	Finality
Ecosystemic	Information – Energy – Matter – Ecology	<i>Natural, self-regulating</i>	♦ Preservation of life
Anthroposystemic	Conscience – Society – Culture	<i>Conscious, rational</i>	♦ Equitable human development
Eco-anthroposystemic	All 7 levels integrated	<i>Conscious-bioethical, synergistic, emergent</i>	♦ Coevolution and continuity of various areas of the biosphere and civilization

As can be seen, ecosystem bioharmonism provides the MODEL, anthroposystemic bioharmonism provides the WILL, and ecoanthroposystemic bioharmonism provides the SYNTHESIS — in a process of conscious

coevolution of life and culture. Consequently, the fundamental principle addressed in this study refers to the fact that instead of reorganizing the territory according to political, historical, or

strictly demographic criteria, the reorganization proposal starts from a logical flow:

the logic of nature → the logic of resources → the logic of communities → only then the administrative logic.

Therefore, as previously stated, the administrative unit is no longer the "county" (political construction), but the eco-anthroposystemic department, namely a FUNCTIONAL TERRITORIAL UNIT, defined by the following benchmarks:

- ecological continuity and similar ecosystems,
- coherent natural resource and agri-food chains,
- energy and autonomy infrastructure,
- socio-cultural identity and functional communities.

A methodological element in the sense of the aforementioned is the approach through the principle of geographical specificity, that is, understanding the flow of resources → ecosystems → communities, DIFFERENTIATED according to the agro-geographical conditions for ensuring food and energy of the Romanian territory:

- ✓ Mountain area – agro-silvo-pastoral EAS, hydro energy, slow tourism.

- ✓ Hill area – viticultural EAS, fruit growing, local bioeconomy.
- ✓ Plain area – intensive agricultural EAS, agri-food logistics.

From the summarized results, a series of advantages of the eco-anthroposystemic approach result, namely: strengthening local autonomy, optimized application of the circular economy, so that the analysed society, which is divided into departments, has the potential to become more balanced and sustainable.

3.2. Principles of Departmental Restructuring

The diagnosis carried out shows that in the related resources of an EAS, the following are taken into account in summary:

- ✓ natural resources (water, forests, biodiversity);
- ✓ agri-food resources and short chains;
- ✓ renewable resources (solar, hydro, wind - depending on the altitudinal zone);
- ✓ human resources (social capital, intellectual capital);
- ✓ identity resources (heritage, traditions, territorial brand).

Through the new territorial restructuring model, resources are not "exploited", but "regenerated" through bioharmonization (table 3).

Table 3. Criteria for Restructuring and Delimitation into Bioharmonic Departments

No. crt.	CRITERIAL CATEGORY	TYPE OF CRITERIA	SPECIFICATION
1	Primary criteria (<i>eco-geographic</i>) As harmonization: resources flow, administration must follow them	<i>Altitude</i>	➤ mountain – hill – plain
		<i>Dominant natural resources</i>	➤ agro, forestry, water, renewable industrial
		<i>River basins</i>	➤ river, stream, sub-basin
2	Secondary criteria (<i>anthropo-socio-economic</i>)	<i>Food</i>	➤ food security and safety, short agri-food chains
		<i>Infrastructure</i>	➤ integrated access, internal mobility and distance to the center
		<i>Culture</i>	➤ regional cultural and historical identity
3	Conceptual criteria (<i>bioharmony paradigm</i>)	<i>Energy</i>	➤ energy autonomy
		<i>Food</i>	➤ food autonomy
		<i>Flows</i>	➤ circulation of information and intellectual capital
		<i>Integration</i>	➤ maintaining the balance between <i>Nature - Community - Culture</i> .

The analysis of table 3 essentially indicates the PROCESS DIAGRAM formed by the flow elements: Ecosystem → Resources →

Anthroposystem → Bioharmonization / Department (fig.1).

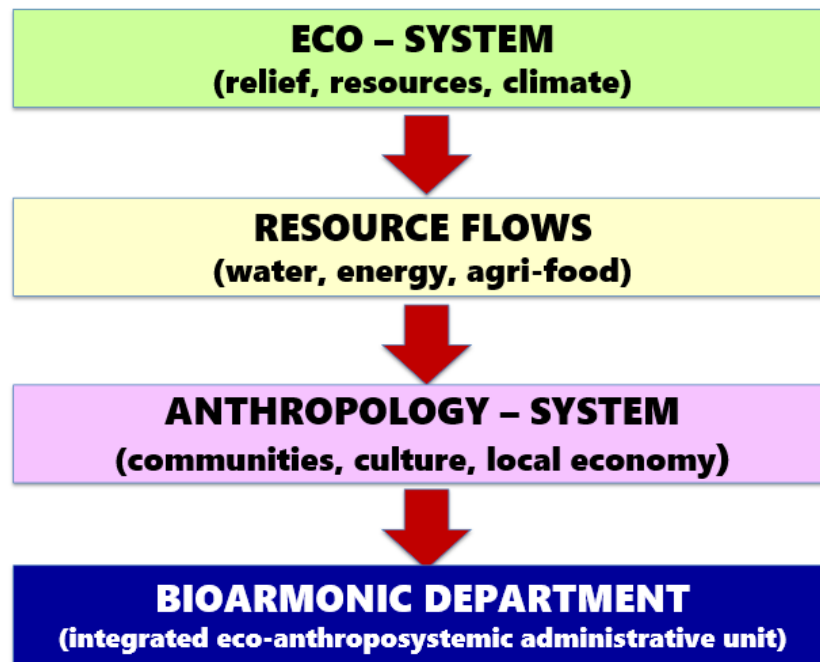


Fig. 1. *Ecoanthroposystemic flow logic diagram*

The advantages of the proposed new model, compared to the current model, are indicated in the box below:

Table 4. *Comparasion between the current and proposed model for restructuring*

Current political-administrative model: COUNTIES	Model based on the bioharmonism paradigm: DEPARTMENTS
Territorial fragmentation	Ecoanthroposystemic continuity (EAS)
Arbitrary territorial pieces	Units based on natural logic and resources
Political line drawn on the map	Natural structure + resources + community
Dependence on the center	Autonomy through resources and real subsidiarity
Institution-oriented governance	Resource- and community-oriented governance
Consumption and waste	Regeneration and circularity
Uneven development	Eco-socio-economic convergence

The model of administrative-territorial reorganization of Romania based on bioharmony, namely taking into account ecoanthroposystemic integration, practically makes possible the multi-faceted integration of the economy, ecology and local community; reduces the center-periphery tension; creates convergence between rural and urban areas; simplifies and accelerates the transition to the circular economy and renewable energy.

The new model supports the idea that Romania should not be redivided, but viewed as a living organism, that is, it should be reharmonized.

The result of these principles, approaches and rules has as applications a series of calculations and comparisons, which are expressed precisely through the administrative-territorial reorganization of our country.

3.3. Proposal for Reorganization Through Territorial Bioharmony

A clear and coherent formulation regarding the territorial reorganization of Romania on the principles of bioharmony, requires a comprehensive analysis and laborious calculation so as to result in the metric indicators necessary for the diagnosis of the EAS.

Following this approach, the data were grouped by departmental areas, taking into account the essential indicators and geographical proximity. Among the concrete data (provided by GIS/ INS/ IFNANRE sources and the necessary weightings) we can list the following: - Number of inhabitants | - Territorial area | - Dominant landscape (geographical and forest) | - Potential for providing agri-food products | - Prosumers (number of key counties) | - Solar potential (kWh/m²/year, estimated regional average) | - Wind potential (observation/estimated average speed) | - Forest cover (estimate % of departmental area) | - Water resources — indicator (m³/inhabitant/year — regional estimate / observation) | - Tourism (arrivals/resident or absolute arrivals by main county).

Within the bioharmonistic analysis prior to the administrative-territorial reorganization, the diagnosis of each regional EAS is based on a coherent set of integrated metric indicators, which reflect the state, potential and territorial vulnerabilities. These were grouped into 6 categories as follows:

- RN = Natural Resources;
- AA = Agro-Food & Short Chains;
- REG = Renewable;
- RU = Human Resources;
- ID = Identity;
- SBF = Final Bioharmonic Score.

Their values are normalized on a scale of 0 – 100, and the 6 synthesis indicators, after analytical modeling, were grouped into 9 departments having as a benchmark the complex systemic integration of the ecoanthroposystems type.

Since the volume of calculations is very large, we will not go into details (they can be presented upon request), but we will show the results per indicator, but also for the integration of indicators in the analysis of the reorganization on the 9 Departments, when the Final Bioharmonic Score (SBF) was calculated.

We assume that SBF was calculated according to the framework formula:

$$SBF = \sum (w_i \cdot I_i)$$

where w_i = indicator weight (0–1), I_i = normalized value (0–100). The weights that we consider balanced at the ecoanthroposystemic level (100%) and indicated to be recommended are: Natural resources: 30%; Agri-food + short chains: 25%; Renewables: 20%; Human resources: 15%; Identity: 10%. The summary of the results is presented in table 5.

Table 5. Resulting Indicators for the 9 Proposed Departments

No. crt.	Bioharmonic Department	RN	AA	REG	RU	ID	SBF
1	Northern Transylvania	82	74	69	66	75	73.1
2	Southern Transylvania	79	70	65	71	83	73.3
3	Northern Moldova	63	59	54	48	57	56.3
4	Southern Moldova	50	61	52	46	49	53.1
5	Western Wallachia	57	68	55	53	62	58.4
6	Eastern Wallachia	44	63	88	49	54	59.8
7	Oltenia	59	65	56	44	48	55.4
8	Banat–Crişana	73	72	81	63	70	71.0
9	Bucharest Region	18	46	22	98	79	52.4

It is noteworthy that the Final Bioharmonic Score is in a balanced range, compared to the current unbalanced gap between counties, the departments having bioharmonistic potential with SBF between 50 – 75%. There are no vulnerable departments, i.e. below 50%, they fall into departments in transition towards a high potential (towards 75%). In the future,

the desired evolution would be towards advanced departments, i.e. between 75–100%. The comparison of the gap in GDP contribution decreases by about 3.3 times in the new reorganization (6.5:1.98), that is, from the current gap of the counties (Cluj vs. Tulcea = 5.2:0.8 = 6.5 times the current difference) to the gap of the departments

(Transylvania North vs. Moldova South = 12.3:6.20 = 1.98 times the difference in the proposal). The specific characteristics of each department are described in table 6 of the proposal for territorial reorganization into 9 departments with bioharmonization potential as complex ecoanthroposystemic units.

Table 6. *Proposal for Territorial Reorganization into 9 Bioharmonic Departments*

No.	DEPARTMENT NAME	INCLUDED COUNTIES	REGIONAL CAPITAL	ECOANTHROPOSYSTEMIC OBSERVATIONS
1	Northern Transylvania	Bihor, Satu Mare, Maramureș, Sălaj, Cluj, Bistrița-Năsăud	Cluj-Napoca	Innovation hub, agro-bioeconomy, West–Europe connection / Agro-silvo-pastoral ecoanthroposystem and cultural heritage / Western agro-bioeconomic transition / major university center and IT development.
2	Southern Transylvania	Brașov, Covasna, Harghita, Sibiu, Alba, Mureș	Brașov	Department of Green Energy and Responsible Mountain Tourism / renewable energy, mountain ecoanthroposystem / – Department of innovation, advanced technological industry and agro-bioeconomy.
3	Northern Moldova	Suceava, Botoșani, Iași, Neamț, Bacău, Vaslui	Iași	Agro-silvo-pastoral ecoanthroposystem and cultural heritage / agriculture, hydropower / light industry / major university center.
4	Southern Moldova	Galați, Brăila, Vrancea, Buzău, Tulcea	Galați	Lower Danube – Agroindustry and river logistics / river logistics, Danube Delta, agri-food on river basins / Sea and Wind – Wind energy, port, Danube Delta & ecotourism.
5	Western Wallachia	Argeș, Dâmbovița, Prahova, Teleorman, Giurgiu	Ploiești	Department of hydro-energy resources and mountain agro-zootechnics / agro-forestry-industrial, energy and urban mobility / Agri-food department based on viticulture and fruit growing Land of Vineyards and Fruits
6	Eastern Wallachia	Ialomița, Ilfov, Călărași, Constanța	Constanța	Danube Grain Plain – Agro-industries and food autonomy / grain agriculture + maritime resources (port / maritime logistics) Dobrogea – Sea, coastal tourism and Wind – Wind energy, seaport.
7	Oltenia	Dolj, Gorj, Vâlcea, Olt, Mehedinți	Craiova	Agri-food department based on viticulture and fruit growing, bioenergy, agriculture, mineral resources, light industry.
8	Banat–Crișana	Timiș, Arad, Caraș-Severin, Hunedoara	Timișoara	Department of Renewable Energy and European Logistics / Technology Industry, Western Eco-Bioeconomy, Cultural Specificity.
9	Bucharest Region	Municipiul București	București	National reference governance pole, industry, trade, innovation, services, financial pole.

As a visual expression, we present the administrative-territorial reorganization model in the map in Figure 2.

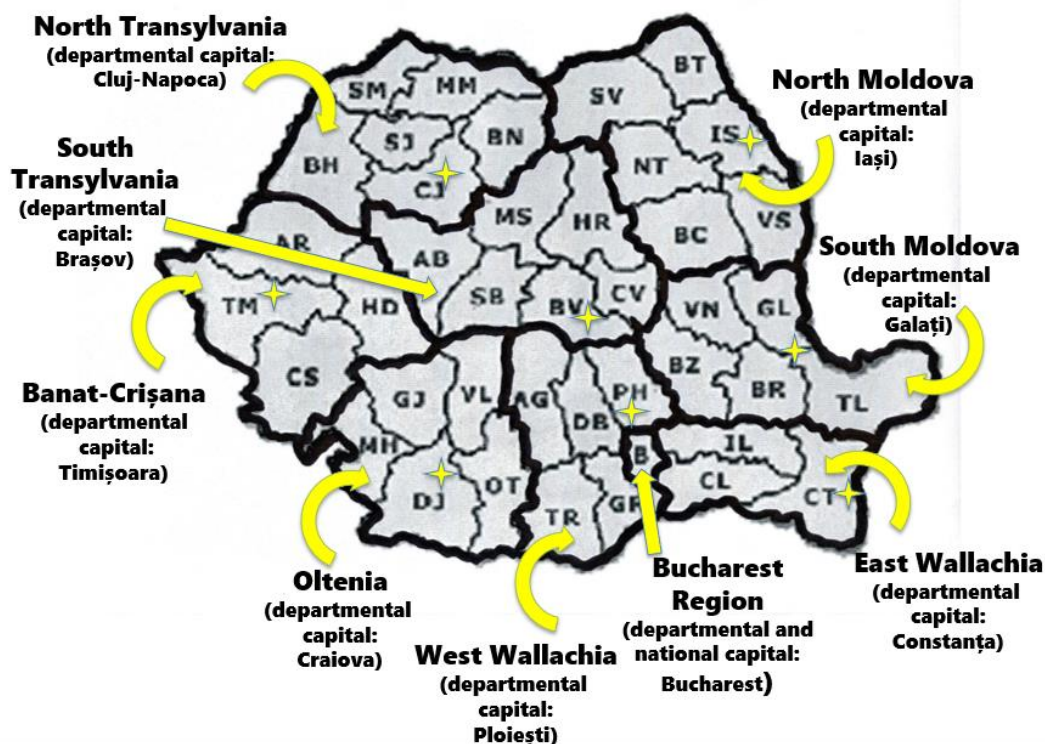


Fig. 2. The proposal for the administrative-territorial reorganization of Romania

3.4. Management Flow Regarding the Functionality of the Proposed Model

Societal bioharmonism applied in public policies ensures the balance between environment, society and culture, in the context of respecting natural resources and the dynamics of local communities. The bioharmonist model of territorial reorganization pursues two objectives simultaneously, namely: (1) Increasing the efficiency of the state (through strategic centralization of functions that require unity); (2) Real and participatory democracy (through operational and decision-making decentralization at the level of departments and communities), as shown in the box below.

✓ The administrative-territorial reorganization of Romania into 9 Departments based on the paradigm of bioharmony, through the integrated model of ecoanthroposystems:			
Intelligent centralization		↔	Democratic decentralization
Centralization	=	Decentralization	=
strategy,	norms,	operational	autonomy
standards and control.		and direct budgets.	
■ Bioharmonic decision-making flow (simplified) State → Department → Community → Citizen with feedback and participatory veto rights (through deliberative electronic voting).			

Putting these aspects into practice requires the establishment of principles, but also the negotiation between state actors of what is centralized at the national level, what is decentralized at the departmental level, and what is micro-decentralized at the local/municipal level, with the idea that there are a lot of elements that must reach as close as possible to the citizen, to cities and communes.

Conclusions

1. Romania should not be redivided, but should be reharmonized through balanced departments with economic and social self-sustainability, a model that induces a reduction in the number of intermediate administrative entities (counties, regions, but also unviable UATs) facilitating the clarity of responsibilities and the acceleration of decision-making processes.
2. The reorganization into 9 departments (instead of 42 counties) optimizes resource management and reduces decision-making fragmentation. The departments centralize strategic functions, while maintaining the connection with the local level, which allows for a better allocation of budget and personnel, but also allows for increased administrative efficiency.

3. The proposed structure takes into account geographical, economic, cultural and bioharmonic criteria, favoring the balance between developed and less developed areas, simultaneously with the reduction of regional divergences, as a result of the increase in social cohesion and zonal (regional) coherence favoring a balanced development.

4. The conceptual basis of the reorganization in the proposed model is supported by the notion of ecoanthroposystem, that is, a complex and coherent system in a special dynamic, when the system functions bioharmonically, manifesting bioharmony, being supported by the bioharmonism paradigm, which is the theory that defines and structures this mode of functioning.

5. The reorganization is not only administrative, but also an opportunity to integrate principles of societal bioharmony into public policies, so that the 9-department model has the potential to provide flexibility in planning infrastructure, agriculture, education and health. Through democratic decentralization, each department can develop personalized strategies, taking into account local specifics, bioharmonic indicators, but also the national interest, essentially supporting better flexibility and adaptability.

References

- 1.Allen, T. (1974). *Vanishing wildlife of North America*. National Geographic Society. Science Buddies+1.
- 2.Benedek, J., Cristea, M., & Szendi, D. (2015). *Spatial polarization and socioeconomic disparities in Romania*. Eastern Journal of European Studies, 6(1), 155–175.
- 3.Benedek, J., & Moldovan, A. (2023). *Regional development and territorial cohesion in Central and Eastern Europe*. European Planning Studies, 31(4), 623–642.
- 4.Breznitz, D., & Zysman, J. (2013). *The Third Globalization: Can Wealthy Nations Stay Rich in the Twenty-First Century?* Oxford Univ. Press.
- 5.Dall'Erba, S., & Fang, F. (2017). *Meta-analysis of the impact of regional development policies*. Journal of Regional Science, 57(4), 651–681.
- 6.Gruia, R., Popescu, A., Gaceu, L. (2024). *The Bioharmonized Reconnection of the Agricultural System in Romania's Territory in the Process of Administrative reorganization*. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(3).
- 7.Hooghe, L., et al. (2016). *Measuring regional authority: Volume I. A postfunctionalist theory of governance*. Oxford University Press.
- 8.Marsden, T. (2013). *From post-productionism to reflexive governance: Sustainability, agriculture and food*. Sociologia Ruralis, 53(4), 377–396.
- 9.OECD. (2023). *Regions and cities at a glance 2023*. OECD Publishing. <https://doi.org/10.1787/10f5f0c5-en>
- 10.OECD. (2024). *Green transformation and sustainable food systems in EU regions*. OECD Publishing. <https://doi.org/10.1787/agr-2024-en>
- 11.Purdue Online Writing Lab. (n.d.). General writing FAQs. Purdue Online Writing Lab. https://owl.purdue.edu/owl/general_writing/general_writing_faqs.html owl.purdue.edu
- 12.Rodríguez-Pose, A. (2013). *Do institutions matter for regional development?* Regional Studies, 47(7), 1034–1047.
- 13.Schneider, S., & McMichael, P. (2010). *Deepening and repairing ecological democracy: Scales of food sovereignty*. Agriculture and Human Values, 27(1), 141–149.
- 14.xxx - Constituția României (articole privind organizarea teritorială). Președinția României+1
- 15.xxx - European Commission. (2024). *Cohesion Policy 2021–2027: Regional Development and Governance*. Bruxelles. https://ec.europa.eu/regional_policy
- 16.xxx - Eurostat. (2024). *GISCO – Administrative boundaries (NUTS 2024)*. Eurostat / GISCO — geometrie NUTS (dacă preferi standard UE). European Commission+1, <https://ec.europa.eu/eurostat/web/gisco>
- 17.xxx - GADM — descarcă limite admin (județe). gadm.org
- 18.xxx - Guvernul României. (2021). *Strategia de dezvoltare teritorială a României 1.2035 (SDTR)*. Ministerul Dezvoltării. <https://www.mdlna.ro/pages/sdtr2035>
- 19.xxx - Institutul Național de Statistică. (2024). *Anuarul statistic al României*. INSSE. <https://insse.ro>
- 20.xxx - Legea administrației publice locale nr. 215/2001 (cadru actual de referință). Legislație+1
- 21.xxx - Ministerul Dezvoltării, Lucrărilor Publice și Administrației. (2022). *Reforma administrației publice – descentralizare și regionalizare*. MDLPA. <https://mdlpa.ro>
- 22.xxx - OpenStreetMap Contributors. (2024). *Romania administrative boundaries (GIS dataset)*. <https://www.openstreetmap.org>
- 23.xxx - Parlamentul României. (2023). *Legea-cadru a descentralizării nr. 195/2023*. Monitorul Oficial.
- 24.xxx - United Nations. (2022). *World Public Sector Report: Building resilient institutions*. New York: UNDESA. <https://publicadministration.un.org>
- 25.xxx - World Bank. (2023). *Rethinking decentralization: From administrative to functional governance*. Washington, DC: World Bank Publications.

BISCUITS ENRICHMENT WITH HAWTHORN FRUITS (*CRATAEGUS MONOGYNA*): TEXTURAL EVALUATION OF DOUGH CHARACTERISTICS

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Abstract: Hawthorn fruits (*Crataegus monogyna*) have a very big potential for obtaining functional food due to their composition in bioactive. Due the high potential for functional food we investigated the technological effects of addition of hawthorn fruits in the formulation of biscuits by replacing the wheat flour with a powder of hawthorn fruits in proportion of 5, 10, 15, 20 and 25%. The hardness, energy and adhesivity of dough were measured in a textural test at 10, 60 and 120 minutes after preparation. The dough hardness increased from 256g for control sample at 967g for sample with 25% replacement of flour, also the hardness increases significantly during the resting time in samples with hawthorn fruits added with up to 17 and 59% for 60 and 120 minutes. The dough energy correlated very well with the hardness, $R^2 > 0.997$. Measured adhesivity increased in experimental test but decreased in sensorial observation.

Keywords: texture, hardness, energy, adhesivity

1. Introduction

Biscuits, traditionally formulated from wheat flour, fat, and sugar, represent a significant segment of ready-to-eat foods globally [1]. Their widespread consumption across all age groups stems from their accessibility, variety in flavor, and extended shelf life [2]. However, conventional biscuits often lack essential health-promoting bioactive compounds like polyphenols and dietary fiber due to their formulation with refined ingredients [3]. Consequently, the food industry has increasingly focused on developing functional biscuits that incorporate nutrient-rich ingredients, such as whole grains or fruit and vegetable by-products, to enhance their nutritional profile and provide added health benefits [3, 4]. This focus aligns with a growing consumer demand for functional foods, which bridges the gap between nutritional diets and healthy living by offering specific physiological benefits and reducing disease risk [5].



Fig. 1. Hawthorn fruits (*Crataegus monogyna*)

The hawthorn (*Crataegus monogyna*) is a shrub that is part of the Rosaceae family, subfamily Maloideae [6]. The genus *Crataegus* (Hawthorn) originates from northern temperate regions and is composed of approximately 280 species, of which *Crataegus pinnatifida* is the most widespread in China and Asia, while *C. monogyna* and *C. laevigata* are distributed mainly in Europe [7]. Hawthorn pharmaceutical preparations belong to the most studied plant based medicines, which are widely prescribed or used in self medication [8]. Hawthorn is used for hypotensive, vasodilatory, sedative effects in coronary and cerebral sclerosis, and angina pectoris [6]. *Crataegus monogyna* is

frequently used in traditional medicine. This plant constitutes a valuable source of bioactive phytochemicals or bionutrients. It has been found that different hawthorn species exert different effects across all populations. These species are usually used in combination with other medicines as antispasmodic, diuretic, antihypertensive, analgesic, sedative, and antidepressant agents [9].

Traditionally, the fruits are used for their astringent properties in heavy menstrual bleeding and in diarrhea. Hawthorn fruits are often used in the treatment of weak cardiac conditions, especially if this is accompanied by hypertension. Studies have confirmed the potential of hawthorn fruits as a good source of antioxidant constituents [10]. Hawthorn species contain several constituents, with pharmaceutical and/or nutritive values. The main biological activity is attributed to a large number of phytochemical classes, mainly flavonoids, coumarins, amines and terpenoids. The most important metabolites in hawthorn are flavonoids.

These are found either free or in the form of glycosides in flowers, fruits and leaves. Hawthorn fruits are abundant in several minerals, mainly potassium, calcium, magnesium and phosphorus and traces of other minerals such as sodium, boron, chromium, iron, cobalt, manganese and zinc.

Hawthorn fruits are generally found in preparations such as herbal multivitamin and mineral supplements [11].

Disorders of lipid metabolism and fatty liver, obesity and the cardiovascular diseases that arise from them have become a serious global health problem. They are characterized by increased total cholesterol (TC) or low-density lipoprotein cholesterol (LDL-C) and total blood triglycerides (TG) or decreased high-density lipoprotein cholesterol (HDL-C). It has been reported that hawthorn dietary extract reduces blood lipids by lowering TC, TG and LDL content [7].

As a fruit rich in organic and phenolic acids, the organic acids in hawthorn are mainly malic, citric, succinic, ascorbic, oxalic, linolenic and lauric acids [7]. Polyphenols and flavonoids are bioactive compounds in hawthorn; they have also been shown to have significant effects in preventing and treating inflammation and it has been reported that flavonoids extracted from hawthorn with ethanol could act with an anti-inflammatory role.

As a rich source of phenols and flavonoids, hawthorn is widely used as a dietary supplement

to prevent or improve oxidation-related diseases [7].

The aim of this paper is to investigate how hawthorn fruits could be integrated in biscuits to obtain a functional food and how the addition of them will influence technology of production and the characteristics of the final products.

2. Materials and method

2.1. Materials

The fruits were added in biscuits as a powder. The fresh harvested fruits were cleaned, sorted, washed and blanched at 95°C for 15 minutes and after that the stones were removed by sieving. The obtained pulp was dried in a thin layer at 40°C, overnight and, for obtaining the powder the dried material was milled with a lab mill and sieved through a sieve with a 0.5 mm aperture.

The used wheat flour was type 550, offered by Cibi Mill, with a wet gluten content 29.5%, ash content 0.54% and 13.5% moisture. Fat, powdered sugar, salt, corn starch, ammonium bicarbonate and sodium bicarbonate were commercial grade, from the local market, and all reagents were chemical grade.

2.2. Methods

2.2.1. Dough Preparation

For the dough preparation was used a lab mixer type Hobart with a capacity of 1 kg of dough. The preparation was done in two stages, in the first stages was creamed dough fat (100% fat) with powdered sugar and after a creamy mixture was obtained, we added all other ingredients, leavening agents and sodium metabisulphite were added dissolved in water. The recipes are presented in table no. 1.

For the control we used a recipe for biscuits type Petit Beurre [12] and, to test the effects of hawthorn addition, we replaced in proportion of 5, 10, 15, 20 and 25% the mixture of flour-starch and we kept all other ingredients in the same proportion. The dough was rested for 10 minutes and after that analyzed and shaped.

Table 1. Recipes for biscuits with hawthorn

Ingredients	CS	S5	S10	S15	S20	S25
Wheat flour	90	85.5	81	76.5	72	67.5
Starch	10	9.5	9.0	8.5	8.0	7.5
Fruit powder	0	5	10	15	20	25
Powdered sugar	22.5	22.5	22.5	22.5	22.5	22.5
Dough fat	12.7	12.7	12.7	12.7	12.7	12.7
Ammonium bic.	0.13	0.13	0.13	0.13	0.13	0.13
Sodium bic.	0.96	0.96	0.96	0.96	0.96	0.96
Salt	0.76	0.76	0.76	0.76	0.76	0.76
Sodium metabisulphite	0.05	0.05	0.05	0.05	0.05	0.05
Water	21	21	21	21	21	21

2.2.2. Dough texture

A penetration test was used to measure the consistency of the dough, the dough was placed in a cylindrical beaker avoiding formation of air pockets and tested using a cylindrical probe with a 5mm diameter. The parameters of test were: pre-test speed 1.0 mm/s; test speed 1.0 mm/s; post-test speed 1.0 mm/s; target distance 20.0 mm; trigger force 5.0 g. Texturometer TA-XT100C (Stable Micro System) equipped with a 5 kg. load cell was used [13]. The doughs were tested at 10, 60 and 120 minutes after preparation for a better understanding of dough's rheology evolution in time. The hardness was measured with the instrument's software as the average maximum force registered during testing and dough energy as the area under the curve of force. At least 6 measurements were made during the test.

Adhesiveness is determined as a negative value in the force time or force displacement curve that appears when the cylinder is retracted [16].

3. Results and Discussion

3.1. Dough Hardness

The maximum force registered during the compression of the dough is assimilated with the dough's consistency. By analysing the curve of force vs. distance (Figure 2) we observed that the consistency increases abruptly at the beginning of the test and after that it varies almost linearly with the movement of the probes, probably due to the increasing of contact surface between the probe and dough while the probe penetrates the dough sample. We measured the variation of the dough consistency in time and in relation with the proportion of flour-starch mixture replacement, in figure 3 are presented the dough hardness for all the dough prepared.

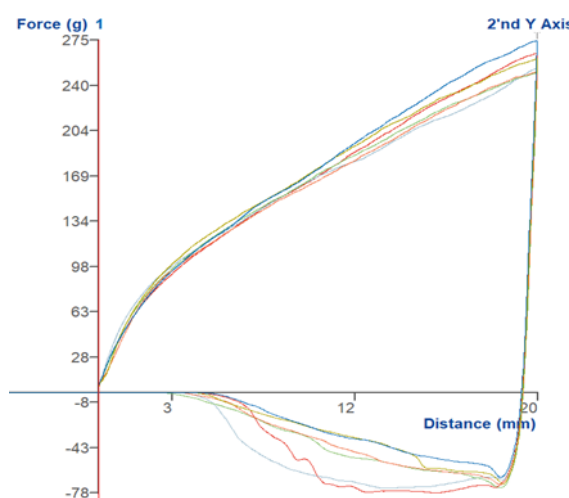


Fig. 2. The plot of compression force vs. distance in the penetration test for control sample at 10 minutes relaxation

The hardness of the dough increased with the level of fruit added. This is due the fact the fruits have a high content of fibres and that fibres absorbed a high amount of water. Despite that the moisture of the doughs are very similar because dried fruits and the mixture of starch and flour have similar moisture content, the doughs look drier and crumblier as the amount of fruits powder increased. The water amount added in the

formulation of the dough was the same for all the samples. The hardness of the control sample varies slightly over time. We expected a small decrease of hardness due to the relaxation of the dough and normal maturation of the dough under the action of the enzymes present in flour, but the hardness was almost the same at 10, 60 and 120 minutes of relaxation, 259.3, 267.6 and respectively 264.0 g.

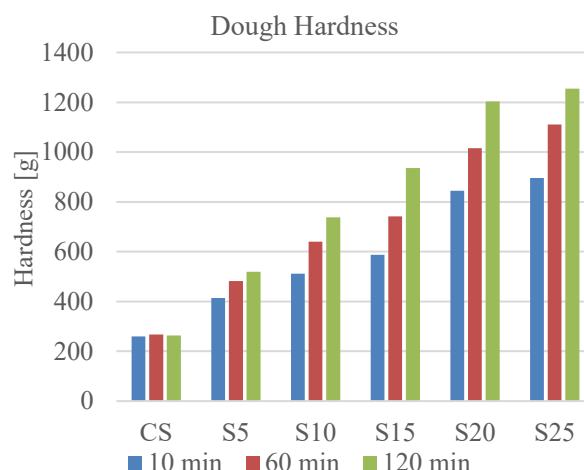


Fig.3. The hardness of doughs with different amounts of fruits powder added, at different times of relaxation

This shows that for this flour and this formulation the resting time of the dough before sheeting and cutting is not crucial. The situation changes for the samples with added fruits, could be observed that the dough hardness increases with the time of relaxation and the increasement was higher as the replacement was higher. In figure 4 is presented how much the hardness of the dough increases during the resting time, as % related to the dough hardness at 10 minutes of resting. We observed that the changes evolve in time but they are not correlated with the amount of replacement. At 60 minutes of resting the increasing of hardness remains in the range of 13-18% but at 120 minutes of resting the values are higher. A maximum was observed at 15% substitution of flour when the hardness increased with almost 59% at 120 minutes after mixing compared with the hardness at 10 minutes after mixing.

We consider that the fibers present in hawthorn fruits contributes at this significant change, fruits

had a high fibres content 13% d.b. [14] and even higher amount of total dietary fibres was determined in *Crataegus pinnatifida* by Lou et al, 41% [15]. At higher level of substitution, the increase of hardness was lower, about 40% for the both level of substitution and probably the fibres present in higher amount compete for the limited amount of water present. These results suggest that, if it is needed to control the rheology of the dough, much attention should be paid at the level of water added at the dough mixing. In the case of the biscuits higher amount of water will lead to doughs with higher plasticity and lower consistency but will increase the cost of production due to the higher amount of water which should be removed during the baking.

Considering that the resting time remains a very important parameter in the control of dough rheology and shorter resting time could improve the machinability of the dough during the shaping process.

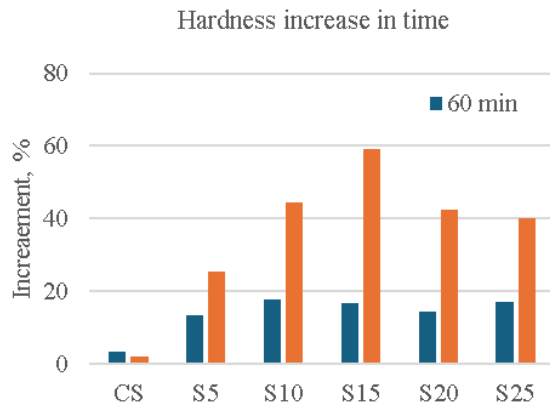


Fig. 4. Dough hardness increase

3.2. Dough Energy

Another important characteristic of the dough is the energy. Dough energy is defined as the area under the curve of force. In figure 5 are presented the energies of the doughs. Comparing the dough energy and dough hardness we observed that they are very similar and that could be explained by that the shape of the curve registered are very similar, in figure 6 are presented the plot of the force vs. distance for all samples tested at 10 minutes of resting. It could be observed that in the linear zone of the plots they are almost parallel.

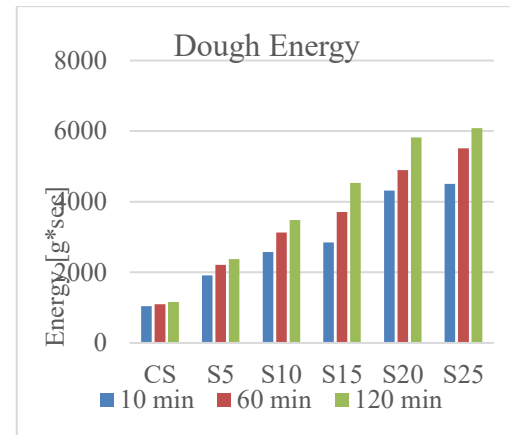


Fig. 5. The energies of doughs

Because of this similarity it is a significant correlation between the force and the energy of the dough and that is shown in the figure 6 where the linear regression coefficient (R^2) is very close to 1. From these results we can conclude that it is not necessary to measure the energy and the hardness of the dough, it is enough to evaluate only one of them.

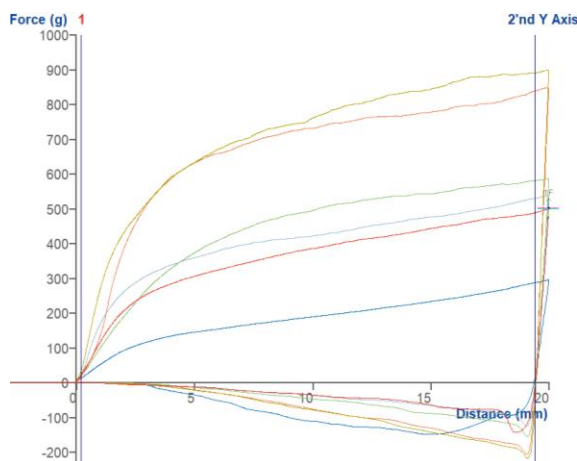
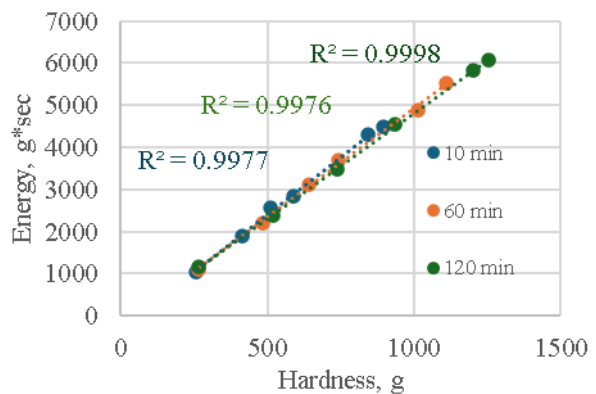


Fig. 6. Hardness of all samples at 10 minutes resting and correlation of dough hardness with dough energy

3.3. Dough stickiness

Dough adhesivity could be an important characteristic because this could influence the proves of shaping. The adhesivity or stickiness could be measured in different ways, one of them is the one which uses a specific device, the Chen-Hoseney cell [16, 17]. We couldn't use this device



because the particles of powder fruits were too big and blocked the holes of the cell. Other devices could be used to measure the dough adhesivity, one of them is a cylindrical probe [16]. Adhesiveness is determined as a negative value in the force time or force displacement curve that appears when the cylinder is retracted and must

overcome the sample's adhesive force at the sample surface. This value reflects the amount of energy required to separate the cylinder from the material, thus expressing the material's ability to adhere to the test sample surface [18]. In the test used to measure the dough hardness we evaluated the dough stickiness too. In the figure 7 are presented the values of dough stickiness for all samples, measured at 10, 60 and 120 minutes after the dough was prepared.

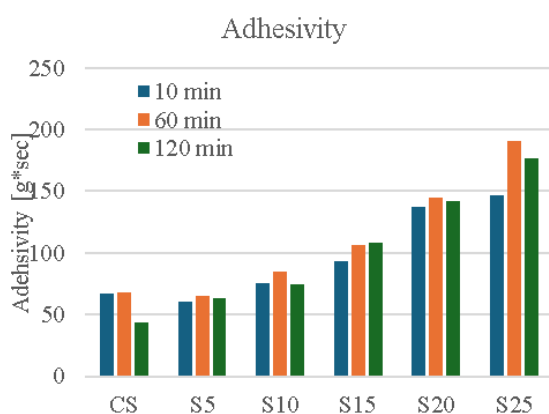


Fig. 7. Adhesivity of the dough prepared without and with hawthorn fruit powder

Could be observed that, in general the adhesivity of the dough increased with the amount of powder added and also with the time of resting. These data do not reflect the reality sensorial observed during the preparation of the dough and shaping. The dough become crumblier and drier in time and when the proportion of fruits increased. We consider that these results are affected by the test condition, the cylindrical probe came in contact with the dough not only with the base of probe, a circle with 5 mm diameter, a bigger surface of contact was the lateral surface area. Other authors [19-21] observed that this type of test does not reflect the reality in all cases, and many factors can affect the results.

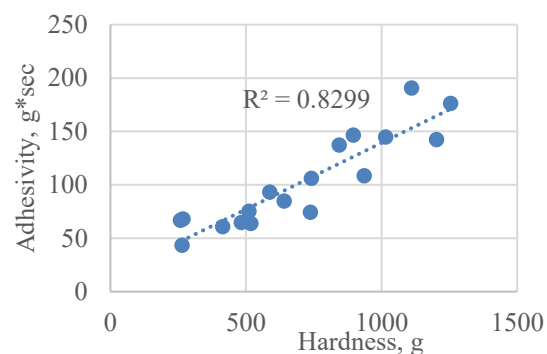


Fig. 8. Correlation of adhesivity with hardness of the dough

Control sample (CS) and the sample with the lowest level of hawthorn fruit addition were the only ones having the expected behaviour, the adhesiveness was lower in time and reduced by fruit addition. We observed that (see Figure 8) that the adhesivity of the dough correlate well with the dough hardness ($R^2=0.8299$).

4. Conclusion

The use hawthorn fruits in the formulation of biscuits aiming to obtain a functional food represent a challenge due the effects of them on the textural properties of the dough. The addition of the powdered hawthorn fruits increases the consistency of the dough from 256 g to 891 g when the flour was replaced in proportion of 25% with powder of hawthorn fruits. The dough consistency increased even more during the resting. We consider that this effect is due the presences of the fibers (pectin and other) in pulp fruits and these fibers compete with the proteins from the flour to the limited amount of water present in the dough. During the resting period the water is redistributed among the dough's component. Similar behavior we observed when we evaluated the dough energy. A very good correlation ($R^2 >0.997$) we observed between dough hardness and dough energy and that suggest measurement of dough hardness is sufficient for textural evaluation of dough. It is needed to check if this is true for other biscuit dough too. Dough adhesiveness increased too when the amount of flour replacement increased and with the time of resting which came in conflict with sensorial observation made during dough processing and

other methods should be used for measurement of dough adhesivity / stickiness.

References

- Goubgou M, Songré-Ouattara, Bationo F, Banhero O, Traoré, Savadogo A. Effect of three types of oils and their level of incorporation on sensory quality of sorghum cookies. *Journal homepage*. 2021;5(3):190-202.
- Karaca Açari İ. Cumhuriyet Science Journal Determination of the chemical structure of diet biscuits with modern instrumental techniques. *Cumhuriyet Sci J*. 2021;42(2):2587-2680.
- Irondi EA, Olatoye KK, Abdulameed HT, Aliyu OM, Ajani EO, Ogbebor OF. Physicochemical, in vitro starch digestibility and sensory characteristics of biofortified yellow maize-cowpea composite flours and biscuits. *Food Production, Processing and Nutrition* 2024 6:1. 2024;6(1):15-.
- Hussain A, Kausar T, Aslam J, et al. Physical and Rheological Studies of Biscuits Developed with Different Replacement Levels of Pumpkin (*Cucurbita maxima*) Peel, Flesh, and Seed Powders. *J Food Qual*. 2023;2023(1):4362094.
- Oručević Žuljević S, Akagić A. Flour-Based Confectionery as Functional Food. *Functional Foods - Phytochemicals and Health Promoting Potential*. Published online November 10, 2021.
- Vârban R. *Resurse Vegetale Din Flora Spontană*. Editura BIOFLUX; 2020.
- Li T, Fu S, Huang X, et al. Biological properties and potential application of hawthorn and its major functional components: A review. *J Funct Foods*. Elsevier Ltd. 2022;90.
- Bahorun T, Aumjaud E, Ramphul H, et al. Phenolic constituents and antioxidant capacities of *Crataegus monogyna* (Hawthorn) callus extracts. *Nahrung - Food*. 2003;47(3):191-198.
- Belabdelli F, Bekhti N, Piras A, et al. Chemical composition, antioxidant and antibacterial activity of *Crataegus monogyna* leaves' extracts. *Nat Prod Res*. 2022;36(12):3234-3239.
- Özcan M, Haciseferoğullari H, Marakoğlu T, Arslan D. Hawthorn (*Crataegus* spp.) fruit: some physical and chemical properties. *J Food Eng*. 2005;69(4):409-413. doi:10.1016/j.jfoodeng.2004.08.032
- Attard E, Attard H. Hawthorn: *Crataegus oxyacantha*, *Crataegus monogyna* and related species. *Nonvitamin and Nonmineral Nutritional Supplements*. Published online January 1, 2019:289-293.
- Manley DJR. Biscuit, cracker, and cookie recipes for the food industry. Published online 2001:189.
- Schober TJ, McCarthy D, Arendt EK. Influence of gluten-free flour mixes and fat powders on the quality of gluten-free biscuits. *European Food Research and Technology*. 2003;216(5):369-376.
- Bouzid W. *Etude de l'Activité Biologique des Extraits du Fruit de Crataegus monogyna Jacq*. Published online 2009.
- Lou X, Yuan B, Wang L, Xu H, Hanna M, Yuan L. Evaluation of physicochemical characteristics, nutritional composition and antioxidant capacity of Chinese organic hawthorn berry (*Crataegus pinnatifida*). *Int J Food Sci Technol*. 2020;55(4):1679-1688.
- Fiszman SM, Damásio MH. Instrumental measurement of adhesiveness in solid and semi-solid foods. A survey. *J Texture Stud*. 2000;31(1):69-91.
- Marzec A, Stępień A, Goclik A, Kowalska H, Kowalska J, Salamon A. Analysis of the Correlation of Microstructure, Instrumental Texture, and Consumer Acceptance of Shortbread Biscuits with Selected Sweeteners and Fibre. *Applied Sciences* 2025, Vol 15,. 2025;15(3). doi:10.3390/app15031137
- Grausgruber H, Hatzenbichler E, Ruckebauer P. Analysis of repeated stickiness measures of wheat dough using a texture analyzer. *J Texture Stud*. 2003;34(1):69-82.
- Armero E, Collar C. Texture properties of formulated wheat doughs Relationships with dough and bread technological quality. *European Food Research and Technology*. 2015;240(4):136-145.
- Brennan Jg, Jowitt R, Mughsi Oa. Some Experiences With The General Foods Texturometer. *J Texture Stud*. 1970;1(2):167-184.
- Laukemper R, Becker T, Jekle M. Surface Energy of Food Contact Materials and Its Relation to Wheat Dough Adhesion. *Food and Bioprocess Technology* 2021 14:6. 2021;14(6):1142-1154.