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RESEARCH ON THE VALORIZATION OF WATERMELON RIND IN MIXTURES WITH APPLE VARIETIES FOR DIVERSIFYING THE FOOD ASSORTMENT

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Abstract

On a large scale worldwide, watermelons and apples are highly appreciated by consumers. Watermelon (Citrullus lanatus) is an excellent source of vitamins A, B1, B6, and C. It is consumed due to its health benefits and low caloric value. Watermelon rind mainly contains carbohydrates rich in pectic substances. The present study demonstrated the possibility of valorizing watermelon rind in combination with apples through the development of watermelon rind and apple jam, representing both a challenge and an opportunity for diversifying the range of preserved food products in the food industry. Laboratory-scale experimental trials demonstrated that such valorization enables the production of food products with valuable nutritional compounds. In line with current trends aimed at meeting consumer demand for healthy and sustainable products, the natural ingredients used-apples and watermelon rind- made it possible to obtain products without the addition of food additives, as these ingredients can act as natural substitutes. Apples are an excellent source of nutrients, with a high content of antioxidants, dietary fiber, and vitamins.

Key words*: apple varieties, by-product, source of nutrients, valorization, watermelon rind.*

INTRODUCTION

Watermelon rind is a by-product that is most often discarded. In order to valorize this material, numerous studies have been conducted and continue to demonstrate its potential for a wide range of applications. Thus, Juan Pablo Capossio (2022) obtained watermelon rind flour, which was used in bakery products, leading to modifications in several quality indicators, including acidity, pH, water-holding capacity (WHC), oil-holding capacity (OHC), and processing time.

Ho et al. (2016) investigated the effect of hot-air oven drying at 40°C and 60°C, as well as freeze-drying, on the nutritional quality of watermelon rind powder, with particular emphasis on carbohydrate content and functional properties. In addition, Ho et al. (2016) used this powder in the production of noodles, and the analysis of their physical, chemical, and sensory properties showed high consumer acceptability for noodles containing watermelon rind powder.

Bread enriched with watermelon rind has the potential to be introduced to the market as a functional food, as reported by Badr et al. (2015). Shivapour (2020) highlighted watermelon rind powder as a promising additive for improving the quality characteristics of toasted bread, with the study focusing on changes in sensory attributes such as moisture and color.

Souad et al. (2012) demonstrated the feasibility of using watermelon rind in the preparation of jams with various flavors, including vanilla, pineapple, strawberry, lemon, and unflavored formulations.

The study conducted by Waghmare (2015) emphasized the potential use of watermelon rind as a source of pectin, in combination with isabgol husk (*Plantago ovata*), for the development of a novel laxative product.

Apples are highly complex fruits in terms of their biochemical composition, and apple juice is one of the most widely consumed fruit juices worldwide. It is preferred by both adults and children due to its characteristic taste and nutritional health benefits. Ghinea et al. (2022) analyzed cloudy apple juice in order to highlight the importance of polyphenols, which are present in higher concentrations compared with

clarified juice. The final products were stored for 7, 14, and 21 days at 20°C to evaluate their physicochemical and sensory properties after processing. Apple juice extraction was performed using a blender and a cold-press juicer. The results demonstrated that the apple juice samples varied depending on both the apple variety and the processing method used.

Immature apples are used to obtain a natural source of acidity (apple-based acidulant). In the food industry, this ingredient is added for the preservation of fruits and vegetables (Crucirescu, 2024).

Apple pomace is a residual biomass generated after apple processing and, on an industrial scale, can be used as a source of food ingredients (Rana, 2015). Lisičar et al. (2020) utilized apple pomace as a substrate for the production of pectin, biofuel (pellets), and concentrated apple pomace extracts, thereby valorizing this residual by-product into value-added products and creating links between different industries.

Sharma et al. (2014) demonstrated that pectin can be extracted from this by-product and described the extraction methodology. Similarly, Gullón et al. (2007) identified apple pomace as a promising raw material for lactic acid production. Perussello (2017) reported the extraction of valuable compounds from apple pomace using novel extraction techniques involving enzymes, electric fields, ultrasound, microwave heating, pressurized liquids, and supercritical/subcritical fluids. The study also discussed the advantages and disadvantages of conventional extraction methods required for the recovery of major compounds, namely pectin and polyphenols.

Apple pomace infusions have been proposed as a direct application of this by-product. Additionally, the volatile composition of beers produced with and without sugar was evaluated to mimic consumer preferences. To achieve this objective, three different valorization strategies were assessed: evaluation of apple aroma quality generated during the juice evaporation stage from different production seasons and its definition as a by-product; recovery of additional apple aroma through hydrodistillation from wet apple pomace; and stabilization of apple pomace as a dried product for infusion preparation (Coelho, 2021).

From apple juice processing waste, a functional ingredient (powder) with a complex biochemical composition and antioxidant potential was extracted, which can be used to improve bakery and pastry products (Catană et al., 2018). Gorjanović et al. (2020) presented apple pomace flour obtained through an innovative technological process (dehydration for 5 h at $T \leq 55°C$, milling to 300 μm), used as a source of bioactive compounds with antioxidant, anti-obesity, and antidiabetic effects.

Corey et al. (2011) demonstrated the possibility of valorizing by-products resulting from apple juice production. These by-products were freeze-dried with the addition of green tea extract and stored for up to 45 days at 30°C under low and intermediate humidity conditions. Kinetic models were developed to describe color changes and reductions in selected monomeric and polymeric flavonoid content.

Rascon et al. (2009) investigated the pectin fraction of apple fruits by analyzing its composition and selected functional physicochemical properties, with the aim of using pectin as a potential texturizing agent in the food industry.

Apples and apple-derived products have beneficial effects on consumer health. Recent studies have shown that these products may be associated with improved outcomes related to age-related cognitive decline, diabetes, weight management, bone health, pulmonary function, and gastrointestinal protection (Dianne, 2011; Boyles, 2000).

In the present study, a comparison is made between jam produced from watermelon rind with apples and a product obtained from apples processed into apple juice. We valorized watermelon rind by obtaining an innovative product, "Watermelon Rind Jam with Apples", and the comparison between the products highlights consumers' preferences for different products.

MATERIALS AND METHODS

The fruits used in this study were obtained from ICDP Pitești - Mărăcineni. The apple varieties included in the study were Idared and Golden Reinders. These raw materials were processed to obtain the following products: watermelon rind jam with apples and apples in apple juice.

For the preparation of the novel product, apples in apple juice, the apple juice was obtained from

a blend of apple varieties - Florina, Idared, and Golden Delicious - harvested from the experimental field of ICDIMPH Horting Bucharest. According to the technological instructions, all processing steps within the apple juice production flow were strictly followed (Figure 1).

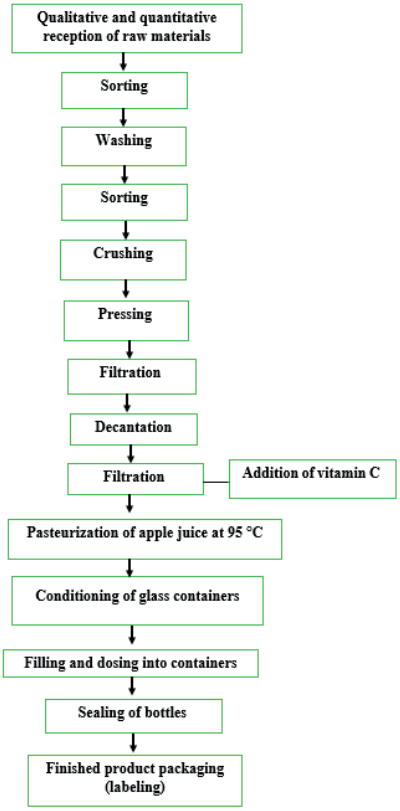

Figure 1. Technological process of apple juice production

The apple juice used in the production of apples in apple juice replaces the syrup traditionally obtained from sugar and water, thereby increasing the nutritional value of the final product.

Under laboratory conditions, the Idared and Golden Reinders apple varieties were evaluated from an organoleptic perspective, and physico-chemical results were taken into account to establish the product formulation. A solid-to-liquid ratio was determined based on the net weight, and calculations were performed to determine the final dry matter content of the product -apples and apple juice (Figure 2). The soluble dry matter balance was carried out in accordance with the legislation.

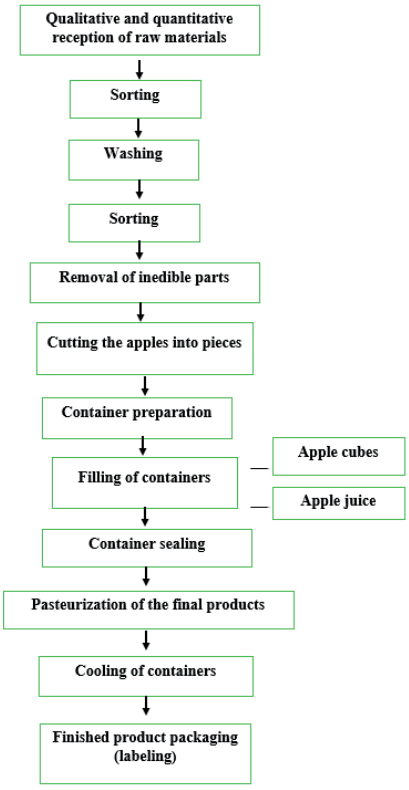

Figure 2. Technological Flow Chart for the Production of Apples in Apple Juice

The product Apples in Apple Juice is obtained from apples cut into pieces and covered with apple juice, packaged in hermetically sealed containers, and pasteurized (Figure 3).



Figure 3. Stages in the Production Process of Apples in Apple Juice

The focus of this study is on the valorization potential of watermelon rinds in combination with apple pulp. The watermelon rind, as a key ingredient in the product *Watermelon Rind Jam with Apples*, meets consumer demands for a novel product, regardless of age.

Transforming watermelon rinds into stable and safe food products represents a technological and economic opportunity, with the potential to

generate innovative products with nutritional value. The sequence of operations in the technological flow is illustrated in Figure 4, showing the preparation process of this product. The first stage involves the reception of raw materials and verification of quality criteria (maturity level, fruit integrity, absence of mechanical and microbiological defects) and the weighing of batches. Sorting aims to eliminate damaged fruits, affected portions, or those showing signs of disease or pest infestation. The washing stage plays a crucial role in preventing contamination during subsequent processing.

After preparation, the raw materials- watermelon rind and apples- are cut into different forms, followed by the blanching operation. Blanching is an essential step for reducing the initial microbial load, inactivating oxidative enzymes, and preventing browning. Watermelon rind was blanched at 85-90°C for 3-5 minutes, while apple pieces were blanched at 80-85°C for 2-3 minutes. Additionally, blanching softens the plant tissues moderately, stabilizes color and texture, and facilitates efficient syrup diffusion.

After blanching, the watermelon rinds are immersed in a sugar syrup to allow syrup penetration into the plant tissues. Syrup concentration and diffusion time are essential parameters for achieving the desired final product texture. Apple pulp is then incorporated into the syrup obtained in the previous step, which ensures the harmonization of the flavor profile, reduces resource losses, and increases process efficiency.

The next stage involves concentrating the product by boiling until the desired final dry matter content is reached. Boiling was carried out until a final soluble solids concentration of 67°Brix was reached, as determined refractometrically. Glass containers are conditioned through sterilization to prevent microbial growth. Filling is followed by hermetic sealing, which prevents contamination and maintains the vacuum required for preservation. Pasteurization is then applied to ensure long-term product stability and is adjusted according to the product's characteristics. Pasteurization of the finished product was carried out at 100°C for 10 minutes. Cooling and labeling of the finished product are the final steps of the production flow.

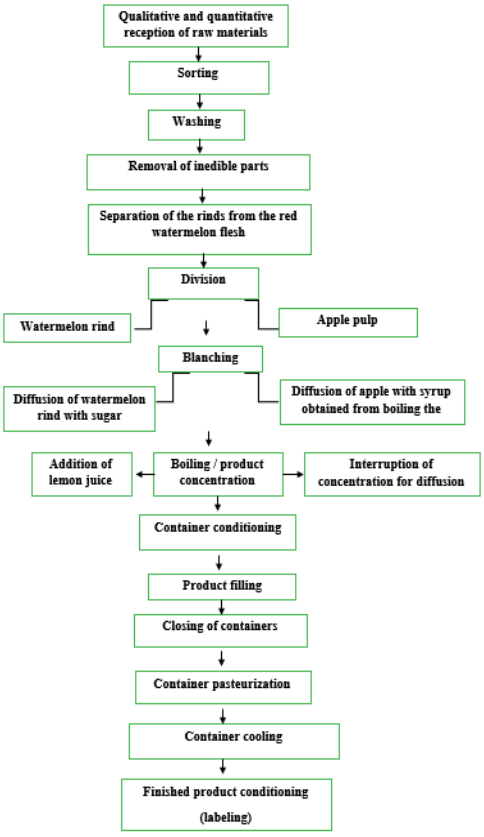

Figure 4. Technological Flow Chart of Watermelon Rind Jam with Apples

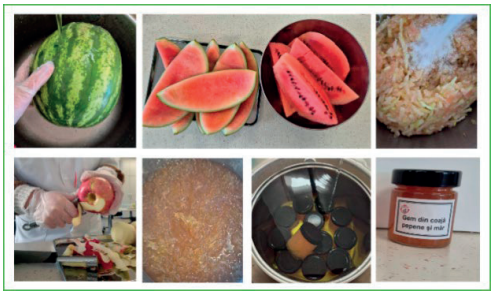

Figure 5. Stages in the Production Process of Watermelon Rind Jam with Apples

RESULTS AND DISCUSSIONS

The apples were analyzed from an organoleptic perspective in their fresh form, evaluating appearance, colour, aroma, and taste. Additionally, characteristics related to impurities, total sugar content, and vitamin C are detailed for the Golden Reinders variety in

Table 1 and for the Idared variety in Table 2. The results of the valorised products are presented in Table 3 for the finished product, *Apples in Apple Juice,* and in Table 4 for *Watermelon Rind Jam with Apples*.

The Idared apple variety has a higher sugar content, which explains its sweeter taste and better juiciness compared to Golden Reinders, which is less sweet. Golden Reinders contains more than twice the vitamin C (0.17 g/100 g) compared to Idared (0.08 g/100 g). This suggests a slightly higher nutritional value for Golden Reinders from the perspective of antioxidant contribution.

Table 1. Initial Analysis Results - Golden Reinders Variety

Characteristics	Maximum allowed	Methods of analysis	Results
Appearance	In accordance with	STAS 756-1/1985	Whole fruit, large size, slightly elongated shape, thin peel
Colour	In accordance with	STAS 756-1/1985	Greenish
Smell	In accordance with	STAS 756-1/1985	Specific
Taste	In accordance with	STAS 756-1/1985	Specific
Impurity content, %	In accordance with	STAS 756-1/1985	Absent
Total sugar content, g/100 g	In accordance with	SR 2213-12:2009	9.23
Vitamin C content, g/100 g	In accordance with	Farm. Rom. ed a X-a/ 93	0.17

Table 2. Initial Analysis Results - Idared Apple Variety

Characteristics	Maximum allowed	Methods of analysis	Results
Appearance	In accordance with	STAS 756-1/1985	Whole fruit, large size, spherical to slightly elongated shape, thin peel, juicy
Colour	In accordance with	STAS 756-1/1985	Red
Smell	In accordance with	STAS 756-1/1985	Specific
Taste	In accordance with	STAS 756-1/1985	Specific
Impurity content, %	In accordance with	STAS 756-1/1985	Absent
Total sugar content, g/100 g	In accordance with	SR 2213-12:2009	14.31
Vitamin C content, g/100 g	In accordance with	Farm. Rom. ed a X-a/93	0.08

The data in Table 3 highlight notable differences between the two apple juices, both in terms of composition and nutritional content. Regarding the initial fruit characteristics, particularly water content, the juice obtained from Idared apples exhibits a slightly higher water content of 84.46%, which aligns with the greater juiciness of the raw fruits, compared to Golden Reinders juice, which contains 83.34%.

The Golden Reinders juice shows a slightly higher sodium content (0.11%) than Idared juice (0.04%), which may result from natural variation. The mineral content is also slightly higher in Golden Reinders juice (0.25%), suggesting a better mineral profile for this variety.

Table 3. Results of the Finished Product - Apples in Apple Juice

Product characteristics	Analysis method	Results for apples in apple juice (*Idared* variety)	Results for apples in apple juice *(Golden* variety)
Moisture content, g%	SR 8613-1:2009	84.46	83.34
Sodium chloride, g%	SR ISO 3634:2009	0.04	0.11
Ash content, g%	SR 8613-1:2009	0.19	0.25
Total fat content, g%	SR 8613-1:2009	0.24	0.21
Saturated fatty acids, g%	SR 8613-1:2009	0.00	0.00
Sugars, g%	SR 2213-12:2009	10.81	8.34
Protein content, g%	SR 8613-6:2009	0.90	0.58
Carbohydrate content, g%	Norma met. 0702/2002	14.21	15.62
Energy value /caloric value, kcal per 100 g of product / kJ per 100 g of product	Norma met. 0702/2002	62.60/265.75	66.69/283.17

Idared juice is sweeter, consistent with the sugar content of the raw fruits (~14.31% in Idared vs. 9.23% in Golden Delicious). This difference remains after processing, with Idared juice

containing 10.81% sugar and Golden juice 8.34%.
Although Idared juice has a higher sugar content, Golden Delicious juice exhibits a slightly higher total carbohydrate content (15.62% vs. 14.21% in Idared), due to its higher content of polysaccharides and non-fermentable carbohydrates.

Table 4. Results of the Finished Product: Watermelon Rind Jam with Apples

Characteristics	Maximum permitted	Methods of analysis	Results
Appearance	According to	STAS 756-1/1985	Dense, homogeneous, uniformly viscous mass, free of impurities
Color	According to	STAS 756-1/01985	Light brown
Taste	According to	STAS 756-1/01985	Characteristic
Aroma	According to	STAS 756-1/01985	Characteristic
Moisture, %	According to	SR 2213-4:2007	17.94
Total inverted sugar, %	According to	SR 2213-12:2009	51.68
Total fats, g/100 g	According to	SR 2213-11:2007	0.37
Saturated fats, g/100 g	According to	SR 2213-11:2007	0.00
"""Protein, %	According to	SR 2213-17:2009	0.13
Fiber, %	According to	Norma met.07/02/2002	0.32
Total carbohydrates, %	According to	Norma met.0702/2002	78.61
Sodium chloride, g/100 g	According to	SR91:2007	0.41
Total ash, %	According to	SR 2213-6:2009	2.60
Caloric/energy value, kcal/100 g product / kJ/100 g product	According to	Norma met. 07/02/2002	318.93/ 1354.83

The appearance of the *Watermelon Rind Jam with Apples* shows pieces of watermelon rind and julienned apple suspended in a gelled mass, with no signs of fermentation or mold. The color is consistent with the ingredients used.
From an organoleptic perspective, the jam complies with STAS 3750/90, and both taste and aroma are pleasant and characteristic, without any off-flavors or off-odors.



Figure 6. Sensory Evaluation of Watermelon Rind Jam with Apples

The *Watermelon Rind Jam with Apples* was analyzed microbiologically, showing yeast and mold counts below 10 CFU/g, according to SR ISO 21527-2:2009, and Enterobacteriaceae counts below 10 CFU/g, according to SR ISO 21528-2:2017.
The microbiological analysis of the products was carried out six months after the product was obtained. This product was developed and tested within the doctoral thesis on watermelon valorization.
The products were evaluated based on five characteristics using a scale from 1 to 5. In Figure 7, the mean scores obtained from the sensory assessments are presented.
Apples in Apple Juice received a score of 24.04, while *Watermelon Rind Jam with Apples* scored 23.76. Both products were rated as “Very Good”, according to Table 5.

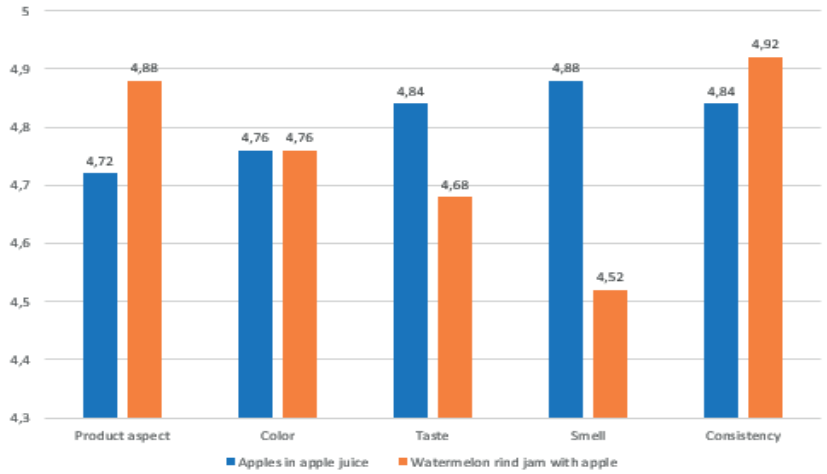

Figure 7. Mean Results of Sensory Evaluation for the Finished Products

Table 5. Classification of Scores from Sensory Analysis

Rating	Score Range
Very Good	23,1 – 25,00
Good	20,1 – 23,00
Satisfactory	16,1 – 20,00
Unsatisfactory	12,1 – 16,00
Bad	5,1 – 12,00
Very Bad	0 – 5,00

In the current study, the products belong to different groups. During the sensory evaluation, they obtained scores that reflect consumer preferences. The sensory analysis was carried out by a panel consisting of 10 semi-trained evaluators aged between 20 and 55 years, including both female and male participants. In the evaluation of appearance, Watermelon Rind Jam with Apples received a score of 4.88, making it slightly more visually appealing than Apples in Apple Juice, which scored 4.72. This small difference indicates an aesthetic advantage for the jam, due to its color and texture.

Both products received the same score for color (4.76), reflecting a similar appreciation from the panelists.

Both products were well rated for taste. Apples in Apple Juice, classified as a compote-type product, scored 4.84 and was perceived as pleasant, balanced, refreshing, and natural. The jam received a score of 4.68, and was appreciated by the panelists as a dessert product (Figure 7).

Each product has a characteristic aroma, with both scores close to the maximum value. Apples in Apple Juice was considered superior in terms of aroma, which had a significant impact on the overall impression of the product.

Regarding consistency, evaluators perceived the jam as having a more appropriate texture (gelation, structure, liquid-solid ratio), with the jam scoring higher (4.92) compared to the apples in juice (4.84).

CONCLUSIONS

The primary characteristic of a food product is its nutritional value, as reflected in the results presented in Tables 3 and 4.

Raw watermelon rinds are plant-based resources with limited potential; however, when combined with the mentioned apple varieties, they can be transformed into safe,sensory-appealing food products. It is recommended to process watermelon rind in combination with both Golden and Idared apple varieties.

The differences between the products-*Watermelon Rind Jam with Apples* and *Apples*

in Apple Juice- are relatively small, as shown by sensory evaluation. *Apples in Apple Juice*, obtained from Golden Reinders and Idared apples, is perceived as pleasant, balanced, refreshing, and natural. The nutritional value of this product is enhanced by the juice obtained from a blend of Florina, Idared, and Golden Delicious apples.

Watermelon Rind Jam with Apples was also well-received by tasters and is recommended for consumption in various culinary applications within the food service and gastronomic industry.

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REFERENCES

Badr, S. (2015) -Calitatea și proprietățile antioxidante ale pâinii îmbogățite cu pudră de coajă de pepene verde. *Curr. Sci. Int*., 4, 117–126.

Boyles, S. (2000). An apple a day may really keep the doctor away. WebMD website. Available at http://www.webmd.com/content/article/26/ 1728%5F58624 htm. Accessed August 8, 2008.

Capossio, JP; Fabani, MP; Román, MC; Zhang, X.; Baeyens, J.; Rodriguez, R.; Mazza, G. (2022). Producerea de pepene verde fără deșeuri prin făină de coajă netradițională: Optimizare multiobiectivă a procesului de fabricație. *Processes*, 10, 1984. https://doi.org/10.3390/pr10101984

Coelho, E.; Pinto, M.; Bastos, R.; Cruz, M.; Nunes, C.; Rocha, SM; Coimbra, MA (2021)- Industria sucurilor de mere concentrate: Evaluarea aromelor și a tescovinelor ca ingrediente alimentare. *Aplic. Sci.*, *11*, 2443. https://doi.org/10.3390/app11052443

Corey, ME; Kerr, WL; Mulligan, JH; Lavelli, V. (2011). Stabilitatea fitochimică a produselor funcționale din mere uscate și ceai verde în raport cu proprietățile de umiditate. *LWT Food Sci. Technol*., 44, 67–74.

Crucirescu Diana (2024). Valorificarea fructelor de mere imature pentru obținerea acidifiantului natural, teză de doctor în științe inginerești, Chișinău,

Dianne, A.H. (2011). A comprehensive review of apples and apple components and their relationship to human health. *Adv Nut*., 2(5):08-20

Gullón, Beatriz & Falqué, Elena & Alonso, José & Parajo, Juan. (2007). Evaluation of Apple Pomace as a Raw Material for Alternative Applications in Food Industries. *Food Technology and Biotechnology*. 45. 426-433

Ho, L.; Dahri, N. (2016)- Efectul pulberii de coajă de pepene verde asupra proprietăților fizico-chimice, texturale și senzoriale ale tăițeilor galbeni umezi. CyTA - *J. Food*, 14, 465–472.

Ho, L.; Suhaimi, M.; Ismail, I.; Mustafa, K. (2016)- Efectul diferitelor condiții de uscare asupra compozițiilor aproximative ale pulberilor de coajă de pepene verde cu pulpă roșie și galbenă. *J. Agric*., 7, 1–12.

Hoque, M.; Iqbal, A. (2015)- Uscarea cojii de pepene verde și obținerea de turte din pulbere de coajă. *Int. J. Novel Res. Life Sci*., 2, 14–21.

Josipa Lisičar Vukušić, Thomas Millenautzki, Ronny Cieplik, Veit Obst, Abdechafik Mokhlis Saaid, Leonard Clavijo, Slododan, Zlatanovic, Jendrik Hof, Marek Mösche, Stéphan Barbe (2020). Remodelarea producției de suc de mere într-un proces de biorafinărie cu zero deversări *Valorificarea Deșeurilor și Biomasei*, volumul 12, numărul 7, paginile 3617-3627

Monica CATANĂ, Luminița CATANĂ, Enuța IORGA, Monica-Alexandra LAZĂR, Anda-Grațiela LAZĂR, Răzvan Ionuț TEODORESCU, Adrian Constantin ASĂNICĂ, & Nastasia BELC (2018). Realizarea ingredientului funcțional din deșeuri de măr rezultate din industria sucurilor de măr. *Jurnalul științific AgroLife*, 7(1). Preluat de pe https://agrolifejournal.usamv.ro/index.php/agrolife/article/view/209

Perussello, Camila & Zhang, Zhihang & Marzochella, Antonio & Brijesh Kumar; Tiwari. (2017). Valorization of Apple Pomace by Extraction of Valuable Compounds. Comprehensive Reviews in *Food Science and Food Safety*. 16. 10.1111/1541-4337.12290. 776-796

Rana, S.; Gupta, S.; Rana, A.; Bhushan, S. (2015)- Proprietăți funcționale, constituenți fenolici și potențial antioxidant ale tescovinei industriale de mere pentru utilizare ca ingredient alimentar activ. *Food Sci. Hum. Wellness*, 4, 180–187

Rascon, Agustin & Martínez-López, Ana & Carvajal-Millan, Elizabeth & León-Renova, Nora & Marquez-Escalante, Jorge & Romo, Alejandro (2009). Pectin from low quality 'Golden Delicious' apples: Composition and gelling capability. Food Chemistry - *FOOD CHEM*., 116, 101-103. 10.1016/j.foodchem.2009.02.016.

Shivapour, M.; Yousefi, S.; Ardabili, SM; Weisany, W. (2020). Optimizarea și atributele de calitate ale unor noi tipuri de pâine prăjită, dezvoltate pe baza pudrei de coajă de pepene verde anti-învechire. *J. Agric. Food Res.*, 2, 100073.

Sharma, P.C. & Gupta, Anil & Kaushal, P. (2014). Optimization of method for extraction of pectin from apple pomace. *Indian Journal of Natural Products and Resources*. 5. 184-189.

Waghmare, A.G.; Patil, S.U.; Arya, SS. (2015). Nou laxativ formator de substanțe în vrac din coajă de pepene verde. *Int. J. Pharm. Sci. Res*., 6, 3877.