

Article

Linking Soil–Orchard Fruit Quality and Circular Food Innovation Through the Valorization of Dried Cherry Pomace in Dairy-Based Spreadable Products

Mariana Rusu ^{1,2}, Irina Gabriela Cara ² , Iuliana Motrescu ³ , Florina Stoica ¹, Denis Constantin Țopa ¹ 
and Gerard Jitäreanu ^{1,*}

¹ Department of Pedotechnics, Faculty of Agriculture, “Ion Ionescu de la Brad” Iasi University of Life Sciences, 3 Mihail Sadoveanu Alley, 700489 Iasi, Romania; mariana.rusu@iuls.ro (M.R.); florina.stoica@iuls.ro (F.S.); denis.topa@iuls.ro (D.C.T.)

² Research Institute for Agriculture and Environment, “Ion Ionescu de la Brad” Iasi University of Life Sciences, 700490 Iasi, Romania; irina.cara@iuls.ro

³ Department of Exact Sciences, Faculty of Horticulture, “Ion Ionescu de la Brad” Iasi University of Life Sciences, 700489 Iasi, Romania; iuliana.motrescu@iuls.ro

* Correspondence: gerard.jitareanu@iuls.ro

Abstract

This study explored the link between orchard-derived cherry quality and circular food innovation through the valorization of dried cherry pomace. Sweet cherry fruits from the cultivars Van and Stella, grown under the pedoclimatic conditions of north-eastern Romania, were evaluated for physicochemical traits, phytochemical profile, antioxidant activity, and heavy metal content. In parallel, cherry pomace obtained during juice processing of cultivar Van was freeze-dried, characterized, and incorporated into dairy-based spreadable formulations at 5% and 10% addition levels in order to assess its bioactive potential. The results showed clear cultivar-dependent differences, with Van exhibiting a superior bioactive profile, including higher total polyphenols, flavonoids, anthocyanins, and antioxidant activity than Stella. Heavy metal concentrations in fruits remained below the maximum allowable limits, while health-risk indices indicated no significant non-carcinogenic risk ($HI = 3.18 \times 10^{-2}$). The dried cherry pomace powder was characterized by high dietary fiber content (49.83 g/100 g dw), substantial total polyphenols (1046.80 mg GAE/100 g dw), anthocyanins (123.27 mg C3G/100 g dw), and antioxidant activity (21.43 μ M TE/g dw). Its incorporation into dairy-based spreadable products significantly improved ash, carbohydrate, fiber, phytochemical content, and antioxidant activity, with the 10% level showing the highest functional enhancement. Sensory evaluation indicated that the 5% formulation achieved the most balanced and preferred overall sensory profile. Overall, the findings support dried cherry pomace as a valuable functional ingredient and highlight a practical circular strategy for reconnecting cherry by-products with value-added food applications.



Academic Editor: Alberto Romero

Received: 29 April 2026

Revised: 19 May 2026

Accepted: 26 May 2026

Published: 29 May 2026

Copyright: © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and conditions of the [Creative Commons Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

Keywords: soil; cherry orchard; dried cherry pomace; phytochemicals; heavy metals; circular food innovation; by-product valorization

1. Introduction

Sweet cherry (*Prunus avium* L.) is a high-value temperate fruit species of major economic, nutritional, and technological relevance, widely appreciated for its early market availability, sensory attributes, and complex biochemical composition [1]. The fruits are consumed both fresh and processed due to their richness in soluble sugars, organic acids,

minerals, vitamin C, anthocyanins, flavonoids, and other phenolic compounds that collectively define their sensory quality and functional properties [2,3]. At the global scale, cherry production is predominantly concentrated in Europe, which accounts for over 65% of total output, estimated at approximately 2.77 million tons [4]. Romania benefits from favorable pedoclimatic conditions for sweet cherry cultivation and remains among the important producing countries, with production particularly concentrated in hilly and sub-Carpathian regions [5].

The performance and quality of sweet cherry production systems are governed by the complex interaction between genotype, orchard management practices, and environmental conditions. Within this framework, soil represents the central regulatory component, as its physical and chemical properties determine water availability, aeration status, nutrient dynamics, and root system functionality, ultimately influencing tree vigor, phenological development, and fruit set [6]. Sweet cherry is particularly sensitive to suboptimal soil conditions such as compaction, poor drainage, water stagnation, and salinity, whereas optimal performance is achieved on well-drained soils with balanced moisture regimes and slightly acidic to neutral pH [7]. In parallel, climatic factors, including solar radiation, temperature, and water availability, modulate physiological processes and fruit ripening, thereby shaping key quality attributes such as fruit size, color, soluble solids content, titratable acidity, pH, mineral composition, and the accumulation of bioactive compounds [6]. Moreover, the transfer and accumulation of essential trace elements such as Zn, Cu, and Fe from soil to fruit further contribute to nutritional value and quality differentiation. Consequently, fruit quality should be understood as an emergent property of the soil–orchard system, reflecting the integrated effects of pedological and climatic drivers throughout the production cycle [8].

In the context of increasing global emphasis on sustainability and circular bioeconomy strategies, the value of fruit production systems extends beyond primary yield and fresh-market performance toward the recovery and functional reintegration of secondary resources. Sweet cherries are directed either to fresh consumption or to industrial processing, depending on their physicochemical characteristics, generating significant amounts of pomace as a by-product. This fraction retains a substantial portion of the fruit's biochemical profile, including phenolic compounds, pigments, dietary fiber, and minerals of both nutritional and technological relevance [9,10]. The conversion of this material into dried cherry pomace powder represents an efficient strategy for stabilizing bioactive compounds and enabling their incorporation into food matrices, thereby contributing to waste reduction, resource efficiency, and value chain extension within sustainable horticultural systems.

Despite extensive research on sweet cherry production, fruit quality dynamics, and compositional attributes, these domains have largely been investigated independently. As a result, the linkage between soil–orchard system variability, fruit quality expression, and the functional potential of derived by-products within a circular food innovation framework remains insufficiently explored. This gap limits a comprehensive understanding of value continuity across the production chain, from primary production to secondary product valorization.

In addition to their phytochemical richness, cherries and their derived by-products represent a valuable source of dietary fiber, which plays a significant role in promoting gastrointestinal health and supporting a balanced gut microbiome through prebiotic effects. In this context, the incorporation of cherry pomace powder as a bioactive ingredient in dairy-based spreadable products emerges as a promising approach to enhance nutritional value while maintaining desirable sensory and technological properties. However, systematic investigations regarding optimal incorporation levels and functional performance in such matrices remain limited.

Within this framework, the present study aims to establish a conceptual and analytical link between soil–orchard systems and circular food innovation by valorizing dried cherry pomace. Specifically, the study evaluates the relationship between orchard soil conditions, sweet cherry fruit quality, and the valorization of dried cherry pomace as a functional ingredient in dairy-based spreadable products. To this end, sweet cherry fruits were characterized in terms of physicochemical, phytochemical, antioxidant, and heavy metal profiles; dried cherry pomace powder was obtained and characterized; and its incorporation at 5% and 10% levels was assessed in relation to the nutritional, functional, technological, and sensory properties of dairy-based spreadable formulations. The novelty of this work lies in the integration of soil-driven production factors, fruit quality metrics, and by-product valorization into a unified soil–fruit–pomace continuum. This integrative approach contributes to the current state of knowledge by demonstrating how environmental conditions in the orchard influence not only primary fruit quality but also the functional potential of derived by-products, thereby contributing to the development of sustainable and circular agri-food systems.

2. Materials and Methods

2.1. Study Area and Orchard Conditions

The study was conducted under the pedoclimatic conditions of the North-Eastern region of Romania (Iasi County), at the “Vasile Adamachi” Student Research and Practice Station (47°15' N, 27°30' E), part of the Ion Ionescu de la Brad University of Life Sciences, Iasi (IULS) (Figure 1). The experimental site is located in the Jijia Plain (Moldavian Plateau), at elevations of 80–95 m.

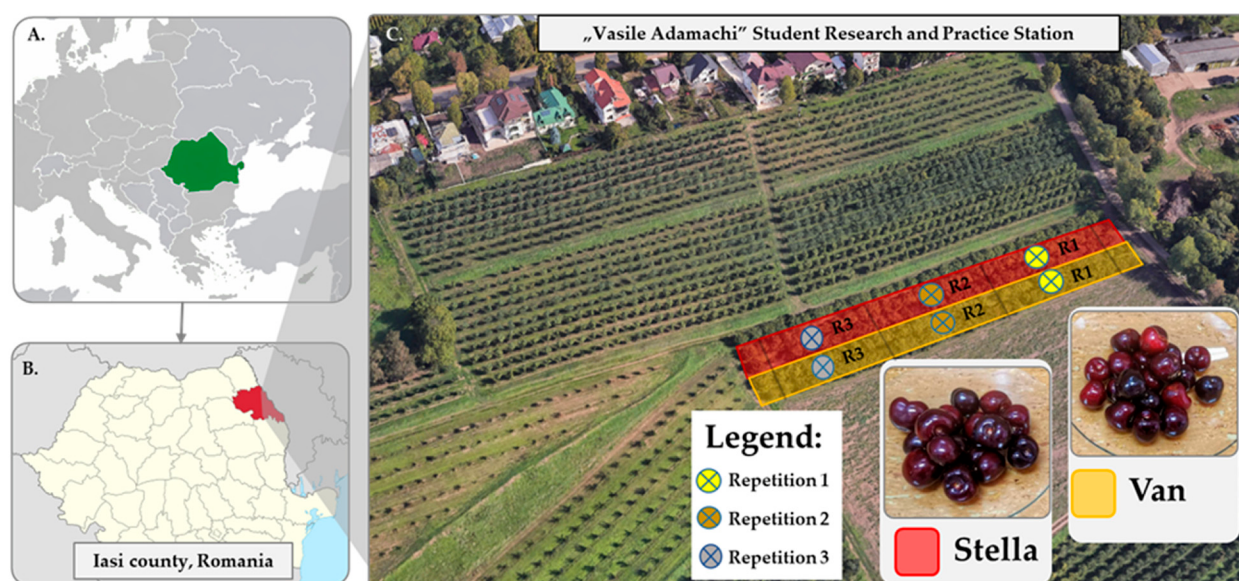


Figure 1. Experimental framework: (A) geographical position of Romania within Europe, (B) location of Iasi County and the experimental site, and (C) aerial view of the experimental orchard with sweet cherry cultivars.

During the study period (April–June 2024), the mean air temperature was 18.02 °C, and cumulative precipitation reached 199.6 mm (<https://www.fieldclimate.com>, accessed on 14 March 2025) [11]. The soil is classified as aric-cambic chernozem (WRB, 2014), with a loamy-clay texture, reflecting the prevailing pedoclimatic conditions that underpin optimal tree growth and fruit development [12].

2.2. Biological Material and Experimental Design

Two sweet cherry (*Prunus avium* L.) cultivars, “Van” and “Stella”, were evaluated under orchard conditions representative of the region to assess genotype-driven variability in phenological response. The spatial configuration of the experimental orchard and the evaluated cultivars is presented in Figure 1.

The experiment was organized using a randomized block design with three replicates, each comprising 20 trees/cultivar.

2.3. Sample Procedure

Sampling was performed at harvest (June 2024). Fruit samples were collected from randomly selected trees within each replicate, ensuring representative sampling across the canopy.

Fruits were harvested at BBCH 89, rinsed with ultrapure water, air-dried, and stored at $-20\text{ }^{\circ}\text{C}$ until analysis.

Soil samples were collected from the 0–20 cm root zone using a soil auger after removal of surface residues. Samples were air-dried, homogenized, and sieved (2 mm) prior to analysis.

2.4. Methodology of Determining Physicochemical Parameters of Soil

Soil chemical parameters were determined using standardized analytical procedures widely adopted in soil science and agricultural chemistry.

Soil pH was measured potentiometrically (1:2.5 soil:water) using a calibrated pH meter [13]. Soil organic matter and organic carbon contents were determined by the Walkley–Black dichromate oxidation method [14].

Total nitrogen (N) was determined using the Kjeldahl method [15]. Available potassium (K) was extracted using neutral ammonium acetate and quantified by spectrophotometry. Available phosphorus (P) was extracted with 0.5 M NaHCO_3 solution at pH 8.5 and determined colorimetrically using the ascorbic acid method [16].

Calcium (Ca) and magnesium (Mg) contents were determined by complexometric titration following extraction with ammonium chloride [17].

2.5. Measuring Heavy Metals in Samples

The concentrations of heavy metals (Zn, Cu, Ni, Cd, and Pb) in soil and cherry fruit samples were determined by flame atomic absorption spectrometry (AAS ContrAA 700, Analytik Jena, Jena, Germany) following microwave-assisted acid digestion (SCP Science, Baie-d’Urfé, QC, Canada), in accordance with USEPA Method 3052 [18].

Soil samples (1 g) were digested using a mixture of 6 mL nitric acid (HNO_3 , 65%) and 2.5 mL hydrochloric acid (HCl), whereas fruit samples (1 g) were subjected to digestion with 5 mL nitric acid (HNO_3 , 65%) and 1 mL hydrogen peroxide (H_2O_2 , 30%), in a Teflon dish at $200\text{ }^{\circ}\text{C}$ for 20 min with a power of 1000 W. After microwave digestion, the resulting solutions were filtered and quantitatively transferred to a final volume of 25 mL using ultrapure water.

Calibration curves were established using multi-element standard stock solutions (1000 mg L^{-1}), with working standards prepared in 5% HNO_3 at five concentration levels (0.05, 0.1, 0.2, 0.25, and 0.5 mg L^{-1}). All solutions were prepared using high-purity deionized water. To prevent external contamination, all glassware and laboratory equipment were pre-cleaned with 10% HNO_3 and thoroughly rinsed with ultrapure water prior to use [19].

2.6. Fruit Quality Analysis

Fruit and stone weights and yield/tree were determined using an analytical balance (± 0.1 mg) (model BL-600; Sartorius, Göttingen, Germany), and the average values were calculated.

Flesh firmness was assessed using a non-destructive penetrometer (Qualitest HPE), with a 10 cm^2 surface measuring device, and the results are expressed in N/ 10 cm^2 [20].

Total soluble solids (SSC) were measured using a digital refractometer (PR-101, Atago Co., Ltd., Tokyo, Japan) [21].

Titrateable acidity (TA) was determined by titration with 0.1 n NaOH (pH 8.1) using phenolphthalein as an indicator, and it was then calculated by determining the amount of NaOH consumed during titration [22].

Fruit pH was measured potentiometrically using a calibrated pH meter (WTW InoLab, Xylem Analytics GmbH, Weilheim, Germany), with prior calibration using standard buffer solutions (pH 4.01 and 7.01) [23]. The vitamin C content of the fruit samples was estimated by quantitative decolorization based on the 2-6-dichlorophenol-indophenol titration method. Values are expressed in mg/100 g [24].

Color measurements were performed using a Minolta Chroma Meter CR-410 (Konica Minolta, Osaka, Japan), and results were expressed in the CIE L, a, b* color space, where L* represents lightness (0 = black, 100 = white), a* indicates the red–green axis, and b* represents the yellow–blue axis [25]. Derived color parameters were also calculated, including hue angle ($h^\circ = \arctan(b^*/a^*)$), and chroma ($C^* = \sqrt{a^{*2} + b^{*2}}$) [26].

2.7. Health-Risk Assessment in Orchard Cherries

2.7.1. Contamination Risk Assessment (ContR)

The contamination risk (ContR) was calculated to quantify soil–fruit metal transfer in relation to food safety using the following equation [27]:

$$\text{ContR} = \frac{C_f}{C_s} \quad (1)$$

where C_f (mg kg^{-1}) represents the metal concentration in cherry fruit tissue, and C_s (mg kg^{-1}) denotes the corresponding concentration in soil.

2.7.2. Health-Risk Assessment of Heavy Metals in Cherry Consumption

The potential health risks associated with the consumption of cherries contaminated with Zn, Cu, Cd, and Pb were evaluated using the following indicators: estimated daily intake (EDI), target hazard quotient (THQ), hazard index (HI), and total carcinogenic risk (TCR) [28]. All abbreviations used in the formulas below are defined in Table 1.

The estimated daily intake (EDI) of metals was calculated using the following Equation (2):

$$\text{EDI} = \frac{E_f \times E_d \times \text{Ir} \times \text{Cm}}{B_w \times \text{TA}} \quad (2)$$

The non-carcinogenic risk was assessed using the target hazard quotient (THQ):

$$\text{THQ} = \frac{\text{EDI}}{R_f D} \quad (3)$$

where $R_f D$ ($\text{mg kg}^{-1} \text{ day}^{-1}$) is the oral reference dose. THQ values < 1 indicate no significant risk, while $\text{THQ} \geq 1$ suggests a potential risk of adverse health effects, according to USEPA guidelines.

The hazard index (HI), representing the cumulative non-carcinogenic risk, was calculated as:

$$HI = \sum THQ_i \quad (4)$$

An HI value greater than 1 ($HI > 1$) indicates a potential health concern due to combined exposure to multiple metals.

The carcinogenic risk (CR) was estimated as:

$$CR = EDI \times C_{sf} \times 10^{-3} \quad (5)$$

where C_{sf} ($\text{mg}/\text{kg}\cdot\text{day})^{-1}$ is the cancer slope factor. The parameters applied in the equation correspond to the assessment of non-carcinogenic risk, whereas the values used for carcinogenic risk (CR) estimation are presented in Table 1. Risk levels were interpreted according to established thresholds: values below 1×10^{-6} are considered to pose no significant health risk; those between 1×10^{-6} and 10^{-5} indicate a low risk; values ranging from 1×10^{-5} to 10^{-4} are classified as moderate; risks between 1×10^{-4} and 1×10^{-3} are regarded as high; and values exceeding 1×10^{-3} are considered to represent a very high risk to human health [29].

Table 1. Input parameters used for adult carcinogenic risk assessment through cherry consumption.

Parameter	Unit	Adult Value/Assumption	References
C _m (Metal concentration)	mg/kg		
B _w (Body weight)	kg	80	[30]
E _f (Exposure frequency)	days/year	90	
E _d (Exposure duration)	years	70	[31]
I _r (Daily ingestion rate)	kg/person/day	0.154	[32]
TA (Averaging time for carcinogenic effects)	days	25.550 ($365 \times E_d$)	[33]
R _f D (Zn)	mg/kg-day	0.37	[34,35]
R _f D (Cd)	mg/kg-day	0.001	[35]
R _f D (Cu)	mg/kg-day	0.04	[36,37]
R _f D (Pb)	mg/kg-day	0.004	[35,38]
R _f D (Ni)	mg/kg-day	0.02	
C _{sf} (Cd)	($\text{mg}/\text{kg}\cdot\text{day})^{-1}$	0.38	
C _{sf} (Ni)	($\text{mg}/\text{kg}\cdot\text{day})^{-1}$	1.7	[29]
C _{sf} (Pb)	($\text{mg}/\text{kg}\cdot\text{day})^{-1}$	0.0085	

2.8. Obtaining Cherry Pomace Powder

The “Van” cultivar was selected for pomace production based on its more favorable overall profile, showing higher phytochemical content and antioxidant activity, together with suitable physicochemical characteristics and acceptable heavy metal levels compared with “Stella”. Sweet cherries var. “Van” were sorted, washed with distilled water, and pre-crushed to remove the pits before pressing. Cherry pomace was obtained during juice extraction using a juicer (Philips HR1855, Royal Dutch Philips Electronics, Amsterdam, The Netherlands). The resulting pomace was packed in plastic bags and stored at $-20\text{ }^{\circ}\text{C}$ until freeze-drying. Drying was performed by lyophilization using a BIOBASE BK-FD10T freeze dryer (Biobase Biodustry Co., Ltd., Jinan, China) at $-42\text{ }^{\circ}\text{C}$ and 10 Pa for 48 h. The dried pomace had a final measured moisture content of 7.9% and was then ground using an MC 12 grinder (Stephan GmbH, Berlin, Germany). The powder was further milled for

50 s, yielding a mean particle size of 450–500 µm. Finally, the obtained powder was packed in a polymer film and stored under dry conditions at 20 °C until further characterization and use [39].

2.9. Characterization of Cherry Pomace Powder

2.9.1. Proximate Composition of Cherry Pomace Powder

The proximate composition of the cherry powder, including moisture, ash, protein, fat, fiber, and carbohydrates (calculated by difference), was determined according to AOAC standard methods [40]. All analyses were performed in triplicate, and the results were expressed as g/100 g dry weight (DW). Protein content was determined by the Kjeldahl method using a conversion factor of $N \times 5.7$, lipid content was measured by Soxhlet extraction, and ash content was determined by incinerating 5 g of sample in a muffle furnace at 600 °C for 4 h, followed by cooling in a desiccator and reweighing. Moisture content was measured by oven drying at 105 °C, while crude fiber was quantified using the enzymatic–gravimetric method described by Chantaro et al. [41]. Total carbohydrate content was calculated by difference using the following equation:

$$[100 - (\text{moisture} + \text{protein} + \text{fat} + \text{ash} + \text{fiber}) \%] \quad (6)$$

2.9.2. Color Analysis of Cherry Pomace Powder

The color characteristics of the cherry pomace powder were measured using a Minolta Chroma Meter CR-410 (Konica Minolta, Osaka, Japan), previously calibrated with a standard white plate according to the manufacturer's instructions. The recorded color parameters were L^* (lightness), a^* (red–green coordinate), and b^* (yellow–blue coordinate). Additionally, the hue angle and chroma, which describe color tone and saturation intensity, respectively, were calculated [42].

2.9.3. Mineral Composition

Zn, Cu, Fe, Mg, K, Na, Ca, and Mn content in cherry pomace powder was determined by atomic absorption spectroscope (ContrAA 700, Analytik Jena, Jena, Germany) according to Stoica et al. [39] method, and values were expressed in mg/100 g dw.

2.9.4. Extraction of Biologically Active Compounds

Bioactive compounds from cherry pomace powder were extracted by ultrasound-assisted extraction according to Milea et al. [43], with minor modifications. One gram of powder was mixed with 10 mL of 70% ethanol containing 1% citric acid (1:9, acid/solvent), sonicated in an Elmasonic S 180 H bath (Elma, Singen, Germany) for 30 min at 40 kHz and 100 W at 40 ± 5 °C, and then centrifuged for 10 min at 6000 rpm and 4 °C. The supernatant was collected for phytochemical analyses.

2.9.5. Total Anthocyanin Content

The total anthocyanin content was determined spectrophotometrically by the pH differential method [44]. For the analysis, the extract was diluted separately with buffer solutions at pH 1.0 (0.025 M potassium chloride) and pH 4.5 (0.4 M sodium acetate). Absorbance was measured at 520 and 700 nm using a UV–VIS spectrophotometer (Analytik Jena Specord 210 Plus, Jena, Germany). The results were expressed as milligrams of cyanidin-3-glucoside equivalents per gram of dry weight (mg C3G/g dw).

2.9.6. Determination of Total Phenolic Content

For the determination of total phenolic content, 500 µL of extract was transferred into test tubes, followed by the addition of 2.5 mL Folin–Ciocalteu reagent and 2 mL of 7.5%

sodium carbonate solution. The mixtures were allowed to react at room temperature for 60 min. Absorbance was then measured at 765 nm using a UV–VIS spectrophotometer (Analytik Jena Specord 210 Plus, Jena, Germany). The results were expressed as milligrams of gallic acid equivalents per gram of dry weight (mg GAE/g dw) [45].

2.9.7. Determination of Total Flavonoid Content

Flavonoid content was determined using a modified aluminum chloride colorimetric method according to Pekal and Pyrzynska [46]. Briefly, 250 μ L of extract (1 mg/mL) was mixed with 1.25 mL of deionized water and 0.075 mL of 5% NaNO₂. After 5 min of incubation in the dark, 0.15 mL of 10% AlCl₃ was added. Following an additional 6 min, 0.5 mL of 1 M NaOH and 0.775 mL of deionized water were added to the reaction mixture. Absorbance was measured at 510 nm using a UV–VIS spectrophotometer (Analytik Jena Specord 210 Plus, Jena, Germany). The flavonoid content was expressed as milligrams of catechin equivalents per gram of dry weight (mg CE/g dw).

2.9.8. Determination of the Antioxidant Activity

The antioxidant activity of the extract was determined using the DPPH radical scavenging assay [47]. Briefly, 100 μ L of extract was mixed with 3.9 mL of 0.1 mM DPPH methanolic solution and incubated in the dark at room temperature for 30 min. A blank was prepared by replacing the extract with methanol. Absorbance was measured at 515 nm using a UV–VIS spectrophotometer (Analytik Jena Specord 210 Plus, Jena, Germany). The results were expressed as percentage inhibition and μ M Trolox equivalents per g dry weight (μ M TE/g dw).

2.10. Dairy-Based Spreadable Product Preparation

To develop the enriched products and assess their functional potential, cherry pomace was incorporated at two levels, 5% (C1) and 10% (C2). These concentrations were selected based on previous studies and nutritional considerations, with the aim of improving both the functional value and sensory quality of the final products. The selected inclusion levels also allowed a systematic evaluation of their impact on the physicochemical and sensory properties of the dairy-based spreadable product formulations.

Three dairy-based spreadable product variants were prepared: a control sample without cherry pomace addition and two experimental samples containing 5% and 10% cherry pomace powder, respectively. The formulations, expressed as % (g/g), were as follows: spreadable cream cheese (72.25/69.60%), milk (10.50/9.60%), water (11/9%), cherry pomace powder (5/10%), salt (1.0/1.6%), and lemon juice (0.15/0.20%).

Sample preparation was carried out in several steps. First, the spreadable cream cheese and milk were vigorously homogenized using a Philips HR2100/40 blender (Philips, Amsterdam, The Netherlands) for 5 min at 1000 rpm. The cherry pomace powder was then added to the mixture and homogenized for 3 min at 1000 rpm. Next, the mixture was incorporated with salt, water, and lemon juice. The final mixture was left to stand for 5 min, then transferred into glass containers, covered with aluminum foil, and stored at 4 °C until analysis.

2.11. Characterization of Dairy-Based Spreadable Products

2.11.1. Proximate and Phytochemical Composition

The value-added dairy-based spreadable samples were physicochemically characterized according to AOAC guidelines [48]. Their proximate composition, including moisture, crude protein, crude fiber, lipids, carbohydrates, and ash, was determined using the same standard procedures. In addition, the phytochemical profile of the dairy-based spreadable product enriched with cherry pomace powder was evaluated by determining total

anthocyanin, total phenolic, and total flavonoid contents, and antioxidant activity using the corresponding analytical methods.

2.11.2. Color Analysis

Dairy-based spreadable samples were characterized for CIELAB color parameters using a portable colorimeter with illuminant C (Chroma Meter CR-410, Konica Minolta, Osaka, Japan), previously calibrated with a white standard tile before each measurement. The measured parameters included L* (lightness), a* (red/green coordinate), and b* (yellow/blue coordinate). Chroma, hue angle, and total color difference (ΔE) were subsequently calculated according to Murariu et al. [49].

2.11.3. Texture Analysis

The textural characteristics of the dairy-based spreadable samples containing cherry pomace powder were determined using a Brookfield CT3 texture analyzer (Brookfield Ametek, Middleboro, MA, USA). Cylindrical samples (10 mm diameter, 20 mm height) were prepared using a piston mold and subjected to texture profile analysis (TPA) with a 25.4 mm cylindrical probe. A double-compression cycle was applied without holding time to 50% deformation at a crosshead speed of 1 mm/s, using a trigger force of 0.067 N and a 9.8 N load cell. The parameters measured were firmness, adhesiveness, cohesiveness, springiness, and chewiness, as described by Frunză et al. [50]. Data were recorded and analyzed with TexturePro CT V1.5, and all measurements were carried out in triplicate.

2.11.4. Scanning Electron Microscopy Analysis

Sample morphology and elemental composition were characterized by SEM-EDS using a Quanta 450 scanning electron microscope (FEI, Thermo Fisher Scientific, Hillsboro, OR, USA) equipped with an EDAX detector (AMETEK Inc., Berwyn, PA, USA). Samples were mounted on aluminum stubs as an approximately 2 mm-thick layer and analyzed after calibration with a standard Al/Cu reference sample. EDS spectra were processed with TEAM V4.1 software (EDAX Inc., Berwyn, PA, USA). Measurements were performed under low vacuum at approximately 6.1×10^{-4} Pa, using an accelerating voltage of 15 kV and $500\times$ magnification [51].

2.11.5. Sensorial Analysis

Sensory evaluation of the dairy-based spreadable samples was performed by 25 untrained panelists from the Department of Food Technologies, aged 18–39 years (40% male, 60% female). The sensory protocol was approved by the Ethics Committee of the Faculty of Agricultural Sciences, “Ion Ionescu de la Brad” Iasi, University of Life Sciences, Romania (approval no. 724/16 April 2026). Sensory evaluation was conducted in a dedicated sensory laboratory at “Ion Ionescu de la Brad” Iași University of Life Sciences, designed and operated in accordance with ISO 8589 [52] requirements for sensory test rooms. The attributes evaluated were appearance, odor, color, taste, aroma, aftertaste, hardness, adhesiveness, chewability, and overall acceptability, using a 7-point hedonic scale (1 = extremely dislike; 7 = extremely like) [39]. Sensory samples were served to the panelists on the day of their preparation. The panelists evaluated the samples at their own pace, following the coded serving order provided on the evaluation form. Bread and drinking water were available between samples for palate cleansing, and panelists were instructed to take a short pause between successive evaluations to reduce carry-over effects. Because the samples were presented in transparent containers, color perception was controlled by conducting the sensory evaluation in an ISO 8589-compliant sensory analysis laboratory under uniform lighting conditions. All samples were served in identical transparent plastic containers and assessed under the same environmental conditions to minimize external

influences on color perception. The samples were labeled with random three-digit codes generated using a random-number procedure. The generated codes were checked before sample presentation to ensure that no duplicate or sequential codes were used.

2.12. Data Analysis

All data are presented as the mean $\pm$ standard deviation of triplicate determinations. The evaluated parameters were subjected to one-way analysis of variance (ANOVA) to determine differences among sample means. When significant effects were detected ($p < 0.05$), Tukey's multiple range test was applied for post hoc comparison at the 5% significance level using SPSS statistical software (version 20.0, IBM Corp., Armonk, NY, USA). Principal component analysis (PCA) was performed on the sensory data using XLSTAT, an add-in software for Microsoft Office Excel (Trial Version 2024, Addinsoft, Paris, France).

3. Results and Discussion

3.1. Soil-Climate Conditions as Determinants of Fruit Quality

Climatic conditions recorded during the April–June interval (18.02 °C and 199.6 mm) fall within a range generally considered favorable for sweet cherry development, supporting both flowering progression and fruit growth. Such thermal conditions are known to enhance carbohydrate accumulation and fruit enlargement, while moderate precipitation ensures adequate water availability without inducing excessive physiological stress [53].

The soil physicochemical characteristics (Table 2) further support this favorable production context. The slightly acidic to neutral pH (6.79) is optimal for nutrient solubility and uptake, particularly for phosphorus and micronutrients, thus facilitating efficient root functioning [10,54]. The relatively high levels of total nitrogen (0.215%), available potassium (374 mg kg^{−1}), and phosphorus (94 mg kg^{−1}) indicate a well-supplied nutrient environment, which is directly associated with improved fruit size and soluble solids accumulation [55]. Similar relationships have been reported by Gonçalves et al. [56], who observed increased total soluble solids (SSC) and fruit weight under potassium-sufficient conditions.

Table 2. Soil physicochemical properties (0–20 cm).

Properties	Unit Measure	Results
pH		6.79 $\pm$ 0.02
Total nitrogen (Nt)	%	0.215 $\pm$ 0.16
Phosphorus (P ₂ O ₅)	mg kg ^{−1}	94 $\pm$ 0.32
Potassium (K ₂ O)	mg kg ^{−1}	374 $\pm$ 0.21
Organic carbon (Corg)	%	2.50 $\pm$ 0.20
Humus	%	4.31 $\pm$ 0.22
Calcium (Ca)	mg kg ^{−1}	2145 $\pm$ 0.41
Magnesium (Mg)	mg kg ^{−1}	276 $\pm$ 0.25

The organic carbon (2.50%) and humus content (4.31%) suggest a structurally stable soil with good water retention capacity, which is essential under fluctuating climatic conditions. In addition, the elevated concentrations of Ca (2145 mg kg^{−1}) and Mg (276 mg kg^{−1}) indicate a balanced cationic status. This is relevant because calcium is associated with cell wall stabilization and maintenance of fruit firmness, while magnesium supports metabolic processes. In sweet cherry, both mineral nutrition and cultivar background are known to contribute substantially to final fruit quality [57].

3.2. Physical–Chemical Analysis of Cherry Fruits

For cherry trees, this physical characteristic varies even within the same variety, depending on the rootstock, the age of the trees, the agricultural practices employed, soil and climate conditions, fruit load, and other factors [58].

The two cultivars showed clear differences in their physicochemical profile, despite being grown under the same pedoclimatic conditions, indicating a strong genotype effect. Fruit weight ranged from 6.94 g in “Van” to 9.51 g in “Stella” (Table 3). These values fall within the interval reported for 23 Portuguese sweet cherry cultivars (4.9–11.8 g), which places both cultivars within the normal commercial range for sweet cherry fruit mass [59]. In the more recent Romanian study of several sweet cherry cultivars, “Van” reached 7.76 g fruit weight and 24.25 kg tree^{−1} yield, values very close to those observed in this study for “Van” (6.94 g and 25.12 kg tree^{−1}), suggesting that the productivity pattern of this cultivar is consistent across temperate cultivation conditions [60]. The current trend is to breed cherry varieties with the largest possible fruit, which has also led to changes in the size classification categories. Thus, while fruits weighing over 6 g were considered large [61], current studies suggest that new varieties should have fruits weighing 11–13 g [10,62].

Table 3. Physical–chemical characteristics of cherry fruits.

Parameters		Varieties	
		Stella	Van
	Weight (g)	9.51 ± 0.21 ^a	6.94 ± 0.19 ^b
	Stone (g)	0.49 ± 0.15 ^a	0.42 ± 0.13 ^a
	Total soluble solids (°Brix)	17.64 ± 0.24 ^b	18.41 ± 0.26 ^a
	Dry matter (%)	25.11 ± 0.25 ^a	24.85 ± 0.28 ^b
	Pulp firmness (units HPE) (N/0.10 cm ²)	51 ± 0.11 ^a	43 ± 0.10 ^b
	pH	3.58 ± 0.08 ^a	3.86 ± 0.07 ^a
	Titrateable acidity (mg malic acid 100 ^{−1})	0.69 ± 0.09 ^a	0.78 ± 0.10 ^a
	C vitamin (mg/100 g)	7.72 ± 0.22 ^b	9.03 ± 0.25 ^a
	Yield/tree (kg)	19.21 ± 0.17 ^b	25.12 ± 0.24 ^a
Colorimetric parameters	L*	30.53 ± 0.23 ^a	29.82 ± 0.22 ^b
	a*	18.97 ± 0.18 ^b	23.00 ± 0.20 ^a
	b*	7.03 ± 0.16 ^b	11.51 ± 0.17 ^a
	C*	20.23 ± 0.14 ^b	25.72 ± 0.18 ^a
	h°	0.35 ± 0.01 ^a	0.46 ± 0.01 ^a

Means within the same row sharing at least one common superscript letter do not differ significantly at $p > 0.05$.

The level of soluble sugars (sucrose, glucose, and fructose) in fruit is an important quality parameter due to its significant influence on fruit flavor, and it also serves as an indicator of ripeness for consumption [63]. The total soluble solids content (SSC) was high in both cultivars (17.64–18.41 °Brix), confirming good sugar accumulation. These values are very close to those reported for “Van” in the recent Romanian dataset (17.85 °Brix), and they are fully consistent with the typical range described for high-quality sweet cherries grown under temperate conditions. Thus, although “Stella” had larger fruits, it also maintained slightly higher SSC, which suggests efficient assimilate accumulation rather than dilution by fruit size increase [60]. Similar scientific studies conducted in various climatic regions around the world have shown that, in the case of cherries, sugar content ranges from 11 to 25 °Brix during the ripening period [64–66], and only cherries with a soluble solids content greater than 18 °Brix are considered to be of superior quality [67].

Total acidity and pH are genetically determined qualitative characteristics, and their variability depends primarily on the variety and climatic factors during fruit development [68]. Changes in acidity are also reflected in the pH value of the vacuolar juice.

The pH values recorded in the present study (3.58 in “Stella” and 3.86 in “Van”) indicate moderate acidity and are close to the values recently reported specifically for these two cultivars during storage experiments, where pH ranged from 3.45 in “Van” to 3.66 in “Stella” at the beginning of storage. More broadly, sweet cherries are generally described as mildly acidic fruits, with pH values usually ranging between 3.7 and 4.2 [69].

Titrateable acidity ranged from 0.69 to 0.78 mg malic acid 100^{-1} , which is in very good agreement with values reported for sweet cherry cultivars from Iasi, Romania, where TA ranged between 0.5 and 0.9 g malic acid 100^{-1} g. The same Romanian source also showed that cultivar strongly influences the sugar-to-acid balance, which supports the present observation that “Van”, despite slightly lower SSC, exhibited higher acidity and therefore a more pronounced fresh taste profile. Similar studies conducted on different cherry varieties have shown that titrateable acidity varied significantly between 0.39 and 0.87 mg malic acid 100 g^{-1} [70,71], and according to the study conducted by Crisosto et al. [72], the recommended range for titrateable acidity in fully ripe cherries is 0.5 to 1.0 mg malic acid $\cdot 100\text{ g}^{-1}$. Cherries are fruits valued by consumers both for their delicious taste and for their numerous nutritional properties with health benefits, such as their high vitamin C content [21,73].

Vitamin C (L-ascorbic acid) is the primary vitamin synthesized by plants and varies widely in fruits depending on species, variety, and soil and climate conditions [74]. Cherries are important sources of vitamin C, whose content ranges from 7.0 to 62.42 mg/100 g fresh fruit [75–77].

The evaluated cherry varieties had an average vitamin C content ranging from 7.72 mg/100 g in “Stella” to 9.03 mg/100 g in “Van”. In contrast to the reports by Średnicka-Tober et al. [78], which indicate that cherries can be characterized by a significantly higher vitamin C content, up to 42.89 mg $\cdot 100\text{ g}^{-1}$, there are also studies [66,79] according to which, depending on the variety and the weather conditions of the study year, the average vitamin C content in cherries can range between 7.0 and 20.0 mg $\cdot 100\text{ g}^{-1}$, values similar to those found in the current study. During the fruit growth and ripening period, a complex process of vitamin biosynthesis takes place, strongly influenced by eco-pedoclimatic conditions. Overall, the data indicate that “Stella” is characterized by larger and firmer fruits, whereas “Van” combines higher productivity with higher acidity and vitamin C, confirming that cultivar identity is a major determinant of fruit quality expression in sweet cherry.

Color is one of the most important indicators of fruit quality, of great interest to consumers as well as for determining marketing strategies (fresh consumption or processing) [80]. In cherries, color is a varietal characteristic and is determined by the presence of pigments in all cells of the epidermis and hypodermis [81].

Depending on the color changes that occur during the fruit ripening process, cherries can be white, white speckled with pink, yellow, red, bicolored (yellow and red), black, or brick-red [82]. The most commonly used varieties range in color from yellow to dark red. The characteristic color of ripe fruits is due to the biodegradation of chlorophyll pigments and the biosynthesis of anthocyanins (red fruits) and flavonoid pigments (yellow or bicolored fruits), and is primarily regulated at the transcriptional level [83]. Currently, varieties with light red, intense, glossy skin are preferred over dark red to black varieties, which have an overripe appearance [1].

The “Van” variety exhibited higher a^* and C^* values than “Stella”, indicating a more intense and saturated red color, consistent with its higher anthocyanin content. Studies on sweet cherry ripening have shown that a^* , chroma, and hue angle are closely related

to anthocyanin development and are reliable markers of color changes associated with ripening [9]. The relatively low L^* values recorded for both varieties indicate dark-colored fruit, while the higher a^* value for “Van” is consistent with this variety’s stronger red hue. In previous studies on sweet cherries, anthocyanin concentrations ranged from approximately 5 to 86 mg/100 g FW in one year and from 6 to 230 mg/100 g FW in another, and these changes were reflected in the CIELAB color parameters, particularly a^* and the hue angle [84].

3.3. Phytochemical Properties of Cherry Extracts

Polyphenols are compounds widely found in horticultural products, whose importance stems from their physiological and biochemical properties, such as antioxidant activity, the ability to inhibit nitrosamine formation and regulate enzyme activity, the reduction of reactive oxygen species, and anticarcinogenic effects [85].

Multiple scientific studies on cherries have reported concentrations of phenolic compounds ranging from 58.31 to 115.41 mg gallic acid/100 g [86], 78.8 mg gallic acid equivalent/100 g fruit [87], 87.9 mg gallic acid equivalent/100 g fruit weight [10], 117.22–196.98 mg gallic acid equivalent/100 g fruit [88], and Kelebek & Selli (2011) [89] noted that they obtained a content ranging from 88.7 to 239.5 mg gallic acid equivalent/100 g in cherries.

The phytochemical results (Table 4) indicate a superior bioactive profile in “Van”, which showed higher antioxidant activity, total polyphenols, flavonoids, and anthocyanins than “Stella”. This pattern is not only internally consistent but also well supported by the literature showing marked cultivar-dependent variability in sweet cherry phenolic composition. In sweet cherries from Vojvodina, total polyphenols ranged from 4.12 to 8.34 mg GAE/g dw, total flavonoids from 0.42 to 1.56 mg/g dw, and total anthocyanins from 0.35 to 0.69 mg C3G/g dw. Against that background, the values obtained in this study for “Stella” and especially “Van” are comparatively higher, particularly for total polyphenols (9.33–10.47 mg GAE/g dw), flavonoids (1.69–2.75 mg CE/g dw), and anthocyanins (0.91–1.23 mg C3G/g dw), which places material at the upper end of reported sweet cherry phytochemical richness [90].

Table 4. Phytochemical properties of cherry fruits.

Phytochemical Properties		Varieties	
		Stella	Van
Antioxidant activity	$\mu\text{mol Trolox/g dw}$	18.52 ± 0.11^b	19.79 ± 0.13^a
	Inhibition %	85.68 ± 0.09^b	91.11 ± 0.12^a
Total polyphenols (mg GAE/g dw)		9.33 ± 0.13^b	10.47 ± 0.15^a
Total flavonoids (mg CE/g dw)		1.69 ± 0.08^b	2.75 ± 0.10^a
Total anthocyanins (mg C ₃ G/g dw)		0.91 ± 0.05^b	1.23 ± 0.08^a

Means within the same row sharing at least one common superscript letter do not differ significantly at $p > 0.05$.

This variation in phenolic content was attributed to the fact that it can vary within a single fruit [91] or increase during ripening, likely due to an increase in anthocyanin content [65].

The antioxidant activity data reinforce this interpretation. In the recent Romanian cultivar study, “Van” showed a DPPH inhibition of 45.8%, whereas in the present study, antioxidant inhibition reached 91.11% in “Van” and 85.68% in “Stella”. Although direct comparison should be made cautiously because the extraction protocol, expression basis, and sample preparation may differ, the magnitude of the present values supports the conclusion that the investigated samples possess a strong antioxidant potential [60].

These data also agree with the broader evidence that phenolic content and antioxidant activity in sweet cherry are strongly cultivar-dependent and closely associated with the anthocyanin-rich fraction of darker fruits. In recent compositional studies, anthocyanins and hydroxycinnamic acids represented the dominant phenolic classes in sweet cherry fruit, and cultivars differed substantially in their total phenolic accumulation [92].

3.4. Concentrations of Heavy Metals in Orchard Cherry

The soil concentrations of Zn, Cu, Ni, Cd, and Pb remained below the upper guideline values listed in Figure 2, indicating that the orchard environment cannot be considered heavily contaminated. This is important because soil contamination status is the first filter controlling elemental transfer to edible tissues. In contrast with contaminated horticultural environments, where elevated soil loads frequently translate into higher dietary exposure, the present orchard appears to provide a comparatively safe production background. Similar conclusions were reported for non-polluted reference areas in Romania, where fruits and vegetables showed substantially lower dietary risk indicators than those produced in mining-affected zones. Heavy metals, including Zn (69.11 mg kg^{-1}) and Cu (47.87 mg kg^{-1}), are involved in key enzymatic and redox processes and contribute to pigment synthesis and overall fruit quality. The availability of these elements is of particular relevance in the context of soil–plant interactions, as it governs their transfer and accumulation in fruit tissues, with direct implications for both nutritional value and safety-related considerations [93]. Cherries are rich in minerals, with average levels ranging from 0.19% to 0.62%. The main minerals found in cherries are: potassium, calcium, magnesium, iron, copper, manganese, and zinc [1].

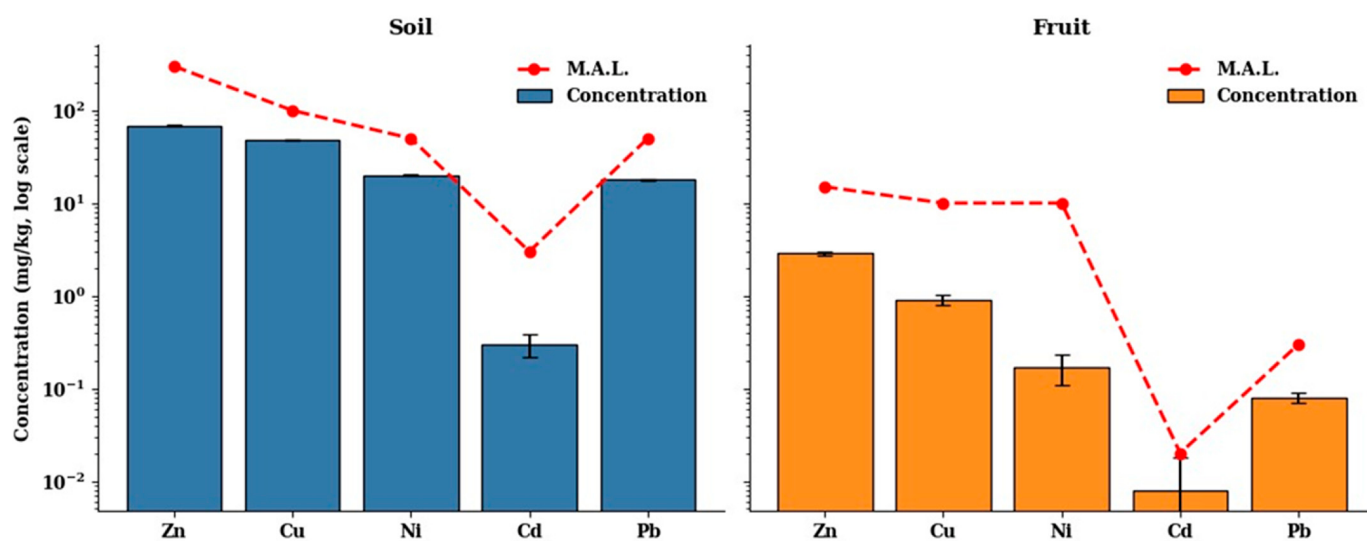


Figure 2. Heavy metals in soil and fruits relative to regulatory limits.

At the fruit level, all measured concentrations were below the maximum allowable limits (Figure 2). This is particularly relevant for Cd and Pb, whose concentrations in the present fruits were 0.008 and 0.08 mg/kg, respectively. These values are clearly lower than those reported in an earlier Romanian study on *Prunus* fruits from an urban environment, where cherry Cd ranged from 0.123 to 0.431 mg/kg dry weight, and Pb was not detected. Even though the basis of expression differs between studies, the comparison still suggests that the present material is characterized by low contaminant burden, especially for cadmium. For Cu, your fruit value (0.91 mg/kg) is also well below the 3.09–4.13 mg/kg dry weight reported for urban-grown cherries in that study [94].

At the same time, Zn and Cu should not be interpreted exclusively through a toxicological lens. Both are essential micronutrients involved in enzymatic activity and redox metabolism, and their presence at moderate concentrations may be compatible with normal plant physiological functioning. What matters in the food-safety context is not only their presence, but whether accumulation in fruit exceeds admissible thresholds, which is not the case here [95].

3.5. Health-Risk Analysis of Heavy Metals Through Cherry Consumption

The contamination risk (ContR) values for Zn, Cu, Ni, Cd, and Pb in cherry fruits (Table 5) were all below 1.0, indicating no significant contamination and confirming their suitability for safe consumption.

Table 5. Health-risk assessment of heavy metals through cherry consumption.

Heavy Metals	ContR	EDI	THQ	HI = Σ THQ _i	CR
Zn	41.24×10^{-2}	1.35×10^{-3}	3.65×10^{-3}	3.18×10^{-2}	-
Cu	19.01×10^{-2}	4.32×10^{-4}	1.08×10^{-2}		-
Ni	8.44×10^{-3}	8.07×10^{-5}	4.04×10^{-3}		1.37×10^{-7}
Cd	2.67×10^{-2}	3.80×10^{-6}	3.80×10^{-3}		1.44×10^{-9}
Pb	4.47×10^{-3}	3.79×10^{-5}	9.49×10^{-3}		3.28×10^{-10}

The health-risk assessment confirms the food-safety relevance of the analytical results. All THQ values were far below 1, and the cumulative HI was 3.18×10^{-2} , also well below the critical threshold of 1. These values indicate the absence of significant non-carcinogenic risk associated with cherry consumption under the exposure assumptions used in the study. This interpretation is fully consistent with risk-assessment frameworks applied in the literature, including the Romanian case study from the Banat area, where lower-risk horticultural products from the reference area also generated THQ/TTHQ values below the concern threshold [96].

The carcinogenic risk values calculated for Ni, Cd, and Pb were also extremely low, all below 10^{-6} – 10^{-7} order of magnitude, indicating negligible carcinogenic concern. From an ISI discussion perspective, this is an important strength of the manuscript: the analytical determination of heavy metals is not left at the descriptive level, but is integrated with an exposure-based interpretation, which substantially increases the relevance of the fruit safety assessment [96].

3.6. Global Characterization of Cherry Pomace Powder

Table 6 presents the phytochemical composition, color, mineral, and nutritional characteristics of the extract derived from cherry pomace powder.

Cherry pomace powder exhibited a composition typical of a bioactive fruit-processing by-product, characterized by high total polyphenols (1046.80 mg GAE/100 g), appreciable flavonoid (275.26 mg CE/100 g), and anthocyanin (123.27 mg C3G/100 g) contents. The antioxidant activity (21.43 ± 1.25 μ M TE/g) further supports the presence of a bioactive phytochemical matrix. Color measurements ($L^* = 50.53$, $a^* = 8.93$, $b^* = 7.02$) placed the powder in the red-yellow region, consistent with the retention of fruit pigments after processing. When compared with optimized sour-cherry-pomace extraction reported by Yilmaz et al. [97], the present total polyphenol content is lower than the reported 14.23 ± 0.38 mg/g (≈ 1423 mg/100 g), but the anthocyanin level is higher than their 0.41 ± 0.02 mg/g (≈ 41 mg/100 g). In addition, cultivar-specific work by Ciccoritti et al. [98] showed that total monomeric anthocyanins in sour cherry pomace may vary widely, from

0.22 ± 0.1 mg/g dw to 4.3 ± 0.1 mg/g dw, confirming that the present anthocyanin content lies within the broad variability expected for cherry pomace matrices.

Table 6. Comprehensive analysis of the cherry pomace powder.

Characteristics	Cherry Pomace Powder
Total anthocyanins, mg C3G/100 g dw	123.27 ± 0.34
Total flavonoids, mg CE/100 g dw	275.26 ± 0.51
Total polyphenols, mg GAE/100 g dw	1046.80 ± 1.64
Antioxidant activity, µM TE/g dw	21.43 ± 1.25
Ash, g/100 g dw	2.71 ± 0.28
Moisture, g/100 g dw	8.11 ± 0.17
Crude protein, g/100 g dw	8.42 ± 0.21
Crude fat, g/100 g dw	3.37 ± 0.14
Carbohydrates, g/100 g dw	27.56 ± 0.26
Total dietary fiber, g/100 g dw	49.83 ± 0.27
L*	50.53 ± 0.22
a*	8.93 ± 0.13
b*	7.02 ± 0.22
Hue angle	0.67 ± 0.02
Chroma	11.36 ± 0.11
Magnesium, mg/100 g	21.15 ± 0.19
Calcium, mg/100 g	40.06 ± 0.23
Potassium, mg/100 g	329.28 ± 0.69
Sodium, mg/100 g	1.86 ± 0.20
Copper, mg/100 g	0.49 ± 0.11
Zinc, mg/100 g	0.16 ± 0.09
Iron, mg/100 g	1.02 ± 0.14
Manganese, mg/100 g	0.26 ± 0.13

Proximate analysis showed that the material was predominantly composed of total dietary fiber (49.83 g/100 g) and carbohydrates (27.56 g/100 g), while protein (8.42 g/100 g) and fat (3.37 g/100 g) were comparatively low, confirming the potential of this powder as a fiber-rich functional ingredient. The moisture content (8.11 g/100 g) suggests good storage stability, whereas the ash value (2.71 g/100 g) indicates the presence of an appreciable mineral fraction. Gumul et al. [99] reported sour cherry pomace with 13.57% protein, 3.02% fat, 10.97% carbohydrates, and 48.7% dietary fiber (4.5% soluble and 44.2% insoluble), while a later study on dried, pitted, fractionated sour cherry pomace reported 5.76–6.71% moisture and 1.06–3.02% ash depending on particle-size fraction. Jūrienė et al. [100].

Potassium was the predominant mineral (329.28 mg/100 g), followed by calcium and magnesium, while sodium and iron remained very low. Pomace mineral composition differs markedly across species, largely because each species has a unique biochemical profile that influences the concentration of potassium, calcium, phosphorus, and other essential micronutrients. Reported variations in the literature have also been associated with factors such as cultivar, climatic conditions, soil properties, processing parameters, and extraction techniques [101].

The results characterize cherry pomace powder as a low-moisture ingredient with a high dietary fiber and phenolic content, a mineral profile dominated by potassium, moderate protein levels, and low fat content, together with a stable reddish chromatic profile. Collectively, these properties highlight its potential as a value-added functional food ingredient, particularly in formulations aimed at improving dietary fiber content, bioactive compound availability, mineral enrichment, and natural color attributes.

3.7. Physicochemical, Phytochemical, and Antioxidant Activity Characterization of Value-Added Dairy-Based Spreadable Samples

The incorporation of cherry pomace powder significantly affected the physicochemical composition of dairy-based spreadable samples (Figure 3). The control sample (C) differed significantly from dairy-based spreadable enriched with 5% (C1) and 10% (C2) cherry pomace powder ($p < 0.05$). The results demonstrate a clear concentration-dependent effect of pomace addition, with progressive compositional changes as the supplementation level increased from 5 to 10%.



Figure 3. Physicochemical, phytochemical, and antioxidant profile of dairy-based spreadable samples (mean values followed by at least one identical letter are not significantly different ($p > 0.05$)).

Compared with the control sample (C), the addition of 5% (C1) and 10% (C2) pomace powder significantly increased ash, carbohydrates, and total dietary fiber, while significantly decreasing moisture, protein, lipid, and energetic value. Ash increased from 3.35 to 5.21 g/100 g, indicating mineral enrichment, whereas moisture decreased from 19.51 to 12.03 g/100 g, reflecting a progressive increase in total solids. The addition of cherry pomace powder also resulted in a significant decrease in protein content, from 23.69 ± 0.20 g/100 g in C to 21.33 ± 0.17 g/100 g in C1 and 19.14 ± 0.15 g/100 g in C2. This represents reductions of approximately 10.0% and 19.2%, respectively. A similar trend was observed for lipid content, which decreased from 52.06 ± 0.44 g/100 g in the control to 48.02 ± 0.31 g/100 g and 45.13 ± 0.28 g/100 g in C1 and C2, respectively. In contrast, carbohydrates rose from 0.62 to 15.34 g/100 g, and total dietary fiber increased from 0.00 to 2.75 g/100 g, confirming the contribution of cherry pomace powder as a source of plant-derived solids and dietary fiber. The energetic value decreased from 565.78 to 549.59 kcal/100 g, mainly due to the reduction in lipid content.

The progressive increase in ash, carbohydrates, and total dietary fiber in the samples obtained in the study is mechanistically compatible with the addition of pomace, as fruit pomace contributes minerals, structural polysaccharides, and non-milk solids to the dairy-based matrix [102,103]. In the Fröhbauerová et al. [104] study, they produced processed cheese spread containing 1% and 2% grape-skin powder derived from grape pomace. In that study, protein content increased significantly at the 2% addition level, from 112.5 g/kg in the control to 128.4–129.7 g/kg, while dry matter also tended to increase, reaching 419.0 g/kg in the sample with 2% oven-dried powder; by contrast, fat and ash did not change significantly.

Cherry powder addition significantly enhanced the phytochemical profile and antioxidant activity of dairy-based spreadable samples ($p < 0.05$) (Figure 3). The data further reveal a clear dose-dependent effect, with the highest values consistently observed in the sample containing 10% (*w/w*) cherry powder (C2).

As expected, total anthocyanin content was not detected in the control sample, whereas the cherry-enriched samples showed substantial anthocyanin levels, reaching 80.52 ± 2.58 mg/100 g DW in C1 and 112.09 ± 2.69 mg/100 g dw in C2. The increase from C1 to C2 was approximately 39.2%, confirming that anthocyanins were directly introduced through cherry-powder addition and accumulated proportionally with increasing fortification level. Total flavonoid content increased from 11.25 in the control to 26.37 and 29.88 mg CE/100 g DW in C1 and C2, respectively, while total polyphenols rose from 24.19 to 67.65 and 86.58 mg GAE/100 g dw. The pronounced rise in total polyphenols confirms that cherry powder acted as a major source of phenolic compounds in the fortified dairy-based spreadable samples. The same dose-dependent trend was observed for antioxidant activity, which rose from 8.96 ± 1.02 μ M TE/g dw in the control to 20.38 ± 1.02 μ M TE/g dw in C1 and 27.41 ± 1.11 μ M TE/g dw in C2. This corresponds to increases of approximately 127.5% and 205.9%, respectively, relative to the control.

In the study by Lucera et al. [102], the researchers fortified a dairy-based spreadable with 5% red grape pomace. In that work, pomace addition markedly improved the functional profile of the cheese: total phenolic content increased from 0.66 mg GAE/g dw in the control to 2.34 mg GAE/g dw in red-grape-pomace cheese. Antioxidant activity also increased substantially, with ABTS values rising from 0.96 in the control to 3.95–4.00 mg TE/g dw. Fröhbauerová et al. [104] reported that the phenolic profile and antioxidant capacity of processed cheese spread improved after enrichment and that freeze-dried grape-skin powder performed better than oven-dried powder for total phenolics and ABTS radical scavenging. The total phenolics increased from 0.13 ± 0.02 in the control to 0.47 ± 0.07 and 0.54 ± 0.07 mg GAE/g dry matter in cheeses enriched with oven-dried and freeze-dried grape-skin powder, respectively. Therefore, the antioxidant effect of the enriched cheese depended on both the antioxidant load of the by-product and the treatment applied to that by-product before incorporation. The concomitant increases in flavonoids, total polyphenols, and antioxidant activity also agree with the broader dairy-based spreadable products literature, which reports that polyphenol-rich plant by-products consistently enhance the antioxidant profile of dairy-based spreadable formulations, although the final values vary with cultivar, geographic origin, treatment, and matrix interactions with dairy proteins. The results demonstrate that the enrichment of dairy-based spreadable with cherry powder significantly improves their mineral and fiber content and slightly reduces caloric density, phytochemical composition, and antioxidant activity in a concentration-dependent manner.

3.8. Colorimetric Parameters of Value-Added Dairy-Based Spreadable Samples

The incorporation of cherry powder significantly influenced the color attributes of dairy-based spreadable samples (Table 7). The data show that cherry powder induced a

marked and concentration-dependent modification of the visual appearance of the dairy-based spreadable product, shifting the product from a light yellow-greenish dairy color toward a darker and more reddish hue.

Table 7. Colorimetric parameters of dairy-based spreadable samples.

Samples of Dairy-Based Spreadable	L*	a*	b*	Chroma	Hue Angle	ΔE
C	90.55 $\pm$ 0.11 ^a	−2.80 $\pm$ 0.06 ^c	14.56 $\pm$ 0.10 ^a	14.83 $\pm$ 0.12 ^b	178.62 $\pm$ 0.02 ^a	-
C1	58.98 $\pm$ 0.07 ^b	13.57 $\pm$ 0.09 ^b	4.37 $\pm$ 0.07 ^b	14.26 $\pm$ 0.10 ^b	0.32 $\pm$ 0.02 ^b	36.99 $\pm$ 0.15 ^b
C2	50.02 $\pm$ 0.04 ^c	16.77 $\pm$ 0.08 ^a	3.99 $\pm$ 0.06 ^c	17.24 $\pm$ 0.14 ^a	0.23 $\pm$ 0.02 ^b	46.23 $\pm$ 0.17 ^a

Mean values followed by at least one common letter in the same column are not significantly different ($p > 0.05$).

Lightness (L*) decreased markedly from 90.55 in the control to 58.98 and 50.02 in C1 and C2, respectively, indicating progressive darkening of the dairy-based spreadable matrix. At the same time, a* values shifted from negative (−2.80) in the control to strongly positive values (13.57 and 16.77), demonstrating a pronounced increase in redness following cherry powder incorporation. In contrast, b* decreased from 14.56 to 4.37 and 3.99, showing a reduction in yellowness. Chroma remained statistically similar between C and C1, but increased significantly in C2, indicating greater color saturation at the higher supplementation level. The color modifications observed in the present study are consistent with the literature on fruit by-product enrichment in dairy-based formulation. A very similar trend was reported by Rațu et al. [105] for cheese supplemented with grape-skin powder. In that study, L* decreased from 68.31 $\pm$ 0.04 in the control to 53.33 $\pm$ 0.09 in the enriched cheese, a* increased from −1.22 $\pm$ 0.27 to 8.31 $\pm$ 0.06, and b* decreased from 11.59 $\pm$ 0.05 to 6.46 $\pm$ 0.08, with all differences significant at $p < 0.05$. Chroma also decreased slightly from 11.66 $\pm$ 0.05 to 10.53 $\pm$ 0.10. Thus, the direction of change in our samples is fully consistent with this grape-skin-cheese model, although the shift toward redness in C1 and especially C2 samples was even stronger. Comparable effects were also described in berry-by-product-enriched curd cheese, particularly with elderberry and blueberry by-products, which produced lower lightness and higher redness than the control. For example, elderberry by-product cheese showed L* = 70.2 $\pm$ 3.82, a* = 7.35 $\pm$ 0.88, and b* = 7.24 $\pm$ 0.49, while blueberry by-product cheese showed L* = 80.4 $\pm$ 3.21, a* = 1.69 $\pm$ 0.39, and b* = 8.26 $\pm$ 0.51 [106]. Overall, these findings confirm that cherry powder acts as a strong natural coloring agent in dairy-based spreadable and that the effect is concentration-dependent.

The large ΔE values (36.99 and 46.23) confirm that the color changes were highly perceptible and intensified with increasing cherry-powder concentration. Overall, cherry powder acted as an effective natural coloring ingredient, producing darker, redder, and more visually distinctive dairy-based spreadable samples.

From a technological and product-development perspective, these findings demonstrate that cherry powder functions not only as a source of bioactive compounds but also as a strong natural colorant in dairy-based spreadable formulations. The addition of 5% cherry powder was sufficient to cause substantial darkening and reddening, whereas 10% addition produced an even more intense and saturated red-toned product. Therefore, the color data support the conclusion that cherry powder has high potential for the development of visually differentiated value-added dairy spreads.

3.9. Texture Analysis of Value-Added Dairy-Based Spreadable Samples

The incorporation of cherry powder significantly influenced most of the textural properties of dairy-based spreadable samples (Figure 4). The results indicate that the

addition of cherry powder progressively modified the dairy-based spreadable matrix, yielding samples that were firmer, less adhesive, and less cohesive, while maintaining similar elastic behavior.

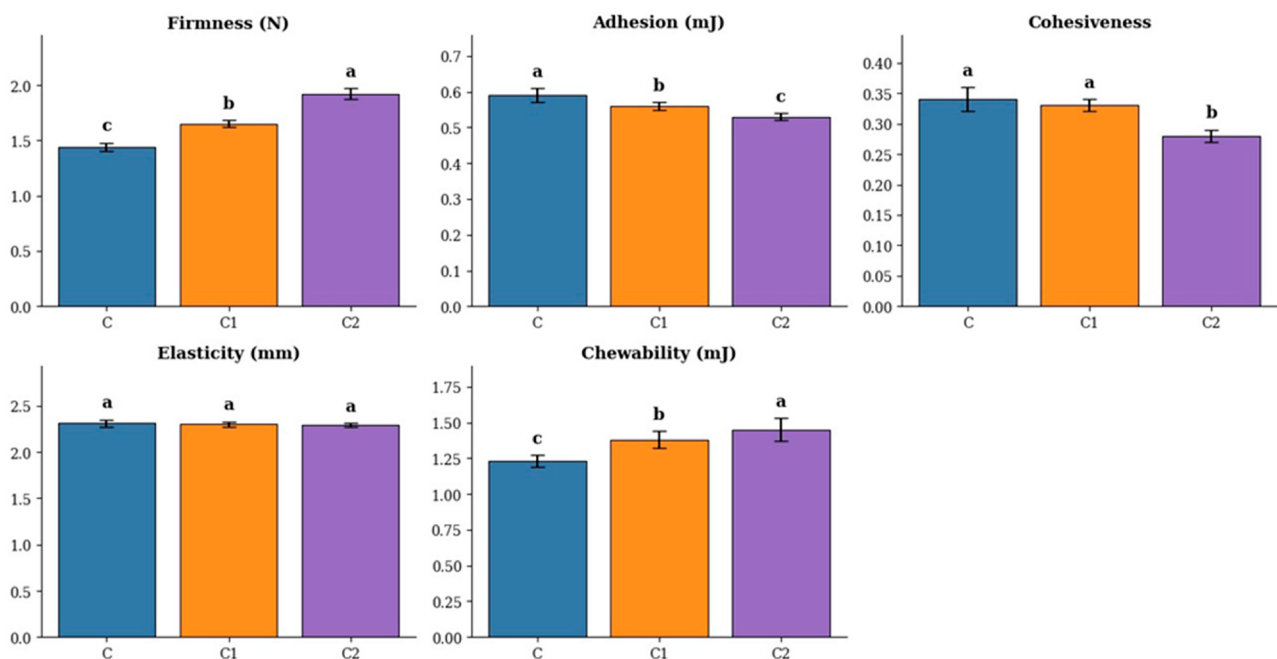


Figure 4. Textural parameters of dairy-based spreadable samples (mean values followed by different lowercase letters differ significantly ($p < 0.05$)).

Firmness increased progressively from 1.44 N in the control to 1.65 N in C1 and 1.92 N in C2, indicating that powder addition promoted the formation of a denser and more resistant matrix. In contrast, adhesion decreased significantly from 0.59 to 0.53 mJ, suggesting reduced stickiness with increasing enrichment. Cohesiveness remained unchanged at the 5% level but decreased significantly at 10%, indicating that higher powder incorporation may weaken matrix continuity. Elasticity was not significantly affected, showing that shape recovery properties were preserved across formulations. Chewability increased significantly in enriched samples compared with the control. The increase in chewability is consistent with the observed rise in firmness and the reduction in moisture, both of which contribute to a denser product requiring greater mechanical energy during oral processing. The textural behavior observed in the present study is in agreement with the literature showing that plant by-products can markedly modify dairy-based spreadable structure, although the direction of change depends on formulation. Previous work on fruit by-products shows that responses are matrix-dependent: wine-pomace cheeses have been reported to become softer and less spreadable, whereas other plant powders or fibers have either increased hardness or weakened cohesiveness by disrupting the cheese network. In particular, studies on date-seed-fortified processed cheese and blueberry-enriched spreadable processed cheese indicate that higher levels of fibrous plant material can impair internal matrix continuity, which agrees with the significant drop in cohesiveness observed here at the 10% fortification level. Thus, cherry powder appears to act as a structuring ingredient at lower addition levels, while at higher concentrations it begins to interfere with the continuity of the dairy-based spreadable matrix [107–110]. Overall, cherry-powder addition resulted in a firmer, less adhesive, and moderately less cohesive dairy-based spreadable matrix, while maintaining elastic behavior.

3.10. Scanning Electron Microscopy of Value-Added Dairy-Based Spreadable Samples

The SEM micrographs presented in Figure 5 highlighted distinct morphological differences between the cherry pomace powder and the dairy-based spreadable samples. Figure 5a, corresponding to cherry pomace powder, showed an irregular, compact, and heterogeneous particle morphology, with rough surfaces and agglomerated structures, characteristic of a fibrous plant-derived material. Such structural features suggest the presence of insoluble cell wall components and fragmented pomace particles.

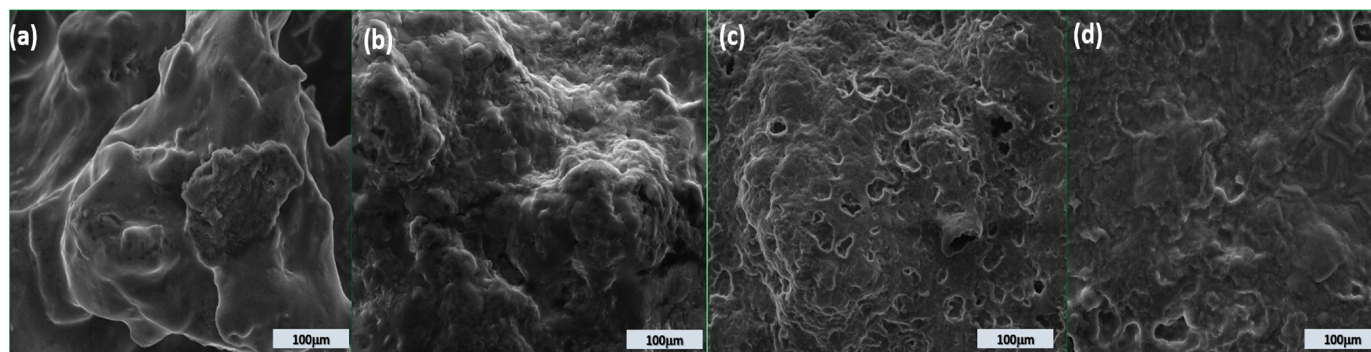


Figure 5. Scanning electron microscopy micrographs of cherry pomace powder (a); control sample without cherry pomace powder addition (b); and dairy-based spreadable samples enriched with cherry pomace powder, containing 5% powder (C1) (c); and 10% powder (C2) (d), respectively.

The control sample without powder addition (Figure 5b) exhibited a more continuous, compact, and homogeneous matrix, with a relatively smoother surface and fewer visible discontinuities. This microstructure indicates a well-organized dairy network, likely reflecting a more uniform distribution of the protein–fat phase in the absence of plant material.

In sample C1, Figure 5c, containing 5% cherry pomace powder, the matrix became more irregular and less compact than the control, with the appearance of pores, voids, and structural heterogeneity. These changes suggest that the incorporation of pomace particles disturbed the continuity of the native dairy matrix and promoted the formation of a more open network.

For sample C2, Figure 5d, containing 10% cherry pomace powder, the structural disruption appeared more pronounced, with a denser accumulation of irregular features and a more heterogeneous surface organization. The higher powder level seemed to intensify matrix discontinuity and reduce structural uniformity, indicating stronger interference of pomace particles within the dairy system.

Overall, the SEM observations suggest that increasing the level of cherry pomace powder progressively modified the microstructure of the spreadable product, shifting it from a compact and cohesive matrix toward a more heterogeneous, fibrous, and disrupted network. These structural modifications may be associated with enhanced functional properties, particularly in terms of texture, water-holding capacity, and sensory characteristics. The microstructural appearance of the fortified samples was comparable to that commonly described for processed cheese [111].

3.11. Sensory Analysis of Value-Added Dairy-Based Spreadable Samples

From a sensory point of view, the dairy-based spreadable samples were analyzed using the following 10 attributes: appearance, odor, color, taste, aroma, aftertaste, hardness, adhesiveness, chewability, and overall acceptability using the scoring scale method from 1 to 7 (Figure 6).

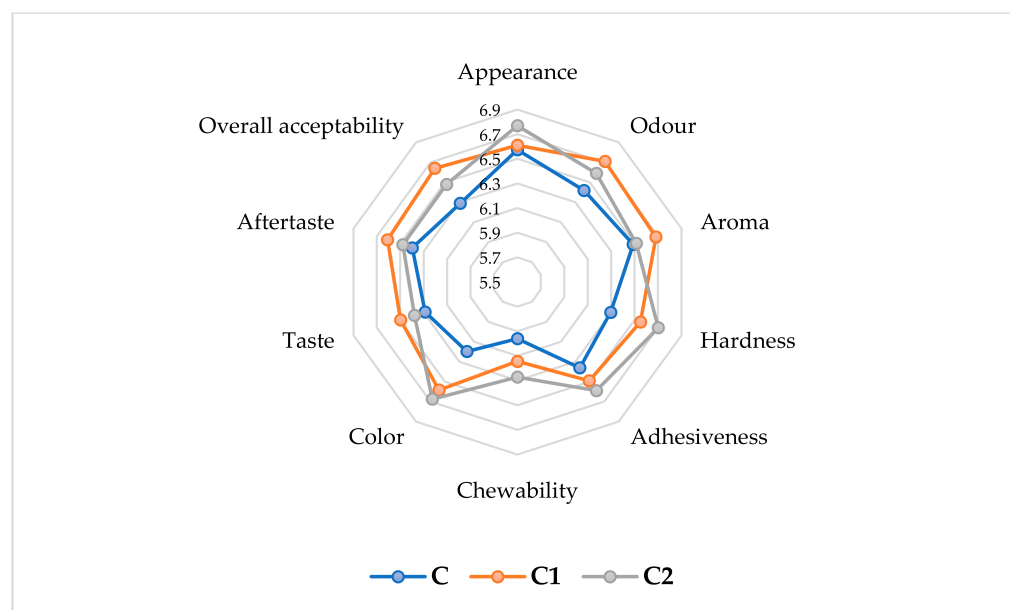


Figure 6. Comparative diagram of sensory attributes specific to the types of dairy-based spreadable: C—dairy-based spreadable without adding cherry powder, C1, and C2—dairy-based spreadable with 5 and 10% cherry powder.

Sensory evaluation showed that all samples received relatively close and favorable scores, ranging from 5.96 to 6.77. The enriched dairy-based spreadable samples generally performed better than the control, indicating a positive sensory effect of cherry-powder incorporation. C1 showed higher scores for odor, aroma, taste, aftertaste, and overall acceptability, suggesting that the 5% addition level provided the most balanced sensory profile. In contrast, C2 received the highest scores for appearance, hardness, adhesiveness, chewability, and color, indicating that the 10% addition level enhanced visual and textural perception more strongly.

The sensory results indicate that cherry-powder addition enhanced the acceptability of the dairy-based spreadable sample, with the 5% formulation (C1) appearing to be the most successful from an overall sensory standpoint. These results suggest that moderate fortification offered the best compromise between improved appearance and texture and desirable flavor perception.

The PCA biplot (Figure 7) revealed a clear separation between the control sample and the cherry powder-enriched samples. The first two principal components explained 100.00% of the total variance, with F1 and F2 accounting for 72.26% and 27.74%, respectively. The control sample was located on the negative side of F1, whereas C1 and C2 were grouped on the positive side, indicating that cherry-powder addition was the main factor in this study influencing sensory differentiation. Sample C1 was more closely associated with aroma, taste, aftertaste, and overall acceptability, suggesting a more balanced and preferred sensory profile. In contrast, sample C2 was associated mainly with appearance, color, hardness, adhesiveness, and chewiness, indicating that the higher level of cherry powder exerted a stronger effect on visual and textural attributes. These results suggest that moderate cherry-powder incorporation improved consumer-related sensory characteristics, while the higher level enhanced structural and visual properties.

The sensory pattern observed in the present study is consistent with the scientific literature on fruit-enriched spreadable and processed cheeses. In a Petit Suisse-type dairy snack, the formulation containing 10 g/100 g blueberry syrup plus 2 g/100 g blueberry bagasse powder achieved the highest sensory scores, showing that fruit-derived ingredients can improve acceptance when used at an optimized level rather than simply at

the maximum possible dose [105]. Similarly, in the present work, the 5% cherry-powder formulation showed the highest odor, aroma, taste, aftertaste, and overall acceptability scores, whereas the 10% formulation achieved the highest appearance, color, and texture-related scores. These findings suggest that moderate cherry-powder incorporation provides the most favorable balance between visual enhancement, textural modification, and flavor acceptance.

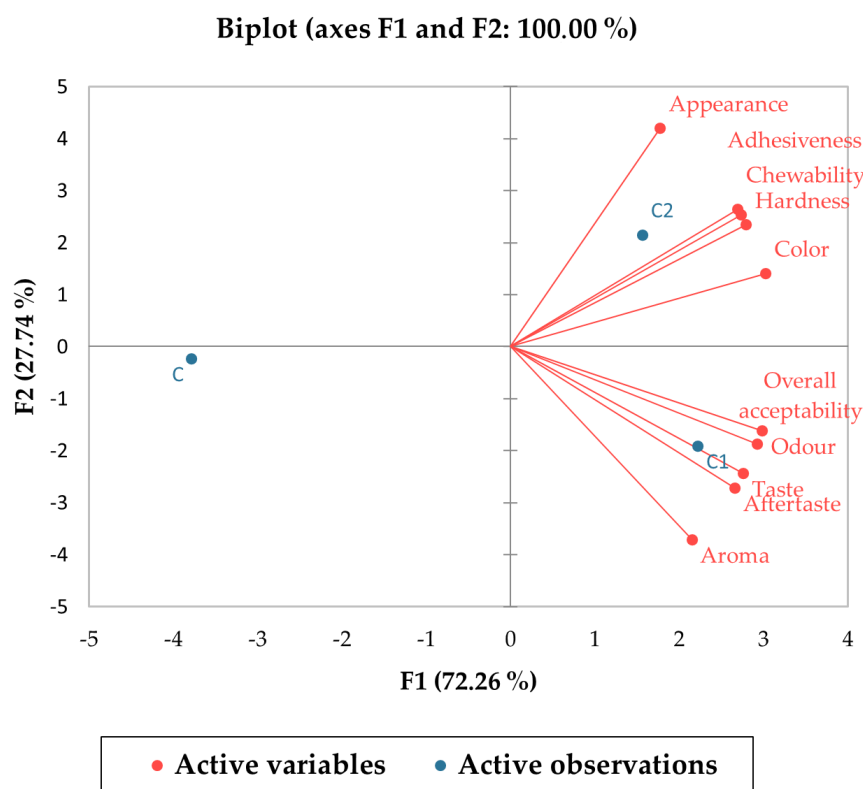


Figure 7. Illustration of Principal Component Analysis (PCA) biplot.

4. Limitations and Future Perspectives

Although this study provides an integrated assessment of orchard fruit quality, cherry pomace characterization, and its valorization in dairy-based spreadable products, several limitations should be acknowledged. The experiment was conducted under the pedoclimatic conditions of a single orchard and during one harvest season; therefore, the relationships observed among soil conditions, cultivar response, fruit quality, and by-product functionality should be validated across different years, locations, orchard management systems, and cultivars. In addition, cherry pomace powder was obtained only from the Van cultivar, which may limit the generalization of the results to other cherry genotypes with different phytochemical and technological profiles.

The dairy-based spreadable formulations were evaluated at two incorporation levels, 5% and 10%, allowing clear concentration-dependent effects to be identified. However, a broader range of inclusion levels should be investigated to optimize the balance between functional enrichment, texture, color, flavor, and consumer acceptability. Further research is also needed to assess shelf-life stability, microbiological safety, pigment and phenolic retention, and possible changes in antioxidant activity during refrigerated storage.

Another limitation is that sensory analysis was performed using untrained panelists. Although this approach provides useful information on consumer-oriented acceptability, future studies could combine consumer testing with trained descriptive sensory analysis to obtain a more detailed understanding of flavor, texture, and aftertaste changes induced by

cherry pomace addition. Moreover, *in vitro* digestion and bioaccessibility studies would help clarify the release and potential availability of phenolic compounds, anthocyanins, minerals, and dietary fiber after incorporation into the dairy matrix.

From an application perspective, the results support the potential of dried cherry pomace as a functional ingredient for circular food innovation. Further work should focus on pilot-scale production, process optimization, economic feasibility, and environmental assessment to evaluate the practical implementation of this strategy within sustainable fruit-processing and dairy product value chains.

5. Conclusions

This study provides a comprehensive framework linking soil–orchard system characteristics with fruit quality expression and the functional valorization of cherry-derived by-products within a circular food innovation context. The results demonstrate that pedo-climatic conditions, particularly soil fertility status and balanced mineral composition, play a decisive role in shaping fruit physicochemical and phytochemical attributes.

Under the studied conditions, both cultivars exhibited distinct quality profiles, confirming the strong influence of genotype on fruit development, while maintaining values within the optimal range reported for high-quality sweet cherries. The observed levels of soluble solids, organic acids, and vitamin C indicate favorable metabolic performance, whereas the elevated phenolic and antioxidant contents, particularly in “Van”, highlight the functional potential of the fruit matrix.

The low concentrations of heavy metals in both soil and fruit, together with THQ and HI values below critical thresholds, confirm the safety of the production system and indicate limited soil-to-fruit transfer of potentially toxic elements. These findings reinforce the suitability of the studied orchard environment for producing safe and nutritionally valuable fruits.

Importantly, the study demonstrates that cherry pomace retains a significant proportion of bioactive compounds, including phenolics, anthocyanins, and dietary fiber, confirming its potential as a high-value functional ingredient. The incorporation of pomace powder into dairy-based spreadable formulations resulted in improved phytochemical composition, antioxidant activity, and mineral content, while also influencing color and textural properties in a concentration-dependent manner.

Taken together, these results support the concept that fruit quality and the functional potential of derived products are intrinsically linked to soil–orchard system characteristics. The integration of primary production factors with by-product valorization highlights a viable pathway for extending the cherry value chain and advancing circular bioeconomy strategies in sustainable horticultural systems.

Author Contributions: Conceptualization, M.R. and F.S.; methodology, M.R., I.G.C., I.M. and F.S.; software, D.C.T.; validation, G.J. and D.C.T.; formal analysis, D.C.T., I.G.C. and I.M.; investigation, M.R. and F.S.; resources, I.G.C., G.J. and D.C.T.; data curation, I.G.C. and I.M.; writing—original draft preparation, M.R. and F.S.; writing—review and editing, G.J. and D.C.T.; visualization, D.C.T. and G.J.; supervision, G.J.; project administration, G.J.; funding acquisition, G.J. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Faculty of Agriculture, University of Life Sciences in Iasi, Romania (protocol code 724/16.04.2026 and 16 April 2026 of approval).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

References

- Budan, S.; Grădinaru, G. *Cireșul*; Editura Ion Ionescu de la Brad: Iași, România, 2000; p. 262, ISBN 973-8014-11-5.
- Beceanu, D. Natural quality, a controversial concept in putting to good use vegetables, fruits and grapes. In *Proceedings of the International Symposium on Horticulture*; International Society for Horticultural Science: Brussel, Belgium, 2009; pp. 839–842. Available online: <https://www.cabidigitallibrary.org/doi/full/10.5555/20103132564> (accessed on 20 March 2026).
- Quero-García, J.; Iezzoni, A.; Puławska, J.; Lang, G.A. (Eds.) *Cherries: Botany, Production and Uses*; CABI: Wallingford, UK, 2017. Available online: <https://www.cabidigitallibrary.org/doi/book/10.1079/9781780648378.0000> (accessed on 1 March 2026).
- Eurostat. Production of Sweet Cherries in EU Standard Humidity. Available online: https://ec.europa.eu/eurostat/databrowser/view/apro_cpsh1_custom_15043237/default/table?lang=en (accessed on 14 March 2025).
- Istrate, R.; Manole, M.S.; Clinciu-Radu, R.A. Ecological aspects regarding biodiversity of microflora and fauna from cherry and sour cherry orchards from UASVM Bucharest. *Sci. Pap. Ser. B Hortic.* **2019**, *63*, 123–130.
- Mihu, G.-D.; Aostăcioaei, T.G.; Ghelbere, C.; Calistru, A.-E.; Țopa, D.C.; Jităreanu, G. Exploring soil hydro-physical improvements under no-tillage: A sustainable approach for soil health. *Agriculture* **2025**, *15*, 981. [\[CrossRef\]](#)
- Afonso, S.; Oliveira, I.; Meyer, A.S.; Gonçalves, B. Biostimulants to improve tree physiology and fruit quality: A review with special focus on sweet cherry. *Agronomy* **2022**, *12*, 659. [\[CrossRef\]](#)
- Faienza, M.F.; Corbo, F.; Carocci, A.; Catalano, A.; Clodoveo, M.L.; Grano, M.; Wang, D.Q.-H.; D’Amato, G.; Muraglia, M.; Franchini, C.; et al. Novel insights in health-promoting properties of sweet cherries. *J. Funct. Foods* **2020**, *69*, 103945. [\[CrossRef\]](#)
- Gonçalves, B.; Landbo, A.-K.; Knudsen, D.; Silva, A.P.; Moutinho-Pereira, J.; Rosa, E.; Meyer, A.S. Effect of ripeness and post-harvest storage on the phenolic profiles of cherries (*Prunus avium* L.). *J. Agric. Food Chem.* **2004**, *52*, 523–530. [\[CrossRef\]](#)
- Usenik, V.; Fabčič, J.; Štampar, F. Sugars, organic acids, phenolic composition and antioxidant activity of sweet cherry (*Prunus avium* L.). *Food Chem.* **2008**, *107*, 185–192. [\[CrossRef\]](#)
- FieldClimate. Available online: <https://www.fieldclimate.com> (accessed on 14 March 2025).
- Rusu, M.; Filip, M.; Cara, I.G.; Țopa, D.; Jităreanu, G. Soil nutrient dynamics and farming sustainability under different plum orchard management practices in the pedoclimatical conditions of Moldavian Plateau. *Agriculture* **2025**, *15*, 509. [\[CrossRef\]](#)
- Cakpo, S.S.; Rusu, M.; Ghelbere, C.; Mihu, G.-D.; Aostăcioaei, T.G.; Boti, I.; Jităreanu, G.; Țopa, D. Synergistic interactions and short-term impact of tillage systems on soil physico-chemical properties and organic carbon sequestration in North-Eastern Romania. *Agriculture* **2026**, *16*, 179. [\[CrossRef\]](#)
- Țopa, D.; Cara, I.G.; Jităreanu, G. Long-term impact of different tillage systems on carbon pools and stocks, soil bulk density, aggregation and nutrients: A field meta-analysis. *Catena* **2021**, *199*, 105102. [\[CrossRef\]](#)
- Cojocaru, A.; Carbune, R.V.; Teliban, G.C.; Stan, T.; Mihalache, G.; Rosca, M.; Rusu, O.-R.; Butnariu, M.; Stoleru, V. Physiological, morphological and chemical changes in pea seeds under different storage conditions. *Sci. Rep.* **2024**, *14*, 28191. [\[CrossRef\]](#)
- Ursu, A.; Cara, I.G.; Birescu, G.; Rusu, M.; Mihu, G.-D.; Cakpo, S.S.; Țopa, D.; Jităreanu, G. Effects of tillage systems and bacterial inoculation on enzyme activities and selected soil chemical properties. *Agriculture* **2025**, *15*, 1285. [\[CrossRef\]](#)
- Brown, J.R. *Soil Testing: Sampling, Correlation, Calibration, and Interpretation*; SSSA Special Publications: Madison, WI, USA, 1987. Available online: <https://access.onlinelibrary.wiley.com/doi/book/10.2136/sssaspecpub21> (accessed on 12 March 2026).
- Remeteiová, D.; Ružičková, S.; Mičková, V.; Laubertová, M.; Slezáková, R. Evaluation of US EPA method 3052 microwave acid digestion for quantification of majority metals in waste printed circuit boards. *Metals* **2020**, *10*, 1511. [\[CrossRef\]](#)
- Filip, C.D.; Coman, M.A. Regarding transfer factor of soil pollution with heavy metals in soil–plant system. *Sci. Pap. Ser. A Agron.* **2025**, *68*, 90–99.
- Karageorgiadou, M.; Rodovitou, M.; Nasiopoulou, E.; Titeli, V.S.; Michailidis, M. Sweet cherry fruit firmness evaluation using compression distance methods. *Horticulturae* **2024**, *10*, 435. [\[CrossRef\]](#)
- Mineață, I.; Murariu, O.C.; Sîrbu, S.; Tallarita, A.V.; Caruso, G.; Jităreanu, C.D. Effects of ripening phase and cultivar under sustainable management on fruit quality and antioxidants of sweet cherry. *Horticulturae* **2024**, *10*, 720. [\[CrossRef\]](#)
- Legua, P.; Modica, G.; Porras, I.; Conesa, A.; Continella, A. Bioactive compounds, antioxidant activity and fruit quality evaluation of eleven blood orange cultivars. *J. Sci. Food Agric.* **2022**, *102*, 2960–2971. [\[CrossRef\]](#)
- Stoica, F.; Răpeanu, G.; Nistor, O.V.; Enachi, E.; Stănciuc, N.; Mureșan, C.; Bahrim, G.E. Recovery of bioactive compounds from red onion skins using conventional solvent extraction and microwave-assisted extraction. *Ann. Univ. Dunarea Jos Galati Fascicle VI Food Technol.* **2020**, *44*, 104–126. [\[CrossRef\]](#)
- Cara, I.G.; Rusu, M.; Filip, M.; Țopa, D.; Jităreanu, G. Exploring ecological and conventional farming practices on plum orchards: Its impact on fruit quality. *Horticulturae* **2025**, *11*, 240. [\[CrossRef\]](#)

25. Enache, I.-M.; Stănciuc, N.; Vasile, A.M.; Dinică, R.M.; Țupu, E.; Vizireanu, C. *Cornus mas*: From plant taxonomy and distribution area to highly valorization of phytochemicals by microencapsulation in biopolymeric matrices containing probiotics. *Plants* **2025**, *14*, 3298. [CrossRef] [PubMed]
26. Anchidin, B.G.; Manoliu, D.R.; Munteanu, M.; Ciobanu, M.M.; Boișteanu, P.C. Formulation of a functional meat product with a compact structure by incorporating *Cetraria islandica*, an underexploited ingredient, and evaluation of its potential in the meat industry. *Sci. Pap. Ser. D Anim. Sci.* **2025**, *68*, 1–10. Available online: <https://animalsciencejournal.usamv.ro/index.php/scientific-papers/past-issues?id=1608> (accessed on 21 March 2026).
27. Taiwo, A.M.; Olowookere, Z.A.; Bada, B.S.; Akinhanmi, T.F.; Oyedepo, J.A. Contamination and health risk assessments of metals in selected fruits from Abeokuta, Southwestern Nigeria. *J. Food Compos. Anal.* **2022**, *114*, 104801. [CrossRef]
28. Saif, U.D.; Ali, S.; Hussain, S.; Hussain, J.; Luqman, M.; Hussain, J.; Ali, S. Evaluation of heavy metal contamination in indigenous fruits and associated human health risk: Evidence from Fuzzy-TOPSIS approach. *Glob. NEST J.* **2022**, *24*, 435–444. [CrossRef]
29. Rajabi, S.; Maleky, S.; Hashemi, H.; Hashemi, M.; Amiri Gharaghani, M.; Shojaadini, H. Health risk assessment of toxic elements and nitrate in tuberous vegetables: Carcinogenic and non-carcinogenic perspectives, Monte Carlo simulation, and sensitivity analysis. *Sci. Rep.* **2025**, *15*, 39316. [CrossRef]
30. United States Environmental Protection Agency (US EPA). *Exposure Factors Handbook; Chapter 8: Body Weight Studies*; US EPA: Washington, DC, USA, 2011. Available online: <https://www.epa.gov/sites/default/files/2015-09/documents/efh-chapter08.pdf> (accessed on 15 March 2026).
31. Zunaidi, A.A.; Lim, L.H.; Metali, F. Comparative assessment of the heavy metal phytoextraction potential of vegetables from agricultural soils: A field experiment. *Heliyon* **2023**, *9*, e13547. [CrossRef] [PubMed]
32. Santos, H.O.; Genario, R.; Gomes, G.K.; Schoenfeld, B.J. Cherry intake as a dietary strategy in sport and diseases: A review of clinical applicability and mechanisms of action. *Crit. Rev. Food Sci. Nutr.* **2021**, *61*, 417–430. [CrossRef] [PubMed]
33. Tefera, M.; Teklewold, A. Health risk assessment of heavy metals in selected Ethiopian spices. *Heliyon* **2021**, *7*, e07048. [CrossRef]
34. United States Environmental Protection Agency (US EPA). *Zinc*; CASRN 7440-66-6; Integrated Risk Information System (IRIS); US EPA: Washington, DC, USA, 2005. Available online: https://iris.epa.gov/static/pdfs/0426_summary.pdf (accessed on 25 March 2026).
35. Barberá, R.; Farré, R.; Mesado, D. Oral intake of cadmium, cobalt, copper, iron, lead, nickel, manganese and zinc in the university student's diet. *Food/Nahrung* **1993**, *37*, 241–245. [CrossRef]
36. Taylor, A.A.; Tsuji, J.S.; McArdle, M.E.; Adams, W.J.; Goodfellow, W.L., Jr. Recommended reference values for risk assessment of oral exposure to copper. *Risk Anal.* **2023**, *43*, 211–218. [CrossRef]
37. Taiwo, A.M.; Olukayode, S.; Ojekunle, O.Z.; Awomeso, J.A. The toxicological risk assessment of trace elements (Co, Cu, Fe, and Zn) in snacks from Ijebu Ode, Ogun State, Southwest Nigeria. *Biol. Trace Elem. Res.* **2021**, *199*, 4847–4855. [CrossRef]
38. Niemeier, R.T.; Maier, A.; Reichard, J.F. Rapid review of dermal penetration and absorption of inorganic lead compounds for occupational risk assessment. *Ann. Work Expo. Health* **2022**, *66*, 291–311. [CrossRef]
39. Stoica, F.; Rațu, R.N.; Motrescu, I.; Răpeanu, G.; Constantin, O.E.; Cara, I.G.; Topa, D.; Jităreanu, G. Utilization of tomato pomace powder as a bioactive ingredient in semi-hard cheese production: A study on nutritional profile and sensory qualities. *Foods* **2026**, *15*, 542. [CrossRef]
40. AOAC. *Official Methods of Analysis of AOAC*, 17th ed.; Association of Official Analytical Chemists: Arlington, VA, USA, 2000. Available online: <https://law.resource.org/pub/us/cfr/ibr/002/aoac.methods.1.1990.pdf> (accessed on 23 March 2026).
41. Chantaro, P.; Devahastin, S.; Chiewchan, N. Production of antioxidant high dietary fiber powder from cherry peels. *LWT Food Sci. Technol.* **2008**, *41*, 1987–1994. [CrossRef]
42. Manoliu, D.-R.; Ciobanu, M.M.; Ciobotaru, C.M.; Postolache, A.N.; Anchidin, B.G.; Boișteanu, P.C. Physico-chemical and sensory evaluation of three types of pork mortadella manufactured in the IULS meat processing microsection. *Sci. Pap. Ser. D. Anim. Sci.* **2023**, *66*, 527–531. Available online: https://animalsciencejournal.usamv.ro/pdf/2023/issue_2/Art63.pdf (accessed on 30 March 2026).
43. Milea, A.Ș.; Vasile, A.M.; Cîrciumaru, A.; Dumitrașcu, L.; Barbu, V.; Răpeanu, G.; Bahrim, G.E.; Stănciuc, N. Valorization of sweet cherry skins phytochemicals by extraction, microencapsulation and development of value-added food products. *Foods* **2019**, *8*, 188. [CrossRef]
44. Sucheta; Chaturvedi, K.; Yadav, S.K. Ultrasonication-assisted salt-spice impregnation in black cherries to attain anthocyanin stability, quality retention and antimicrobial efficacy during hot-air convective drying. *Ultrason. Sonochem.* **2019**, *58*, 104661. [CrossRef] [PubMed]
45. Cojocar, A.; Vlase, L.; Munteanu, N.; Stan, T.; Teliban, G.C.; Burducea, M.; Stoleru, V. Dynamics of phenolic compounds, antioxidant activity, and yield of rhubarb under chemical, organic and biological fertilization. *Plants* **2020**, *9*, 355. [CrossRef] [PubMed]
46. Pękal, A.; Pyrzyńska, K. Evaluation of aluminium complexation reaction for flavonoid content assay. *Food Anal. Methods* **2014**, *7*, 1776–1782. [CrossRef]

47. Ouis, N.; Hariri, A. Phytochemical analysis and antioxidant activity of flavonoid extracts from pods of *Ceratonia siliqua* L. *Banat's J. Biotechnol.* **2017**, *8*, 93–104. [\[CrossRef\]](#)
48. Horwitz, W.; Latimer, G.W. *Official Methods of Analysis of AOAC International*; AOAC: Arlington, VA, USA, 2010. Available online: <https://www.scrip.org/reference/referencespapers?referenceid=1519360> (accessed on 28 March 2026).
49. Murariu, O.C.; Lipşa, F.D.; Ulea, E.; Murariu, F.; Ciobanu, M.-M.; Frunză, G.; Cârlescu, P.M.; Stoica, F.; Diaconu, N.; Caruso, G. Influence of sea buckthorn fruit part on physical, quality and bioactive properties of white chocolate under the circular economic framework. *Horticulturae* **2025**, *11*, 1187. [\[CrossRef\]](#)
50. Frunză, G.; Ciobanu, M.-M.; Murariu, O.C.; Raţu, R.N.; Radu-Rusu, R.-M.; Simeanu, C.; Boişteanu, P.-C. Effect of gender and muscle type on fatty acid profile, sanogenic indices, and instrumental and sensory analysis of Flemish Giant rabbit meat. *Agriculture* **2023**, *13*, 2265. [\[CrossRef\]](#)
51. Motrescu, I.; Lungoci, C.; Luchian, C.E.; Rîmbu, C.M.; Ciolan, M.A.; Calistru, A.-E.; Miron, L.-D.; Jităreanu, G. Non-thermal plasma as a novel environmentally friendly agricultural biotechnology for seed treatment and stimulation of early plant growth. *Agronomy* **2026**, *16*, 731. [\[CrossRef\]](#)
52. ISO 8589:2007; Sensory Analysis—General Guidance for the Design of Test Rooms. ISO: Geneva, Switzerland, 2007.
53. Chiorescu, E.; Filipov, F. Examining the influence of sludge from municipal wastewater treatment plants processed by Euphore installations on the quantity and quality of rapeseed and soybean production. *Agriculture* **2021**, *11*, 278. [\[CrossRef\]](#)
54. Neilsen, G.H.; Neilsen, D.; Kappel, F.; Forge, T. Interaction of irrigation and soil management on sweet cherry productivity and fruit quality at different crop loads that simulate those occurring under environmental extremes. *HortScience* **2014**, *49*, 215–220. [\[CrossRef\]](#)
55. Rutkowski, K.; Łysiak, G.P. Effect of nitrogen fertilization on tree growth and nutrient content in soil and cherry leaves (*Prunus cerasus* L.). *Agriculture* **2023**, *13*, 578. [\[CrossRef\]](#)
56. Gonçalves, B.; Aires, A.; Oliveira, I.; Baltazar, M.; Cosme, F.; Afonso, S.; Pinto, T.; Anjos, M.R.; Inês, A.; Morais, M.C.; et al. From orchard to wellness: Unveiling the health effects of sweet cherry nutrients. *Nutrients* **2024**, *16*, 3660. [\[CrossRef\]](#)
57. Matteo, M.; Zoffoli, J.P.; Ayala, M. Calcium sprays and crop load reduction increase fruit quality and postharvest storage in sweet cherry (*Prunus avium* L.). *Agronomy* **2022**, *12*, 829. [\[CrossRef\]](#)
58. Olmstead, J.W.; Iezzoni, A.F.; Whiting, M.D. Genotypic differences in sweet cherry fruit size are primarily a function of cell number. *J. Am. Soc. Hortic. Sci.* **2007**, *132*, 697–703. [\[CrossRef\]](#)
59. Gonçalves, A.C.; Campos, G.; Alves, G.; Garcia-Viguera, C.; Moreno, D.A.; Silva, L.R. Physical and phytochemical composition of 23 Portuguese sweet cherries as conditioned by variety (genotype). *Food Chem.* **2021**, *335*, 127637. [\[CrossRef\]](#)
60. Lukács, L.; Roman, G.M.; Moldovan, I.; Rózsa, S.; Gocan, T.M.; Borsai, O. Pomological and chemical characterization of some sweet cherry varieties grown in urban orchards. *Sci. Pap. Ser. B Hortic.* **2025**, *69*, 1–10. Available online: https://horticulturejournal.usamv.ro/pdf/2025/issue_1/Art8.pdf (accessed on 24 March 2026).
61. Petre, L.; Precup, L.; Petre, R.P. *Istoric, Prezent și Perspective Ale Culturii Cireșului Și Vișinului în NE Moldovei*; Editura Performantica: Iași, România, 2005; p. 142.
62. Vignati, E.; Lipska, M.; Dunwell, J.M.; Caccamo, M.; Simkin, A.J. Fruit development in sweet cherry. *Plants* **2022**, *11*, 1531. [\[CrossRef\]](#)
63. Ricardo-Rodrigues, S.; Laranjo, M.; Agulheiro-Santos, A.C. Methods for quality evaluation of sweet cherry. *J. Sci. Food Agric.* **2023**, *103*, 463–478. [\[CrossRef\]](#) [\[PubMed\]](#)
64. Sîrbu, S.; Beceanu, D.; Corneanu, G.; Petre, L.; Anghel, R.M.; Iurea, E. Fruit quality evaluation of some sweet cherry cultivars in Iași, Romania. *Lucr. Științifice Univ. Științe Agric. Med. Vet. Ion Ionescu Brad Iași Ser. Hortic.* **2009**, *52*, 419–422.
65. Serradilla, M.J.; Hernández, A.; López-Corrales, M.; Ruiz-Moyano, S.; Córdoba, M.; Martín, A. Composition of the cherry (*Prunus avium* L. and *Prunus cerasus* L.; Rosaceae). In *Nutritional Composition of Fruit Cultivars*; Academic Press: London, UK, 2016; pp. 127–147. [\[CrossRef\]](#)
66. Ivanova, I.; Serdiuk, M.; Malkina, V.; Bandura, I.; Kovalenko, I.; Tymoshchuk, T.; Tonkha, O.; Tsyg, O.; Mushtruk, M.; Omelian, A. Study of soluble solids content accumulation dynamics under the influence of weather factors in cherry fruits. *Potravin. Slovak J. Food Sci.* **2021**, *15*, 350–359. [\[CrossRef\]](#) [\[PubMed\]](#)
67. Drake, S.R.; Fellman, J.K. Indicators of maturity and storage quality of ‘Rainier’ sweet cherry. *HortScience* **1987**, *22*, 283–285. [\[CrossRef\]](#)
68. Blando, F.; Oomah, B.D. Sweet and sour cherries: Origin, distribution, nutritional composition and health benefits. *Trends Food Sci. Technol.* **2019**, *86*, 517–529. [\[CrossRef\]](#)
69. Beinsan, C.; Velicevici, G.; Sumalan, R.; Scedei, D.; Borza, M. Studies on quality characteristics after fruit storage in some cherry varieties. *J. Hortic. For. Biotechnol.* **2025**, *29*, 369–377. [\[CrossRef\]](#)
70. Sîrbu, S.; Niculaua, M.; Chiriță, O. Physico-chemical and antioxidant properties of new sweet cherry cultivars from Iași, Romania. *Agron. Res.* **2012**, *10*, 341–350. Available online: <https://www.cabidigitallibrary.org/doi/pdf/10.5555/20133015302> (accessed on 25 March 2026).

71. Corneanu, M.; Iurea, E.; Sîrbu, S. Biological properties and fruit quality of sweet cherry (*Prunus avium* L.) cultivars from Romanian assortment. *Agron. Res.* **2020**, *18*, 2353–2364. [CrossRef]
72. Crisosto, C.H.; Crisosto, G.M.; Metheney, P. Consumer acceptance of ‘Brooks’ and ‘Bing’ cherries is mainly dependent on fruit SSC and visual skin color. *Postharvest Biol. Technol.* **2003**, *28*, 159–167. [CrossRef]
73. Golache, I.E.; Herea, M.; Perju, I.; Mineață, I.; Ungureanu, I.V.; Tălmăciu, M. Observations on arthropods existing in some *Aronia* plantations in the NE area of Romania. *Sci. Pap. Ser. B Hortic.* **2024**, *68*, 37–44. Available online: https://horticulturejournal.usamv.ro/pdf/2024/issue_1/Art4.pdf (accessed on 19 March 2026).
74. Murariu, O.C.; Irimia, L.M.; Robu, T. *Analiza Și Controlul Calității Produselor Din Fructe Și Legume*; Editura Ion Ionescu de la Brad: Iași, România, 2017; ISBN 978-973-147-250-8.
75. McCune, L.M.; Kubota, C.; Stendell-Hollis, N.R.; Thomson, C.A. Cherries and health: A review. *Crit. Rev. Food Sci. Nutr.* **2010**, *51*, 1–12. [CrossRef] [PubMed]
76. Rios de Souza, V.; Pimenta Pereira, P.A.; Silva, T.L.; Lima, L.C.; Pio, R.; Queiroz, F. Determination of bioactive compounds, antioxidant activity and chemical composition of Brazilian blackberry, red raspberry, strawberry, blueberry and sweet cherry fruits. *Food Chem.* **2014**, *156*, 362–368. [CrossRef]
77. Usenik, V.; Štampar, F.; Petkovšek, M.M.; Kastelec, D. Effect of fruit size and fruit colour on chemical composition in ‘Kordia’ sweet cherry (*Prunus avium* L.). *J. Food Compos. Anal.* **2015**, *38*, 121–130. [CrossRef]
78. Średnicka-Tober, D.; Ponder, A.; Hallmann, E.; Głowacka, A.; Rozpara, E. Profile and content of polyphenols and carotenoids in local and commercial sweet cherry fruits (*Prunus avium* L.) and their antioxidant activity in vitro. *Antioxidants* **2019**, *8*, 534. [CrossRef]
79. Hallmann, E.; Rozpara, E. Estimation of bioactive compounds content in organic and conventional sweet cherry (*Prunus avium* L.). *J. Res. Appl. Agric. Eng.* **2017**, *62*, 141–145.
80. Beceanu, D.; Bostacă-Sîrbu, S. European criteria to appreciate cherries’ quality. In *Realizări Și Perspective în Horticultură, Viticultură, Vinificație și Silvicultură*; Universitatea Agrară de Stat din Moldova: Chișinău, Moldova, 2007; pp. 306–310. Available online: https://ibn.idsi.md/sites/default/files/imag_file/306-310_6.pdf (accessed on 15 March 2026).
81. Burzo, I.; Toma, S.; Olteanu, I.; Dejeu, L.; Delian, E.; Hoza, D. *Fiziologia Plantelor de Cultură*; Editura Știința: Chișinău, Moldova, 1999; Volume 3. Available online: <https://biblioteca.valahia.ro/wp-content/uploads/2022/05/BurzoI.Fiziologiaplantelordeculturavol.1.pdf> (accessed on 9 March 2026).
82. Pérez-Sánchez, R.; Gómez-Sánchez, M.Á.; Morales-Corts, M.R. Description and quality evaluation of sweet cherries cultivated in Spain. *J. Food Qual.* **2010**, *33*, 490–506. [CrossRef]
83. Jin, W.; Wang, H.; Li, M.; Wang, J.; Yang, Y.; Zhang, X.; Yan, G.; Zhang, H.; Liu, J.; Zhang, K. The R2R3 MYB transcription factor PavMYB10.1 is involved in anthocyanin biosynthesis and determines fruit skin colour in sweet cherry (*Prunus avium* L.). *Plant Biotechnol. J.* **2016**, *14*, 2120–2133. [CrossRef]
84. Gonçalves, B.; Silva, A.P.; Moutinho-Pereira, J.; Bacelar, E.; Rosa, E.; Meyer, A.S. Effect of ripeness and postharvest storage on the evolution of colour and anthocyanins in cherries (*Prunus avium* L.). *Food Chem.* **2007**, *103*, 976–984. [CrossRef]
85. Huang, M.T.; Ferraro, T. Phenolic compounds in food and cancer prevention. In *ACS Symposium Series*; American Chemical Society: Washington, DC, USA, 1992; Volume 507, pp. 8–34. [CrossRef]
86. Hayaloğlu, A.A.; Demir, N. Physicochemical characteristics, antioxidant activity, organic acid and sugar contents of 12 sweet cherry (*Prunus avium* L.) cultivars grown in Turkey. *J. Food Sci.* **2015**, *80*, C564–C570. [CrossRef]
87. Marinova, D.; Ribarova, F.; Atanassova, M. Total phenolics and total flavonoids in Bulgarian fruits and vegetables. *J. Univ. Chem. Technol. Metall.* **2005**, *40*, 255–260.
88. Mozetič, B.; Simčič, M.; Trebše, P. Anthocyanins and hydroxycinnamic acids of ‘Lambert Compact’ cherries (*Prunus avium* L.) after cold storage and 1-methylcyclopropene treatment. *Food Chem.* **2006**, *97*, 302–309. [CrossRef]
89. Kelebek, H.; Selli, S. Evaluation of chemical constituents and antioxidant activity of sweet cherry (*Prunus avium* L.) cultivars. *Int. J. Food Sci. Technol.* **2011**, *46*, 2530–2537. [CrossRef]
90. Prvulović, D.; Malenčić, Đ.; Ljubojević, M.; Barać, G.; Ognjanov, V. Phenolic compounds and antioxidant capacity of sweet cherry fruits from Vojvodina province. *Contemp. Agric.* **2019**, *68*, 1–6. [CrossRef]
91. Gherghi, A.; Burzo, I.; Bibicu, M.; Mărgineanu, L.; Bădulescu, L. *Biochimia și Fiziologia Legumelor și Fructelor*; Editura Academiei Române: București, România, 2001; ISBN 973-27-0791-7.
92. Boskov, D.; Milatovic, D.; Rakonjac, V.; Zec, G.; Hudina, M.; Veberic, R.; Mikulic-Petkovsek, M. The phenolic profile of sweet cherry fruits influenced by cultivar/rootstock combination. *Plants* **2023**, *12*, 103. [CrossRef]
93. Bedreag, I.C.; Cioroiu, I.B.; Niculaua, M.; Nechita, C.B.; Cotea, V.V. Volatile compounds as markers of terroir and winemaking practices in Fetească Albă wines of Romania. *Beverages* **2025**, *11*, 67. [CrossRef]
94. Soceanu, A. Presence of heavy metals in fruits from *Prunus* genera. *Ovidius Univ. Ann. Chem.* **2009**, *20*, 108–110. Available online: https://anale-chimie.univ-ovidius.ro/anale-chimie/chemistry/2009-1/full/21_Soceanu.pdf (accessed on 10 March 2026).

95. Rai, P.K.; Lee, S.S.; Zhang, M.; Tsang, Y.F.; Kim, K.H. Heavy metals in food crops: Health risks, fate, mechanisms, and management. *Environ. Int.* **2019**, *125*, 365–385. [\[CrossRef\]](#)
96. Manea, D.N.; Ienciu, A.A.; Ștef, R.; Șmuleac, I.L.; Gergen, I.I.; Nica, D.V. Health risk assessment of dietary heavy metals intake from fruits and vegetables grown in selected old mining areas—A case study: The Banat area of Southern Carpathians. *Int. J. Environ. Res. Public Health* **2020**, *17*, 5172. [\[CrossRef\]](#)
97. Yılmaz, F.M.; Karaaslan, M.; Vardin, H. Optimization of extraction parameters for the isolation of phenolic compounds from sour cherry (*Prunus cerasus* L.) pomace. *J. Food Sci. Technol.* **2015**, *52*, 2851–2859. [\[CrossRef\]](#)
98. Ciccoritti, R.; Paliotta, M.; Centioni, L.; Mencarelli, F.; Carbone, K. Effect of genotype and drying conditions on bioactive compounds of sour cherry pomace. *Eur. Food Res. Technol.* **2018**, *244*, 635–645. [\[CrossRef\]](#)
99. Gumul, D.; Korus, A.; Ziobro, R. Extruded preparations with sour cherry pomace influence quality and increase the level of bioactive components in gluten-free breads. *Int. J. Food Sci.* **2020**, *2020*, 8024398. [\[CrossRef\]](#)
100. Jūrienė, L.; Morkūnienė, V.; Venskutonis, P.R. Supercritical CO₂ extraction of valuable lipophilic compounds from pre-fractionated sour cherry pomace and evaluation of their composition and properties. *J. CO₂ Util.* **2024**, *85*, 102890. [\[CrossRef\]](#)
101. Mandache, M.B.; Cosmulescu, S. Mineral content of apple, sour cherry and peach pomace and the impact of their application on bakery products. *Foods* **2025**, *14*, 3146. [\[CrossRef\]](#) [\[PubMed\]](#)
102. Lucera, A.; Costa, C.; Marinelli, V.; Saccotelli, M.A.; Del Nobile, M.A.; Conte, A. Fruit and vegetable by-products to fortify spreadable cheese. *Antioxidants* **2018**, *7*, 61. [\[CrossRef\]](#)
103. Difonzo, G.; Antonino, C.; Squeo, G.; Caponio, F.; Faccia, M. Application of agri-food by-products in cheesemaking. *Antioxidants* **2023**, *12*, 660. [\[CrossRef\]](#)
104. Frūhbauerová, M.; Červenka, L.; Hájek, T.; Salek, R.N.; Velichová, H.; Buňka, F. Antioxidant properties of processed cheese spread after freeze-dried and oven-dried grape skin powder addition. *Potravin. Slovák J. Food Sci.* **2020**, *14*, 230–238. [\[CrossRef\]](#) [\[PubMed\]](#)
105. Rațu, R.N.; Stoica, F.; Usturoi, M.G.; Velescu, I.D.; Arsenoiaia, V.N.; Cârlescu, P.M.; Postolache, A.N. A preliminary investigation into the enhancement of cheese with grape skin powder. *Sci. Pap. Ser. D Anim. Sci.* **2023**, *66*, 484–496. Available online: https://animalsciencejournal.usamv.ro/pdf/2023/issue_1/Art64.pdf (accessed on 5 March 2026).
106. Starkute, V.; Lukseviciute, J.; Klupsaite, D.; Mockus, E.; Klementaviciute, J.; Rocha, J.M.; Özogul, F.; Ruzauskas, M.; Viskelis, P.; Bartkiene, E. Characteristics of unripened cow milk curd cheese enriched with raspberry (*Rubus idaeus*), blueberry (*Vaccinium myrtillus*) and elderberry (*Sambucus nigra*) industry by-products. *Foods* **2023**, *12*, 2860. [\[CrossRef\]](#)
107. Zhang, X.; Yu, Y.; Zhao, D. Effect of blueberry on spreadable processed cheese. *J. Northeast Agric. Univ. Engl. Ed.* **2011**, *18*, 73–78. [\[CrossRef\]](#)
108. Darwish, A.A.; Tawfek, M.A.; Baker, E.A. Texture, sensory attributes and antioxidant activity of spreadable processed cheese with added date seed powder. *J. Food Dairy Sci.* **2020**, *11*, 377–383. [\[CrossRef\]](#)
109. Alqahtani, N.K.; Alnemr, T.M.; Alqattan, A.M.; Aleid, S.M.; Habib, H.M. Physicochemical and sensory properties and shelf life of block-type processed cheeses fortified with date seeds (*Phoenix dactylifera* L.) as a functional food. *Foods* **2023**, *12*, 679. [\[CrossRef\]](#) [\[PubMed\]](#)
110. Cunha, C.R.; Dias, A.I.; Viotto, W.H. Microstructure, texture, colour and sensory evaluation of a spreadable processed cheese analogue made with vegetable fat. *Food Res. Int.* **2010**, *43*, 723–729. [\[CrossRef\]](#)
111. Hurtado-Romero, A.; Zepeda-Hernández, A.; Uribe-Velázquez, T.; Rosales-de la Cruz, M.F.; Raygoza-Murguía, L.V.; García-Amezquita, L.E.; García-Cayuela, T. Utilization of blueberry-based ingredients for formulating a synbiotic Petit Suisse cheese: Physicochemical, microbiological, sensory and functional characterization during cold storage. *LWT* **2023**, *183*, 114955. [\[CrossRef\]](#)

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.