



Mountain ash (*Sorbus aucuparia*): From forest to functional food with bioactive health benefits

Areg Karapetyan¹, Zhanna Fafuryan¹, Ivan Gabrielyan²

¹Mountain Forestry Laboratory Scientific Group, A.Takhtajan Institute of Botany of the NAS RA, Acharyan 1, 0040, Yerevan, Armenia; ²Department of Palaeobotany, A.Takhtajan Institute of Botany of the NAS RA, Acharyan 1, 0040, Yerevan, Armenia.

***Corresponding Author:** Areg Karapetyan, PhD in Biology, Acting Head of the Scientific Group "Mountain Forestry Laboratory", Co-Head of the Project 23RL-1F017 A. Takhtajan Institute of Botany of the NAS RA, Acharyan 1, 0040, Yerevan, Armenia

Submission Date: August 28th, 2025; **Acceptance Date:** December 30th, 2025; **Publication Date:** January 7th, 2026

Please cite this article as: Karapetyan A., Fafuryan Z., Gabrielyan I. Mountain ash (*Sorbus aucuparia*): From forest to functional food with bioactive health benefits. *Functional Food Science* 2026; 6(1):12-26. DOI: <https://doi.org/10.31989/ffs.v6i1.1830>

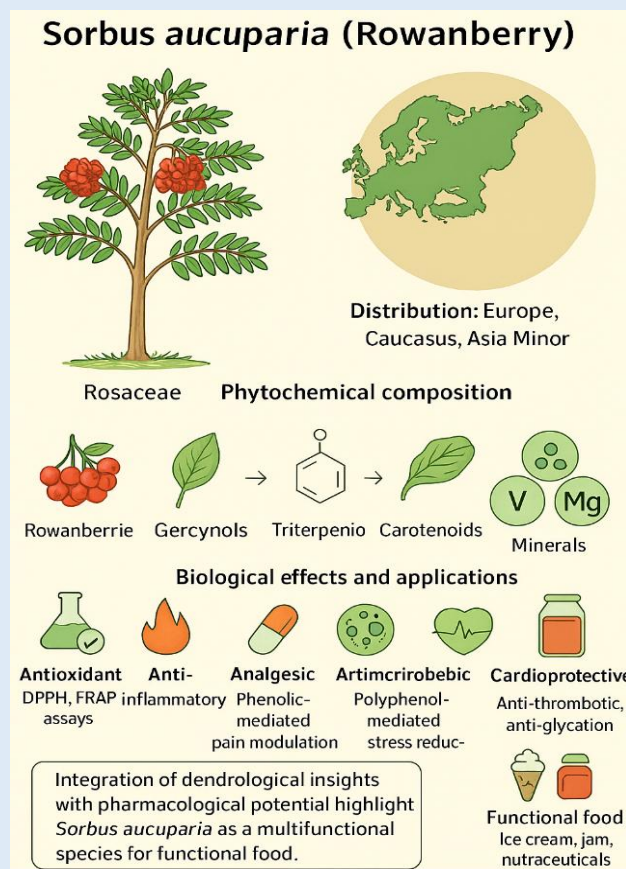
ABSTRACT

Sorbus aucuparia L. (Rowan or Mountain Ash) is a deciduous tree of the Rosaceae family with considerable dendrological importance and emerging pharmacological and nutritional value. This review provides an integrated overview of its botanical characteristics, phytochemical composition, and biological activities, highlighting its potential in functional foods and natural therapeutics. The species is rich in diverse bioactive constituents, including polyphenols (flavonoids, phenolic acids, and tannins), triterpenoids, carotenoids, vitamins, organic acids, and essential minerals. These compounds contribute to its pronounced antioxidant, anti-inflammatory, analgesic, antimicrobial, and cytoprotective properties. Antioxidant activity is largely attributed to chlorogenic and neochlorogenic acids, rutin, catechin, and vitamin C, which effectively scavenge free radicals and protect biomolecules from oxidative damage. The anti-inflammatory effects are mediated through inhibition of COX/LOX pathways and protein denaturation, while analgesic potential involves the modulation of oxidative stress and prostaglandin synthesis. Additionally, *S. aucuparia* extracts exhibit cardioprotective, hepatoprotective, and antidiabetic activities, supporting their application in chronic disease prevention. Seasonal variation and extraction methods significantly influence bioactive compound yield, with early summer identified as optimal for leaf and fruit harvesting. From a dendrological perspective, *S. aucuparia* is an ecologically resilient species with high adaptive capacity, contributing to forest regeneration and soil stabilization.

Integrating dendrological, phytochemical, and functional perspectives, this review underscores *S. aucuparia* as a multifunctional species of ecological, pharmacological, and biotechnological significance, offering promising

prospects for sustainable forestry, nutraceutical production, and functional food innovation.

Keywords: *Sorbus aucuparia*; rowan; dendrology; polyphenols; functional food; antioxidant; bioactive compounds.



Graphical Abstract. From Forest to Functional Food: The Multifunctional Potential of *Sorbus aucuparia* (Mountain Ash)

©FFC 2025. This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0>)

INTRODUCTION

Sorbus aucuparia L. (rowan) fruits are a promising natural source of bioactive phenolic compounds with antimicrobial potential. An ethanolic extract of *S. aucuparia* fruits contained a diverse array of phenolics—such as gallic acid, catechins, ellagic acid, quercetin derivatives, and chlorogenic and caffeic acids—and exhibited strong antimicrobial activity against *Staphylococcus aureus*, *S. epidermidis*, and *Propionibacterium acnes*. Moreover, the extract

demonstrated synergism with erythromycin, effectively restoring antibiotic sensitivity in erythromycin-resistant *Staphylococci*, suggesting its potential utility in the treatment of pyodermitis and acne-related infections [1]. “Functional foods” are those that supply bioactive compounds beyond basic nutrition with health-promoting properties such as antioxidant, anti-inflammatory, or metabolic effects. According to recent scholarships, functional foods should be scientifically validated not only for their bioactive composition but

also for safety, bioavailability, and demonstrated health effects rather than being marketed on assumed benefits [2].

The genus *Sorbus* comprises numerous species rich in phenolic compounds—particularly flavonols, phenolic acids, and anthocyanins—that contribute to their antioxidant, antimicrobial, and anti-inflammatory properties. Recent investigations on *S. aucuparia* L. fruit extracts have demonstrated potent antimicrobial activity against *Staphylococcus aureus*, *S. epidermidis*, and *Propionibacterium acnes*, key pathogens associated with pyodermitis and acne. The ethanolic extract, rich in gallic acid, catechins, ellagic acid, and quercetin derivatives, exhibited synergism with erythromycin, restoring antibiotic sensitivity in resistant *Staphylococci*. Such findings highlight the pharmacological potential of *Sorbus* fruits and support continued phytochemical exploration of diverse *Sorbus* subgenera [3]. Recent studies have emphasized the nephroprotective and antioxidant potential of wild fruits rich in polyphenols. Notably, *Sorbus aucuparia* (rowanberry) and *Cornus mas* (cornelian cherry) have been shown to mitigate gentamicin-induced nephrotoxicity in Wistar rats through modulation of nitro-oxidative stress and improvement of specific renal biomarkers such as KIM-1 and iNAG [4]. These findings highlight the therapeutic promise of *Sorbus*-derived bioactive compounds in protecting against oxidative renal damage [4]. *Sorbus aucuparia* (rowanberry) fruits are rich in vitamins, minerals, organic acids, polysaccharides, and especially polyphenols, which are linked to antioxidant, anti-inflammatory, and other protective effects [5]. Despite their astringent taste and underutilization, recent studies have highlighted their potential as functional foods and therapeutic adjuvants [5]. *Sorbus aucuparia* is an ecologically and pharmacologically significant species with multifaceted value. Ecologically, it acts as an important pioneer tree for forest regeneration and

provides a valuable food source for wildlife during periods of scarcity. Recent environmental analyses of *S. aucuparia* fruits collected from 11 Tatra valleys revealed that element accumulation patterns are influenced by altitude, anthropogenic activity, and urban proximity, with elevated levels of Cl, Ca, and Hg near industrial centers and higher Mn, Rb, and Pb concentrations in mountain regions. These findings suggest that environmental contamination and soil composition can substantially affect the elemental profile of *S. aucuparia* fruits [6]. *Sorbus* species, particularly *S. aucuparia*, are valuable sources of polyphenols, flavonoids, and phenolic acids with notable antioxidant and antimicrobial activities. Environmental studies show that elemental composition in *S. aucuparia* fruits varies with altitude and urban exposure, reflecting both ecological adaptability and anthropogenic influence. Leaf extracts of various *Sorbus* species, including *S. aucuparia*, exhibit strong antimicrobial effects against *Klebsiella pneumoniae*, *Staphylococcus epidermidis*, and fluconazole-resistant *Candida albicans*. Moreover, *S. aucuparia* fruit extract demonstrated nephroprotective efficacy in gentamicin-induced oxidative injury in rats. Together, these findings highlight *Sorbus* as a promising source of natural antioxidants and antimicrobial agents with potential functional and therapeutic applications [7]. Plant cell culture (PCC) technology is emerging as a sustainable approach to produce plant-derived foods independent of conventional agriculture. Rowan (*S. aucuparia*) cell cultures have been investigated to generate bioactive berry ingredients while ensuring safety and nutritional quality for food applications [8].

Methodology:

A comprehensive literature search was conducted using the databases PubMed, ScienceDirect, FFHDJ.com, and Web of Science to collect up-to-date information on the pharmacological activities and major phytochemical constituents of *Sorbus aucuparia* (rowan). The search

covered publications from 1939 to 2025 and employed the following keywords and their combinations: “rowan”, “rowanberry”, “*Sorbus aucuparia*”, “*Sorbus*”, “polyphenols”, and “triterpenoids”. Peer-reviewed original research articles, reviews, and experimental studies reporting phytochemical analyses, extraction methods, and biological activities (antioxidant, anti-inflammatory, analgesic, antitumor, and related pharmacological effects) were included to ensure a broad and current overview. Articles not available in English, duplicated records, and studies lacking primary data were excluded.

Botanical Description of Rowan: *Sorbus aucuparia* L. (rowan or mountain ash) is a deciduous tree of the *Rosaceae* family with both dendrological significance and valuable pharmacological potential.

Description: *Sorbus aucuparia* L., Rowan or Mountain ash is a deciduous tree from the *Rosaceae* family which belongs to angiosperm plants. It is a slim tree that can grow up to 15–20 m tall in favorable growing areas, but it can present itself as a bush in poor soils. The tree has a round or ovoid crown, with grey, grayish-white or red brown branches in its youth, which later become glabrescent, smooth and shiny. The bark is first smooth and grey, but later it forms a slim rhytidome and cracks into wide strips. The leaves are compound, 10-20 cm long, lanceolate in outline, with 9-19 leaflets and a shared petiole. They can be quite long, measuring 10–25 cm. Leaflets are 3-5 cm long, 1-1.5 cm wide, from oblong to oblong-lanceolate, pubescent at the base, sometimes glabrous, dark green above, glaucous or vermilion below, they become orange in the autumn. The inflorescence is located at the ends of shortened shoots, 5-15 cm in diameter, corymbed, multifloral and thick, with approximately 250 flowers. They are white, emitting a pleasant fragrance. The fruits are fake drupe, spherical, longer than they are wide, ovate, rarely ellipsoidal, 8–10 mm in diameter, often red colored but

rarely red-orange or yellowish-red. They stay on the tree in the winter, providing food for the birds. The seeds are usually three in number, narrowly oblong, sharp at the tips, reddish. A significant range of fluctuations in the quantitative characteristics of mountain ash wood elements increases its adaptive capabilities, helping it to occupy a variety of ecological niches in nature, as evidenced by the wide range of this species [8, 9].

Distribution: *Sorbus aucuparia* originating from the colder regions of the Northern Hemisphere (Western Europe, Eastern Europe, Crimea, Caucasus, Asia Minor, northern Africa). In Armenia, it grows abundantly in forest areas, although it is found in almost all regions of the republic [9].

According to E. Gabrielyan [8], the primary center of origin and differentiation of the genus *Sorbus* is Southeast Asia. It was from this region that migration of *Sorbus* species towards Europe and North America began. Secondary centers have developed in the Himalayas (especially of subgenus *Aria*), the Caucasus and Armenia (giving rise to numerous hybridogenous taxa) and Europe, where there has been much differentiation through hybridization and the stabilization of new forms by apomixis [9-10].

Recent global analyses confirm that *Sorbus* diversity and distribution patterns are strongly shaped by climatic and environmental factors. Wang et al. (2025) demonstrated that temperature, solar radiation, and precipitation are the primary ecological drivers of *Sorbus* richness worldwide, with mountainous regions such as the Hengduan Mountains and Caucasus serving as key diversity centers due to their climatic seasonality and elevational gradients [11].

Bio-ecological Type: It grows along forest edges, clearings, in the undergrowth, less often among meadows, in well-drained soils, also on rocky or stony

places, along cliffs of riverbanks, in deciduous or even coniferous forests, in peat lands. It vegetates well in fertile soils, with moderate acid humus, in the process of decomposition. In the Caucasus it grows along the upper limit of the forest at high altitudes, at subalpine level and on sunny slopes. It is a stress-tolerant species and characterized by high drought, frost and shadow resistance. It bears drought well, if the drought is not prolonged [12]. Like other plant species from Armenian mountain ecosystems, *S. aucuparia* may also experience the effects of technogenic contamination and climate variability. A recent study from the Syunik region of Armenia revealed elevated levels of heavy metals in traditional edible plants near mining areas, demonstrating how anthropogenic pressure can influence the chemical composition and safety of native flora [13].

Uses: The fruits (rowanberries) of *Sorbus aucuparia* L. are food products with acknowledged nutritional value, high phenolic content, and traditional application in diabetes [14]. In Armenia where the rich and diverse flora has been used for medicinal purposes for at least 3000 years [15], the fruits of *Sorbus aucuparia* are used in folk medicine as a mild laxative, biliary, and diuretic [15]. The rowan tree (*Sorbus aucuparia* L.) is one of the most important species of the genus *Sorbus*, which has a medicinal value [16]. The usage of medicinal plants confirms the position of Armenia as a country at the crossroads of Asia and Europe because of its traditional usage of medicinal plants from both continents [15]. In folk medicine, they have been used to prevent scurvy and bleeding or as a diuretic and laxative [14-16].

Biological Activities of *Sorbus aucuparia* Compounds:

Sorbus aucuparia L. is rich in bioactive compounds,

including polyphenols (flavonoids, phenolic acids, tannins), organic acids, vitamins, and triterpenoids. These constituents contribute to a broad spectrum of biological and pharmacological activities, many of which have been experimentally validated [17-18].

A study on *Sorbus aucuparia* (rowan) fruits from 12 populations in the Alpine–Dinaric region of Croatia evaluated their proximate composition, antioxidant capacity, and elemental profile. The fruits contained, on average, 76.53% water, 17.45% total carbohydrates, 2.98% crude proteins, 1.49% crude fats, 1.07% cellulose, and 1.29% ash. The total phenolic content reached 932 mg/100 g, with antioxidant activity of 60.1% (DPPH) and 4.1 mmol/100 g (FRAP). The predominant elements were potassium (2485 mg/kg), calcium (459 mg/kg), phosphorus (206 mg/kg), and magnesium (193 mg/kg). These findings indicate that rowan fruits are rich in phenolics and essential minerals, showing a composition comparable to that of blueberry and raspberry, thus supporting their potential as a valuable functional food ingredient [19].

A recent study examined the chemical composition of *Sorbus aucuparia* CO₂ subcritical extract obtained for the first time in Kazakhstan. Using GS–MS, the extract contained major compounds such as 5-methyl-2(3H)-furanone (30.18%), 5-(3-ethoxy-4,5-dihydro-isoxazol-5-yl)-5-methyl-imidazolidine-2,4-dione (3.20%), and 4H-pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl (2.53%).

Analysis of the fatty acid profile revealed linoleic (37.7%) and oleic (50.5%) acids as the dominant components. These findings highlight the potential of *S. aucuparia* CO₂ extract as a source of bioactive compounds for pharmaceutical applications [20]. The ethanolic extract of *S. aucuparia* fruits showed a high content of polyphenols (1.11 mg GAE/g dry matter),

flavonoids (430.06 µg QE/g dry matter), and carotenoids (95.68 µg/g dry matter) [21]. The therapeutic potential of *Sorbus aucuparia* is illustrated in Table 1.

Table 1. Therapeutic activities and supporting evidence for *Sorbus aucuparia*

Activity	References	Main Bioactive Compounds	Mechanism / Experimental Evidence
Antioxidant	Aurori M, et al. [29]	Chlorogenic acid, neochlorogenic acid, quercetin, catechin, rutin, carotenoids, vitamin C	Strong DPPH and FRAP activity; scavenging of free radicals; ferric-reducing capacity; upregulation of stress-related genes
Anti-inflammatory	Southall, O. [44]	Polyphenols (flavonoids, phenolic acids), triterpenoids	Inhibition of protein denaturation and COX/LOX enzymes; correlation between phenolic content and anti-inflammatory effect
Analgesic	Majdan M., et al. [48]	Flavonoids (quercetin, rutin, isoquercitrin), triterpenoids	Suppression of COX/LOX-mediated prostaglandin synthesis; possible opioid receptor interaction
Antimicrobial	Aurori M., et al. [51]	Phenolic acids, flavonoids, tannins	Inhibition of <i>S. aureus</i> , <i>S. epidermidis</i> , <i>P. acnes</i> , and <i>Enterococcus faecalis</i> ; synergism with erythromycin; MIC = 0.01 µg/µL
Antitumor	Xie B. et al. [64]	Phenolic acids, flavonoids, triterpenoids (ursolic, oleanolic, betulinic acids)	Induction of apoptosis via Bax/Bcl-2 and caspase pathways; inhibition of NF-κB, COX-2
Neuroprotective	Samilyk M., et al. [56]	Polyphenols, vitamin C, minerals (K, Ca, Mg, Si)	Antioxidant and anti-inflammatory protection against neuronal oxidative stress; functional food powders improve neuronal metabolism
Cardioprotective	Rutkowska M, et al. [61]	Polyphenols (rutin, chlorogenic acid), triterpenoids	Antioxidant and antithrombotic action; protection of fibrinogen from oxidative modification; inhibition of thrombin and protein glycation
Antidiabetic / Hepatoprotective	Bejenaru C., et al. [66]	Phenolic acids, flavonoids, triterpenoids	Inhibition of α-glucosidase and α-amylase; hepatoprotection via reduction of ROS and NF-κB modulation
Functional food potential	Ispiryan, A., et al. [74]	Polyphenols, vitamins, minerals, dietary fiber	Enhances antioxidant and sensory properties in probiotic ice cream, jams, pomace extracts, and seed oils

Antioxidant activity: *Sorbus aucuparia* fruits are recognized as a valuable source of natural antioxidants. The high content of phenolic compounds, particularly chlorogenic and neochlorogenic acids, quercetin and its glycosides, catechin, and procyanidins, contributes to their pronounced free radical-scavenging potential. The strong antioxidant properties of *S. aucuparia* extracts suggest potential applications in the prevention of

oxidative stress-related diseases and in the development of natural antioxidant formulations [21-22]. The antioxidant potential of *S. aucuparia* fruit extract was evaluated using DPPH radical scavenging and FRAP assays. The results demonstrate that the high content of phenolic compounds, flavonoids, and carotenoids in the fruit extract contributes substantially to its antioxidant activity [21]. Comparable antioxidant

trends were reported for *Rosa canina* fruit extracts, which showed high phenolic and flavonoid contents correlating with strong DPPH and FRAP activities. The close phytochemical relationship among *Rosa* and *Sorbus* species in the Rosaceae family suggests a similar potential for incorporation into functional food products [23].

In vivo studies using *Drosophila melanogaster* demonstrated that the extract modulated stress resistance in a sex- and concentration-dependent manner. Males treated with the extract showed increased resistance to starvation, while females exhibited enhanced tolerance to hyperthermia. Treatment also induced subtle changes in the basal expression of cellular stress response genes, including heat shock proteins (hsp27, hsp68, hsp83), oxidative stress-related genes (hif1, nrf2, sod1), circadian rhythm genes (clk, per), and the longevity gene sirt1, which may underlie the observed sex-specific effects. These findings suggest that the antioxidant compounds in rowan berries contribute to stress resilience and may influence longevity through modulation of stress-response pathways [24].

Antitumor Activity: The antitumor potential of *Sorbus aucuparia* has been attributed to its rich phytochemical composition, particularly phenolic acids, flavonoids, and triterpenoids. These bioactive constituents exhibit strong antioxidants and cytotoxic properties that may contribute to the inhibition of cancer cell growth [25]. Extracts obtained from the fruits and leaves of *S. aucuparia* have demonstrated dose-dependent cytotoxic activity against several human carcinoma cell lines [22,26].

The underlying mechanisms of the antitumor effects are associated with the induction of apoptosis through mitochondrial pathways, regulation of pro- and

anti-apoptotic proteins (Bax/Bcl-2), and activation of caspases [27–28]. Additionally, rowan polyphenols modulate oxidative stress, promote cell cycle arrest, and inhibit inflammatory signaling pathways such as NF- κ B and COX-2, which are involved in tumor progression [29–30]. Triterpenoids such as ursolic, oleanolic, and betulinic acids—commonly identified in *Sorbus* species—exhibit notable anticancer activity and may act synergistically with flavonoids to enhance cytotoxic effects [31–32]. These findings suggest that rowan represents a promising natural source of chemopreventive and anticancer agents [32]. “Similar to oleuropein’s observed inhibition of migration in breast cancer cells, compounds from *Sorbus aucuparia* (e.g. flavonoids, phenolic acids) could potentially modulate cytoskeletal remodeling or adhesion dynamics—a hypothesis that warrants targeted in vitro assays [33].

Anti-inflammatory Activity: The anti-inflammatory potential of *Sorbus aucuparia* has been through its ability to inhibit heat-induced protein denaturation, a commonly used model for evaluating the anti-inflammatory activity of natural extracts. Ethanolic extracts of *S. aucuparia* leaves significantly reduced the denaturation of albumin in a dose-dependent manner, indicating stabilization of protein structure under inflammatory conditions [34]. At the highest tested concentration, the inhibitory activity of *S. aucuparia* extract reached nearly half that of the reference drug diclofenac, suggesting notable anti-inflammatory efficacy [35].

Correlation analysis has shown a strong positive relationship between the total phenolic content and the inhibition of albumin denaturation, confirming the important role of these metabolites’ antioxidant and enzyme-modulating effects on the anti-inflammatory mechanism [36]. The efficiency of phenolic compound recovery observed in the present study aligns with findings by Kobus et al. (2025), who demonstrated that

ethanol concentration exerts a key influence on polyphenol extraction from *S. aucuparia* using ultrasound-assisted extraction. Their optimized protocol yielded high levels of neochlorogenic and chlorogenic acids, compounds also abundant in our extracts, confirming the reliability of ethanol-based extraction for maximizing antioxidant and anti-inflammatory potential [37]. As emphasized by Lykholat et al., rowanberries contain a wide range of bioactive metabolites such as polyphenols, vitamins, and organic acids that contribute to their therapeutic potential and may play an important role in reducing inflammatory responses. These compounds can modulate enzymes involved in inflammation, such as cyclooxygenase and lipoxygenase, and suppressing the formation of pro-inflammatory mediators [38–39].

Analgesic Activities: The analgesic potential of *Sorbus aucuparia* is closely related to its high content of phenolic compounds, flavonoids, and triterpenoids. Although specific studies on the analgesic activity of *S. aucuparia* are limited, related research on *Sorbus* species indicates that their extracts exhibit significant pain-relieving effects in both central and peripheral models of nociception. The mechanism is primarily associated with the inhibition of cyclooxygenase (COX) and lipoxygenase (LOX) enzymes, resulting in reduced synthesis—key mediators of pain and inflammation [40].

Flavonoids such as quercetin, rutin, and isoquercitrin, which are abundant in *S. aucuparia* extracts, may also interact with the opioid system and modulate oxidative stress, thereby enhancing analgesic responses [41]. The dual antioxidant and anti-inflammatory properties of these compounds further reinforce their analgesic potential.

Antimicrobial and Cell-Protective Properties: The antimicrobial potential of *Sorbus aucuparia* extract was evaluated using the broth microdilution method

according to previously established protocols [42]. The serial dilutions of the extract were prepared in Mueller–Hinton (MH) broth, and bacterial strains were incubated under standard conditions. The minimum inhibitory concentration (MIC) was defined as the lowest concentration at which no visible turbidity was observed, indicating inhibition of bacterial growth. The minimum bactericidal concentration (MBC) was determined as the lowest concentration at which no bacterial colonies were recovered on agar plates, reflecting bactericidal activity [43].

The MIC index was calculated as the ratio of MBC/MIC, providing insight into the extract's mode of action: an index ≤ 4 indicates a bactericidal effect, whereas an index >4 suggests a bacteriostatic effect [2]. *Sorbus aucuparia* L. fruit hydro-ethanolic extracts demonstrated notable antimicrobial activity, particularly against Gram-positive bacteria. In vitro assays involving urine-derived bacterial isolates from companion animals with urinary tract infections, *S. aucuparia* showed the highest activity against *Enterococcus faecalis*. The antimicrobial efficacy was quantified using the broth microdilution method, yielding a minimum inhibitory concentration (MIC) of 0.01 $\mu\text{g}/\mu\text{L}$ and a minimum bactericidal concentration (MBC) of 0.05 $\mu\text{g}/\mu\text{L}$. The calculated MIC index indicated a predominantly bactericidal effect, suggesting the extract not only inhibited bacterial growth but also effectively killed the pathogens [44–45].

Neuroprotective Effect: *Sorbus aucuparia* has been reported to exhibit significant neuroprotective potential, primarily attributed to its high content of polyphenols, flavonoids, vitamin C, and essential minerals. These bioactive constituents act synergistically to counteract oxidative stress, neuroinflammation, and neuronal damage, thereby supporting brain health and potentially preventing neurodegenerative disorders [46–47]. Several studies have demonstrated the

feasibility of processing *S. aucuparia* into functional food ingredients with neuroprotective properties. The resulting powders possess a crystalline, porous structure, elevated vitamin C levels, and abundant essential elements (K, Ca, Mg, Si) that support neuronal metabolism. Collectively, the strong antioxidant and anti-inflammatory activities reported for rowan suggest its potential application as a natural neuroprotective agent in functional food formulations [48-50].

Cardiovascular Effect: Rowanberry has potential cardiovascular benefits due to its high content of polyphenols, which act as antioxidants and protect against oxidative stress [51–52]. Studies suggest that it may help mitigate conditions linked to cardiovascular issues by reducing oxidative damage in blood vessels and acting as a mild anticoagulant [53]. Moreover, rowanberry extracts have been shown to protect human fibrinogen against oxidative modifications, inhibit thrombin activity, and reduce fibrin clot density. These effects indicate potential antithrombotic properties, which could be beneficial in preventing cardiovascular events associated with thrombosis [54].

Antidiabetic and Hepatoprotective Activities: Extracts of *Sorbus aucuparia* exert inhibitory effects on key carbohydrate-hydrolyzing enzymes, namely α -glucosidase and α -amylase, thereby attenuating postprandial hyperglycemia. The antioxidant properties of these phytochemicals also protect pancreatic β -cells against oxidative stress, enhancing insulin secretion and improving glycemic control [55–56]. Additionally, the potent antioxidant and anti-inflammatory effects of rowan extracts protect hepatocytes from oxidative stress and liver injury [57–58]. Experimental studies confirm that these extracts can inhibit α -glucosidase and α -amylase, contributing to reduced postprandial hyperglycemia [59]. This hepatoprotective potential of

berry derived polyphenols is supported by analogous studies: e.g., methanol extract of *Moringa oleifera* leaves prevented carbon tetrachloride-induced liver damage in rats, normalizing liver enzyme levels and reducing oxidative stress—underscoring the feasibility of plant derived extracts as functional food ingredients for liver health [60]. In addition, rowan demonstrates hepatoprotective activity by decreasing reactive oxygen species, limiting lipid peroxidation, and modulating inflammatory pathways in liver tissues. These effects align with the general biological activities of plant-derived compounds, including antioxidant, anti-inflammatory, and cytoprotective properties [61].

***Sorbus aucuparia* as a Functional Food:** *Sorbus aucuparia* L. (rowan or rowanberry) is considered a functional food due to its rich content of vitamins, minerals, and polyphenolic compounds, which provide various health-promoting effects, including antioxidants, anti-inflammatory, and cytoprotective activities. According to recent functional-food science perspectives, functional foods should be scientifically validated for their bioactive composition, safety, and health-promoting properties rather than simply marketed on assumed benefits [62]. The fruit can be made into jams, jellies, beverages, and other products. Traditionally, rowanberries have been valued for supporting general health, and recent studies suggest their potential in managing cardiovascular disorders and diabetes through inhibition of key carbohydrate-hydrolyzing enzymes and reduction of oxidative stress. Raw rowanberries contain parasorbic acid, a potentially toxic compound; however, cooking or freezing converts it into non-toxic sorbic acid, making processed berries safe for consumption.

Rowanberries are a rich source of bioactive phytochemicals, including polyphenols, flavonoids, anthocyanins, and phenolic acids, which are associated

with various health benefits. A recent study published in *Functional Foods in Health and Disease* further confirmed the strong functional food potential of *Sorbus aucuparia*, demonstrating that rowanberry-derived ingredients significantly enhance antioxidant capacity and overall nutritional value in formulated food products [63]. The incorporation of rowanberry pulp into probiotic ice cream formulations has demonstrated strong potential as a functional ingredient. Ice creams enriched with 2.5–20% rowanberry pulp and *Lactocaseibacillus rhamnosus* showed enhanced antioxidant capacity, improved probiotic viability, and good sensory acceptability, particularly at 5% pulp addition, highlighting rowanberry's suitability for functional dairy products [64].

Beyond direct consumption, byproducts of rowanberry processing, such as pomace and seeds, have been evaluated for functional food and cosmetic applications. Pomace from various cultivars of *S. aucuparia* ('Likernaja', 'Burka', 'Alaja Krupnaja', 'Granatnaja', 'Rubinovaja', 'Bussinka', 'Vefed', 'Angri', 'Krasnaja', 'Solnechnaja', 'Sahharnaja', 'Oranzevaja', 'Kubovaja', 'Moravica', 'Rosina', and 'Rossica') was analyzed for total dietary fiber (TDF), protein, fat, minerals, pectin, and fatty acid composition. The highest TDF contents were observed in hybrid cultivars 'Granatnaja' (63.04% DM), 'Burka' (64.52% DM), 'Rubinovaja' (65.66% DM), and 'Likernaja' (67.17% DM). Pomace from cv 'Rubinovaja' exhibited the highest protein content (7.58% DM), cv 'Alaja Krupnaja' the highest pectin content (8.39% DM), and cv 'Oranzevaja' the highest fat content (7.47% DM). The highest average macro-element content was found in cv 'Sahharnaja' (1.56 g/kg DM). Fatty acid profiling revealed high levels of linoleic acid (51.94%), oleic acid (20.55%), and palmitic acid (12.96%), with the lowest n6/n3 ratio in cv 'Alaja Krupnaja' (6.70%) [65]. These results indicate that pomaces from specific rowanberry cultivars are rich in

valuable components, supporting their use in functional foods and cosmetics.

Rowanberry seeds, a byproduct of juice production, were also evaluated for oil quality before and after primary fermentation. Fermentation significantly reduced seed sugars and carbohydrates (>50%) while increasing relative protein content, reflecting microbial utilization of fermentable substrates. Oil yield remained largely stable, and the fatty acid profile—dominated by linoleic and α -linolenic acids—was not altered by fermentation, confirming that seeds from both fermented and non-fermented sources retain functional oil quality suitable for food applications [66].

Ethanol extracts generally exhibited stronger antibacterial effects than aqueous extracts. Among the tested bacteria, *Staphylococcus aureus* was most sensitive, followed by *Listeria monocytogenes*, while *Escherichia coli* and *Campylobacter jejuni* were less affected. These findings indicate that rowanberry berries and pomace are a promising source of bioactive compounds with potential applications in functional foods and natural food preservation, highlighting the value of extracting these compounds from juice press residues [67].

CONCLUSION

Sorbus aucuparia L. (rowan or mountain ash) represents a remarkable species that bridges dendrological significance with pronounced pharmacological and nutritional potential. Its wide ecological adaptability, strong stress tolerance, and ability to thrive in diverse forest habitats underscore its importance as a resilient pioneer and soil-stabilizing species in temperate ecosystems. Botanically, the tree exhibits substantial morphological plasticity, reflecting its capacity to adapt to varying climatic and edaphic conditions across its distribution range.

From a functional and therapeutic perspective, the rich phytochemical composition of *S. aucuparia*—particularly its polyphenols, flavonoids, triterpenoids, carotenoids, and vitamins—confers potent antioxidant, anti-inflammatory, and cytoprotective properties. These bioactive constituents support the use of rowan-derived products in preventing oxidative stress-related disorders and promote its integration into functional food formulations such as jams, beverages, and probiotic dairy products.

By combining dendrological insights with emerging biochemical evidence, this study highlights *S. aucuparia* as a multifunctional species of high ecological and biotechnological value. Continued interdisciplinary research on its phytochemical variability, seasonal dynamics, and sustainable utilization will further enhance its contribution to forest biodiversity, natural therapeutics, and functional food innovation.

Scientific Innovations: This review synthesizes recent evidence on the phytochemical composition and functional properties of *Sorbus aucuparia*, highlighting its underexplored potential as a source of phenolic antioxidants and antimicrobial agents. The manuscript integrates data from multiple research domains—including phytochemistry, food science, and therapeutic applications—to provide a unified perspective not previously reported. It also identifies critical gaps in mechanistic and clinical evidence, thereby offering a roadmap for future experimental studies.

Practical Implication: The findings emphasize the promising role of *Sorbus aucuparia* fruits and extracts in developing functional foods, nutraceuticals, and natural antimicrobial formulations. Food manufacturers may utilize these insights to innovate high-value products enriched with phenolic compounds. Additionally, the review supports future in vivo and clinical studies aimed

at validating the health benefits of rowan-derived bioactives for chronic disease prevention and wellness applications.

Abbreviations: COX – Cyclooxygenase; LOX – Lipoxygenase; KIM-1 – Kidney Injury Molecule-1; iNAG – N-acetyl- β -D-glucosaminidase (urinary marker); PCC – Plant Cell Culture; DPPH – 2,2-Diphenyl-1-picrylhydrazyl; FRAP – Ferric Reducing Antioxidant Power; GS–MS - Gas Chromatography–Mass Spectrometry; QE – Quercetin Equivalents; MIC – Minimum Inhibitory Concentration; NF- κ B – Nuclear Factor kappa-light-chain-enhancer of activated B cells; MBC – Minimum Bactericidal Concentration; DM – Dry Matter; β -cells – beta cells; ROS – Reactive Oxygen Species; GAE – Gallic Acid Equivalents.

Competing Interests: The authors have no financial interests or conflicts of interest.

Authors' contribution: All authors contributed to this study. AK– conceptualization, supervision, critical revision of the manuscript, writing–review and editing; ZhF– preparation of the graphical abstract and table; IG – literature review, data organization, writing – original draft preparation.

Acknowledgement and funding: The research was supported by the Higher Education and Science Committee of the Republic of Armenia (project 23RL-1F017 “Current trends of forest tree species adaptation in the face of climate change in Armenia”).

REFERENCES

1. Maliuvanchuk S, Grytsyk A, Melnyk M, Kutsyk R, Yurkiv K, Raal A, et al. *Sorbus aucuparia* L. Fruit extract and its cosmetics—as promising agents for prophylactic and treatment of pyodermitis: Phytochemical and microbiological research. *The Open Agriculture Journal*. 2023;17(1). DOI:<https://doi.org/10.2174/0118743315268063231123051128>
2. Martirosyan D. Functional food science and bioactive compounds. *Bioactive Compounds in Health and Disease*. 2025;8(6):218–229.

- DOI: <https://doi.org/10.31989/bchd.v8i6.1667>
3. Wojdyło A, Siniawska M, Bąbelewski P, Turkiewicz I. Profiling of polyphenolic compounds using LC-QTOF/ESI-MS in fruits of the *Sorbus* subgenus as a valuable source of polyphenolic compounds. 2025;51
DOI: <http://dx.doi.org/10.2139/ssrn.5445361>
 4. Aurori M, Andrei S, Dreanca AI, Morohoschi AG, Cotul M, Niculae M, et al. The nephroprotective effect of cornelian cherry (*Cornus mas* L.) and Rowanberry (*Sorbus aucuparia* L.) in gentamicin-induced nephrotoxicity on *Wistar rats* with emphasis on the evaluation of novel renal biomarkers and the antioxidant capacity in correlation with nitro-oxidative stress. *Nutrients*. 2023;15(20):4392.
DOI: <https://doi.org/10.3390/nu15204392>
 5. Arvinte OM, Senila L, Becze A, Amariei S. Rowanberry—A source of bioactive compounds and their biopharmaceutical properties. *Plants*. 2023;12(18):3225.
DOI: <https://doi.org/10.3390/plants12183225>
 6. Surovčík D, Solár J. Selected elements in fruits of *Sorbus aucuparia* in the Tatra Mountains and urbanized areas of its foreland. *Oecologia Montana*. 2024;33(2):102-110
 7. Cristea AM, Smeu A, Cîmpeanu IA, Iftode A, Liga S, Tchiakpe-Antal D, et al. Biological effects of rosaceae species in skin disorders—an up-to-date overview. *Plants*. 2025;14(11):1605.
DOI: <https://doi.org/10.3390/plants14111605>
 8. Felicianna F, Lam Cheung H, Zhang F, Leung HKM, Ismaiah MJ, Rosa-Sibakov N, et al. H. Toxicological and nutritional evaluation of plant cell cultures from scurvy grass (*Cochlearia danica*) and rowan (*Sorbus aucuparia*). *Frontiers in Toxicology*. 2025;7:1655489.
DOI: <https://doi.org/10.3389/ftox.2025.1655489>
 9. Gabrielyan ETs. Rowan (*Sorbus* L.) of Western Asia and the Himalayas / Yerevan: *Publishing house of the Academy of Sciences of the Arm SSR*. 1978;1-264,33.26
 10. Chytrý M, Řezníčková M, Novotný P, Holubová D, Preislerová Z, Attorre F, et al. FloraVeg. EU — An online database of European vegetation, habitats and flora. *Applied Vegetation Science*. 2024;1-12.
DOI: <https://doi.org/10.1111/avsc.12798>
 11. Wang X, Li Y, Zhang Z, Li M, et al. Unraveling the impact of environmental factors and evolutionary history on species richness patterns of the genus *Sorbus* at global level. *Plants*. 2025;14(3):338.
DOI: <https://doi.org/10.3390/plants14030338>
 12. Raspé O, Findlay C, Jacquemart AL. *Sorbus aucuparia* L. *Journal of Ecology*. 2000;88(5):910-930.
DOI: <https://doi.org/10.1046/j.1365-2745.2000.00502.x>
 13. Sevoyan G, Ghazaryan K, Yesayan T, Hayrapetyan A, Minasyan S, Babayan B, et al. Traditional vegetarian food products in villages of Syunik, Armenia: Technogenic contamination risks assessment. *Functional Food Science*. 2024;2767-3146,4(10):380-389.
DOI: <https://doi.org/10.31989/ffs.v4i10.1463>
 14. Rutkowska M, Kolodziejczyk-Czepas J, Olszewska MA. The Effects of *Sorbus aucuparia* L. fruit extracts on oxidative/nitrative modifications of human fibrinogen, impact on enzymatic properties of thrombin, and hyaluronidase activity in vitro. *Antioxidants*. 2021;10(12):2009.
DOI: <https://doi.org/10.3390/antiox10122009>
 15. Ayvazyan A, Zidorn C. Traditionally used medicinal plants of Armenia. *Plants*. 2024;13(23):3411.
DOI: <https://doi.org/10.3390/plants13233411>
 16. Yousefzadeh H, Raeisi S, Esmailzadeh O, Jalali G, Nasiri M, Walas Ł, et al. Genetic diversity and structure of rear edge populations of *Sorbus aucuparia* (Rosaceae) in the Hyrcanian Forest. *Plants*. 2021;10(7):1471.
DOI: <https://doi.org/10.3390/plants10071471>
 17. Khromykh NO, Liashenko OV, Anishchenko AO. Evaluation of bark phytochemical composition of the genus *Sorbus* plants as a source of biologically active compounds. *Ecology and Noospherology*. 2024;35(1):47-51.
DOI: <https://doi.org/10.15421/032408>
 18. Liashenko OV. Phenolic compounds and antimicrobial activity of leaves of the genus *Sorbus* species and natural hybrids. *Ecology and Noospherology*. 2023;34(2):117-122.
DOI: <https://doi.org/10.15421/032318>
 19. Sulimanec A, Kragić K, Sekovanić A, Jurasović J, Panjkota Krbavčić I, Vahčić N, et al. Rumora Samarina I. Chemical characterization and antioxidant potential of the rowan (*Sorbus aucuparia* L.) fruits from Alpine-Dinaric region of Croatia. *Food Technology and Biotechnology*. 2023;61(4):465-474.
DOI: <https://doi.org/10.17113/ftb.61.04.23.8225>
 20. Mombekov S, Datkhayev U, Kalamkul D, Kozhamzharova A, Baidullayeva A, Assel M, et al. Study of the chemical components of CO2 extracts from the fruits of *Sorbus aucuparia* L. *ScienceRise: Pharmaceutical Science*. 2024;2(48):83-89.
DOI: <https://doi.org/10.15587/2519-4852.2024.303000>
 21. Aurori M, Niculae M, Hanganu D, Pall E, Cenariu M, Vodnar DC, et al. The antioxidant, antibacterial and cell-protective properties of bioactive compounds extracted from rowanberry (*Sorbus aucuparia* L.) fruits in vitro. *Plants*. 2024;13(4):538.
DOI: <https://doi.org/10.3390/plants13040538>
 22. Lykholat YV, Khromykh NO, Liashenko OV, Sklyar TV, Anishchenko AO, Balalaiev OK, et al. Phytochemical profiles and

- antimicrobial activity of the inflorescences of *Sorbus domestica*, *S. aucuparia*, and *S. torminalis*. *Biosystems Diversity*. 2023;31(3):290-296.
DOI: <https://doi.org/10.15421/012333>
23. Džarić T, Petrović D, Božović M. Antioxidant activity and total phenolic content of different extracts from *Rosa canina* L. fruits. *Natural Product Communications*. 2025;20(8).
DOI: <https://doi.org/10.1177/1934578X251369>
 24. Platonova EY, Golubev DA, Zemskaya NV, Shevchenko OG, Patov SA, Shaposhnikov MV, et al. The antioxidant and geroprotective properties of an extract of mountain ash (*Sorbus aucuparia* L.) fruits. *Molecular Biology*. 2023;57(6):978-992.
DOI: <https://doi.org/10.1134/S0026893323060134>
 25. Yuri, L., Nina, K. and Olena, L., 2023, May. Variability of the flavonoids distribution in fruit peel and pulp of different rowan (*Sorbus* L.) species. In The 20th International Scientific and Practical Conference "Technologies, innovative and modern theories of scientists" (May 23–26, 2023) *Graz, Austria. International Science Group*. 2023; 525 (39).
DOI: <https://doi.org/10.46299/ISG.2023.1.20>
 26. Ak G, Tüfekci EF, Mustafa AM, Caprioli G, Altunoglu YC, Baloglu MC, et al. Exploring *Sorbus torminalis* leaves: unveiling a promising natural resource for diverse chemical and biological applications. *Chemistry & Biodiversity*. 2024;21(2):e202301596.
DOI: <https://doi.org/10.1002/cbdv.202301596>
 27. Kostecka-Gugała A. Quinces (*Cydonia oblonga*, *Chaenomeles* sp., and *Pseudocydonia sinensis*) as medicinal fruits of the Rosaceae family: current state of knowledge on properties and use. *Antioxidants*. 2024;13(1):71.
DOI: <https://doi.org/10.3390/antiox13010071>
 28. Lahlou RA, Carvalho F, Pereira MJ, Lopes J, Silva LR. Overview of ethnobotanical-pharmacological studies carried out on medicinal plants from the Serra da Estrela natural park. 2024.
DOI: <https://doi.org/10.20944/preprints202402.1579.v1>
 29. Li Y, Yang J, Zhou J, Wan X, Liu J, Wang S, et al. Multi-omics revealed molecular mechanism of biphenyl phytoalexin formation in response to yeast extract-induced oxidative stress in *Sorbus aucuparia* suspension cells. *Plant Cell Reports*. 2024;43:62.
DOI: <https://doi.org/10.1007/s00299-024-03155-5>
 30. Gonçalves AC, Rodrigues S, Fonseca R, Silva LR. The Role of Dietary Anthocyanins in Cancer Prevention. In: *Interdisciplinary Cancer Research. Springer, Cham*. 2024;1-39.
DOI: https://doi.org/10.1007/16833_2024_443
 31. Uuh Narvaez JJ, Segura Campos MR. Combination therapy of bioactive compounds with acarbose: A proposal to control hyperglycemia in type 2 diabetes. *Journal of Food Biochemistry*. 2022;46(10):e14268.
DOI: <https://doi.org/10.1111/jfbc.14268>
 32. Arvinte O, Amariei S. Study on the content of polyphenols in some plants from the spontaneous flora from the mountainous area of suceava county. *Food and Environment Safety Journal*. 2023;22(2).
DOI: <http://dx.doi.org/10.4316/fens.2023.014>
 33. Haffani Y, Torkhani M, Halim NB, Chrigui S, Mami NB, Boudhrioua N, et al. Oleuropein exhibits anticancer effects by inducing apoptosis and inhibiting cell motility in MCF7 and MDA-MB231 breast cancer cells. *Functional Foods in Health and Disease*. 2025;15(3):162-175.
DOI: <https://doi.org/10.31989/ffhd.v15i3.1577>
 34. Khromykh NO, Didur OO, Sklyar TV, Procházková L, Nedbalová L, Nebesarova J, et al. Characterization of *Sorbus aria*-mediated silver nanoparticles and evaluation of antibacterial activity against *Staphylococcus epidermidis* clinical strains. *Regulatory Mechanisms in Biosystems*. 2025;25;16(2):e25056.
DOI: <https://doi.org/10.15421/0225056>
 35. Olszewska MA, Kolodziejczyk-Czepas J, Rutkowska M, Magiera A, Michel P, Rejman MW, et al. The effect of standardised flower extracts of *Sorbus aucuparia* L. on proinflammatory enzymes, multiple oxidants, and oxidative/nitrative damage of human plasma components in vitro. *Oxidative Medicine and Cellular Longevity*. 2019;2019(1):9746358.
DOI: <https://doi.org/10.1155/2019/9746358>
 36. Southall, O. (2023). *Rowan*. Reaktion books.
 37. Kobus Z, Krzywicka M, Lakatošová J, Ivanišová E. Optimization of ultrasound-assisted extraction of polyphenols from rowan (*Sorbus aucuparia* L.): A response surface methodology approach. *Processes*. 2025;29;13(9):2778.
DOI: <https://doi.org/10.3390/pr13092778>
 38. Lykholat Y, Khromykh N, Liaschenko O. Features of polyphenols accumulation in the fruit peel and pulp of the genus *Sorbus* L. *Plants. Scientific Collection «InterConf»*. 2023;(156):376-8.
 39. Vasilieva AR, Slynko NM, Tatarova LE, Efimov VM, Kuibida LV, Asbaganov SV, et al. A GC-MS chemotaxonomic study on lipophilic compounds in the bark of *S. aucuparia* subsp. *sibirica* trees from the population growing in Akademgorodok, Novosibirsk (Russia). *Metabolites*. 2023;19;13(6):768.
DOI: <https://doi.org/10.3390/metabo13060768>
 40. Majdan M, Bobrowska-Korcza B. Active compounds in fruits and inflammation in the body. *Nutrients*. 2022;16;14(12):2496.
DOI: <https://doi.org/10.3390/plants12183225>

41. Patel M, Wahezi S, Mavrocordatos P, Abd-Elseyed A. The effects and mechanisms of phytochemicals on pain management and analgesic. *Nutrients*. 2025;11;17(4):633.
DOI: <https://doi.org/10.3390/nu17040633>
42. Benedec D, Oniga I, Hanganu D, Tipericiu B, Nistor A, Vlase AM, et al. Stachys species: Comparative evaluation of phenolic profile and antimicrobial and antioxidant potential. *Antibiotics*. 2023;12:1644.
DOI: <https://doi.org/10.3390/antibiotics12111644>
43. Aurori M, Niculae M, Hanganu D, Pall E, Cenariu M, Vodnar DC, et al. Phytochemical profile, antioxidant, antimicrobial and cytoprotective effects of cornelian cherry (*Cornus mas* L.) fruit extracts. *Pharmaceuticals*. 2023;16:420.
DOI: <https://doi.org/10.3390/ph16030420>
44. Aurori M, Novac CŞ, Nadăş GC, Crăciun S, Fiş N, Andrei S. The antimicrobial effect of *Cornus mas* L. and *Sorbus aucuparia* L. Fruit extracts against resistant uropathogens in correlation with the prevalence of urinary tract infections in companion animals. *Pharmaceuticals*. 2024;17(6):814.
DOI: <https://doi.org/10.3390/ph17060814>
45. Vepšaitė-Monstavičė I, Lukša-Žebelovič J, Apšegaitė V, Mozūraitis R, Lisicinas R, Stanevičienė R, et al. Profiles of killer systems and volatile organic compounds of rowanberry and rosehip-inhabiting yeasts substantiate implications for biocontrol. *Foods*. 2025;14(2):288.
DOI: <https://doi.org/10.3390/foods14020288>
46. Demidova E, Samilyk M. Prospects for the use of wild berry processing products as functional food ingredients. *Food Science & Technology (2073-8684)*. 2023;17(4).
DOI: <https://doi.org/10.15673/fst.v17i4.2780>
47. Tamayo-Vives C, Úbeda M, Morales P, García-Herrera P, Sánchez-Mata MC. *Crataegus monogyna* Jacq., *Sorbus aria* (L.) crantz and *Prunus spinosa* L. from edible fruits to functional ingredients. *Foods*. 2025;14(13):2299
DOI: <https://doi.org/10.3390/foods14132299>
48. Samilyk M, Demidova E, Nazarenko Y, Tymoshenko A, Ryzhkova T, Severin R, et al. Formation of the quality and shelf life of bread through the addition of rowanberry powder. *Eastern-European Journal of Enterprise Technologies*. 2023;10;123(11).
DOI: <https://doi.org/10.15587/1729-4061.2023.278799>
49. Stabnikova O, Stabnikov V, Paredes-López O. Fruits of wild-grown shrubs for health nutrition. *Plant Foods for Human Nutrition*. 2024;79(1):20-37.
DOI: <https://doi.org/10.1007/s11130-024-01144-3>
50. Rustemkulov AG, Gontova TM, Makhatova BG, Rustemkulova AE, Datkhayev UM, Koshovyi M. Standardization parameters of *Alfredia nivea* KAR. & KIR herb. *Journal of Organic and Pharmaceutical Chemistry*. 2023;3;21(1):46-53.
DOI: <https://doi.org/10.24959/ophci.23.276004>
51. Moskalets V, Hulko B, Rozhko I, Moroz V, Ivankiv M. Morphophysiological characteristics of plants and biochemical parameters of rowan berries, common rowan, and domestic rowan grown in the conditions of the Northern Forest-Steppe of Ukraine. *Scientific Horizons*. 2023;26(10):78-92
DOI: <https://doi.org/10.48077/scihor10.2023.78>
52. Martysiak-Żurowska D, Orzolek M. The correlation between nutritional and health potential and antioxidant properties of raw edible oils from cultivated and wild plants. *International Journal of Food Science and Technology*. 2023;58(2):676-685.
DOI: <https://doi.org/10.1111/ijfs.16217>
53. Rutkowska M, Kolodziejczyk-Czepas J, Owczarek A, Zakrzewska A, Magiera A, Olszewska MA. Novel insight into biological activity and phytochemical composition of *Sorbus aucuparia* L. fruits: Fractionated extracts as inhibitors of protein glycation and oxidative/nitrative damage of human plasma components. *Food Research International*. 2021;147:110526.
DOI: <https://doi.org/10.1016/j.foodres.2021.110526>
54. Łysiak GP, Szot I. The possibility of using fruit-bearing plants of temperate climate in the treatment and prevention of diabetes. *Life*. 2023;13(9):1795.
DOI: <https://doi.org/10.3390/life13091795>
55. Korić E, Milutinović V, Hajrudinović-Bogunić A, Bogunić F, Kundaković-Vasović T, Gušić I, et al. Phytochemical characterisation of *Sorbus* species: Unveiling flavonoid profiles related to ploidy and hybrid origin. *Plants*. 2025;14(1):119.
DOI: <https://doi.org/10.3390/plants14010119>
56. Xie B, Chen P, Hong Y, Xu C, Zhang W. Effects of a dietary compound tablet on glucose metabolism in a hyperglycemic mouse model. *Dietary Supplements and Nutraceuticals*. 2025;4(06):1-11.
DOI: <https://doi.org/10.31989/dsn.v4i6.1621>
57. Berganayeva G, Kudaibergenova B, Litvinenko Y, Nazarova I, Sydykbayeva S, Vassilina, et al. Medicinal plants of the flora of Kazakhstan used in the treatment of skin diseases. *Molecules*. 2023;28(10):4192.
DOI: <https://doi.org/10.3390/molecules28104192>
58. Bejenaru C, Radu A, Mogoşanu GD, Bejenaru LE, Biţă A, Segneanu AE. Rosaceae Juss. Family. Natural products and medicinal properties of carpathian (Romanian) *Plants* CRC Press. 2024;30:357-388.
59. Li Y, Yang J, Zhou J, et al. Multi-omics revealed molecular mechanism of biphenyl phytoalexin formation in response to

- yeast extract-induced oxidative stress in *Sorbus aucuparia* suspension cells. *Plant Cell Rep.* 2024;43,62.
DOI: <https://doi.org/10.1007/s00299-024-03155-5>
60. David Z, Bshir A, Amoka A, Idris E, Anoze A, Moyosore A, et al. Antioxidant and hepatoprotective activities of methanol extract of *Moringa oleifera* leaves in carbon tetrachloride-induced hepatotoxicity in rats: Implications for functional food development. *Agriculture and Food Bioactive Compounds.* 3068-8051, 2025;2(7):157-170.
DOI: <https://doi.org/10.31989/afbc.v2i7.1722>
61. Bineid MM, Liu L, Ventura EF, Bansal S, Curi-Quinto K, Del Valle-Mendoza J, et al. The effect of probiotics, prebiotics and synbiotics on gut microbial community profile in overweight and obese Latin American and Caribbean populations: A systematic review of human trials. *Gut Microbiome (Camb).* 2025;6:e2:1-17.
DOI: <https://doi.org/10.1017/gmb.2024.12>.
62. Szöke É, Kéry Á, Lemberkovics É. Biological activity of compounds of plant origin. From Herbs to Healing. *Springer, Cham.* 2023;411–511.
DOI: https://doi.org/10.1007/978-3-031-17301-1_5
63. Miyasaka K, Takeda S, Guang O, Itoi K, Miyazaki K, Manse Y, et al. Rice-derived glucosylceramides activate innate immune responses in myeloid lineage differentiated dendritic cells via toll-like receptors 2 and 4. *Journal of Natural Medicines.* 2025;24. DOI: <https://doi.org/10.1007/s11418-025-01951-1>
64. Goktas H. Enrichment of antioxidant activity of ice cream samples with addition of rowanberry (*Sorbus aucuparia* L.) pulp and production of functional probiotic ice cream with using *L. rhamnosus*. *International Journal of Food Science and Technology* 2023;58(11):5962-5971.
DOI: <https://doi.org/10.1111/ijfs.16701>
65. Sarv V, Shehzad H, Reelika Rätsep, and Ave Kikas. The proximate composition, mineral and pectin content and fatty acid profile of the pomace fraction of 16 rowanberry cultivars. *Plants* 2024;13(12):1615.
DOI: <https://doi.org/10.3390/plants13121615>
66. Ispiryan A, Jariéné E. Comparative assessment of fermented and non-fermented berry seeds as sources of functional oils. *Foods*, 2025;14(20),3494.
DOI: <https://doi.org/10.3390/foods14203494>
67. Meremäe K, Raudsepp P, Rusalepp L, Anton D, Bleive U, Roasto M. In vitro antibacterial and antioxidative activity and polyphenolic profile of the extracts of chokeberry, blackcurrant, and rowan berries and their pomaces. *Foods.* 2024;13(3):421.
DOI: <https://doi.org/10.3390/foods13030421>