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The Influence of Temperature, Storage Conditions, pH, and Ionic Strength on the Antioxidant Activity and Color Parameters of Rowan Berry Extracts

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Abstract: Recent trends in the food industry combined with novel methods in agriculture could transform rowan into a valuable raw material with potential technological applications. Thus, the aim of this research was to investigate the content of bioactive compounds in its fruits and to assess the color and antioxidant stability of the extracts prepared from such fruits during various thermal treatments and at different pH and ionic strength values. Various spectrophotometric methods, HPLC, and capillary electrophoresis were used to quantify the concentrations of bioactive compounds—polyphenols, carotenoids, organic acids, and to assess antioxidant activity and color. The results show that rowan berries contain circa 1.34–1.47 g/100 g of polyphenols among which include catechin, epicatechin, ferulic acid methyl ester, procyanidin B1, etc.; ca 21.65 mg/100 g of carotenoids including zeaxanthin, β-cryptoxanthin, all-*trans*-β-carotene, and various organic acids such as malic, citric, and succinic, which result in a high antioxidant activity of 5.8 mmol TE/100 g. Results also showed that antioxidant activity exhibited high stability when the extract was subjected to various thermal treatments, pHs, and ionic strengths, while color was mainly impacted negatively when a temperature of 100 °C was employed. This data confirms the technological potential of this traditional, yet often overlooked species.

Keywords: rowan berries; antioxidant activity; CIELab color parameters; polyphenols; carotenoids; bioaccessibility; organic acids; stability

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1. Introduction

Sorbus aucuparia L. is a *Rosaceae* family species interesting for its bright-colored yellow compounds which also possess functional properties. Some of its common names are mountain ash, rowan, keirn, cuirn, and witch wiggin tree. Native to the cooler regions of the northern hemisphere, it used to grow most often at high altitudes. Nowadays, this tree also serves for decorative purposes and can be seen in gardens and parks [1].

Its bright scarlet fruits are also known for their high content in potassium, calcium, and phosphorus, vitamin C, unsaturated fatty acids, and polyphenols, although discrepancies in concentrations due to growing region and climatic conditions have been reported. For the aforementioned reasons, many authors expressed support for future research on this non-traditional species, which can grow in regions with harsh climate and poor soil [2].

Due to recent trends in the food industry and the ever-growing desire for a clean label and "natural" declaration, combined with novel methods in agriculture such as permaculture [3,4], this species has become a great source of extracts with potential technological roles in food processes. Ongoing research shows that phenolic extracts from *Sorbus aucuparia* L. can protect oils from thermal and oxidative degradation during frying [5]. In another study, rapeseed oil was supplemented with phenolic extracts from rowan berries (*Sorbus aucuparia* L.) and Siberian apple tree (*Malus baccata*). The results of antiradical and antioxidant activity have demonstrated that natural extracts are more effective than BHT (butylated hydroxytoluene) and can be an alternative to synthetic antioxidants during frying and storing plant oils [5].

Nowadays, the increasing awareness of the benefits of fruits and vegetables for health, and the need for comfort due to an accelerated lifestyle have increased the demand for ready-to-eat products. In recent years, manufacturers have developed various foods, the purpose of which is to bring convenience to consumers. Food products are subjected to various technological treatments that may involve high temperatures, high pressure, microwaves, etc., and biological activity, as well as sensory characteristics such as color, which may change after such treatments [6]. Food composition and pH that can vary significantly, from very acidic with a pH of around 2–3 in products such as vinegar or lemon juice to mildly alkaline with a pH of about 7–8 in various ready-to-eat soups or cheeses, are also important factors for the stability of bioactive compounds and sensory properties. Furthermore, a large array of temperatures/time regimes are employed to ensure food safety [7].

The aim of this research was to investigate the content of bioactive compounds in rowan (*Sorbus aucuparia* L.) berries—polyphenols, organic acids, carotenoids, and their bioaccessibility. The influence of different thermal regimes, storage conditions, pH, and ionic strength on antioxidant activity and CIELab color parameters were investigated. This paper will provide some practical answers to researchers who study natural extracts which will subsequently be used either as food dyes or antioxidants, new product development specialists, and food technologists.

2. Results and Discussion

2.1. Polyphenol and Carotenoid Composition, Antioxidant Activity, and Carotenoid Bioaccessibility in Rowan Extracts

Table 1 presents the total polyphenol content tested using two different methods, as well for various classes of polyphenols, the antioxidant activity, the bioaccessibility of carotenoids, the carotenoids' content, the concentration of various individual phenolics, carotenoids, and organic acids.

As the results show, rowan berry extract contains a high amount of polyphenols, i.e., between ca 1.34 g/100 g and 1.47 g/100 g depending on the testing method. A large proportion of these polyphenols are flavonoids.

As a result, antioxidant activity also exhibits high levels, which may be correlated with either polyphenol content or, also, a relatively high carotenoid content. With regards to polyphenol content, other authors report values between 4.27 and 8.19 g/kg fresh material, depending on the cultivar. The highest documented value from Mlcek et al. [2] of 8.19 ± 0.56 g/kg was reported for the Granatnaya variety. The cultivar, harvest year, soil, and climatic conditions are some of the factors that will affect the content of polyphenols. The documented antioxidant capacity varies between 6.58 g ascorbic acid/kg and 9.62 g ascorbic acid/kg, depending on the cultivar [2].

The documented flavonoid content varies between 3.11 g rutin/kg and 5.65 g rutin/kg. Fresh fruits were analyzed in the above-mentioned studies, however, considering that dry matter content in fresh berries is usually between 19% and 34% [8], the numbers obtained in the current study are consistent with what was previously reported. The content is similar to the ones of other species popular for their functional properties.