



Valorisation of Raspberries By-Products for Food and Pharmaceutical Industries

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Abstract

Raspberries processing industry produces huge amount of waste that is rich in bioactive compounds. Waste and by-products generated from raspberries processing are not only of high relevance, can potentially be upgraded in the other production processes and may be used such as antioxidants, anthocyanins, flavonoids, phytochemicals, carotenoids, polyphenols, vitamins, and minerals, but also could bring measurable economical and environmental profits. This review demonstrates that the use of raspberries waste for the production of various crucial bioactive components is an important step toward sustainable development. This review describes as well the bioactive compounds and health – promoting properties of raspberries, their extraction techniques, and the potential utilization of the obtained bioactive compounds. As increased population needs much higher levels of energy, food, but natural resources are limited and the current production system is highly polluting. In such a complex context, attention has been given in this paper to the raspberry processing industry solutions, high valued by-products. Extracted compounds can be used in food, pharmaceuticals, cosmetic, and chemical industries, and also in food research, and the development of functional foods.

Raspberry waste is very important because it is produced in large quantities, it is expensive and it is important for business competition, national GDP. Harvesting and recycling waste can be improved in production processes and can be used as a resource for bioactive compounds such as

antioxidants, anthocyanins, flavonoids, phytochemicals, carotenoids, polyphenols, vitamins and minerals. Many significant studies in recent years have identified environmental, biochemical, and genetic controls that accumulate specific compounds in raspberry berries. These components are known for their health benefits, commonly used for their anti-inflammatory and antioxidant properties in the food, cosmetic and pharmaceutical industries. However, medicine has long recognized the healing effects of this berry component and recommends its use not only in daily use, but also in treating, helping to manage or prevent various human diseases such as cancer, diabetes, neurodegenerative disorders, cardiovascular, heart disease. In the light of new developments in berry waste products and increased processing technologies, the current main uses of raspberry waste need to be defined. The paper focuses on the waste from raspberry cultivation and industrial processing, and reviews their valorisation techniques. In addition, the current uses of highly valued raspberry products in food, cosmetics, pharmaceuticals and other industries.

Keywords: Bioactive compounds; By-products; Industrial application; Raspberry valorization

Introduction

Due to various application possibilities and its economic impact, the valorization of food waste has attracted increasing attention [1]. This solves both environmental and economic problems. The red raspberry (*Rubus idaeus*) is a species widely

known for its edible fruits [2], is a fruit in the genus *Rubus*, grown as a perennial crop. There are about 200 raspberry species and most of these have red berries (European). Raspberry is one of the oldest fruit, has medicinal purposes and is the fourth most important berry crop in the world [3]. Raspberries are greatly used in food manufacturing for purees, juices, jams, wines etc. Raspberry seeds are an important by-product in the production process of raspberry wines and juices, but usually be discarded and thus underexploited [4]. Various researchers have discovered that due to raspberries seeds high content of antioxidant, phenolic acids, flavonoids, polyphenols and fibers, as well as the high amount of waste released during industry manufacturing, these by-products could be used successfully recovered and for different industry purposes [5]. Furthermore, it is known by recent works that raspberries in particularly high not only in anthocyanin content, but also in total phenolics [6-8].

Valorization of By-Products from the Industry Processing Raspberry

Raspberry seed components can be separated into two parts: oil and flour. The flour remains following oil extraction, which is performed by many methods including solvent extraction and cold-pressing. Seeds have very different and complex chemical compositions that are nutritionally grouped as macronutrients, micronutrients, and other components. Other components include other phytochemicals such as phenolic antioxidants that have demonstrated potential beneficial health properties. Seeds oils also have other properties that include oxidative stability and color. These components and properties of seeds are valuable and need to be examined and reported which may ultimately lead to increased crop values and increase farm-gate profits for growers and processors [9].

Waste and by-products generated from raspberries processing are of high relevance, can potentially be upgraded in the other production processes and may be used such as antioxidants, anthocyanins, flavanoids, phytochemicals, carotenoids, polyphenols, vitamins, and minerals. The isolation

and characterization of these compounds known generally as "bioactive compounds" is a very current research topic. Many studies are now exploring the possibility of their transformation into ingredients that can be incorporated into different food, cosmetic or pharmaceutical products. This particular interest is due to the fact that in recent years men have started to reorient itself towards the use of natural products to the detriment of those resulting from chemical synthesis. In addition, the results of epidemiological studies highlight the ability of these bioactive compounds to participate in the smooth running of the vital functions of the human organism [10].

The extracted compounds have a potential use as functional ingredients or additives in the food and pharmaceutical industries due to their health properties, antioxidant and antimicrobial activities [11, 12]. Raspberries bioactive compounds are recommended for use not only in daily consumption but also treating help manage or prevent various human diseases such as cancer, diabet, neurodegenerative disorders, cardiovascular, heart disease [13-16, 6]. This review demonstrates the potential of raspberries waste focusing on mainstream sectors as food, nutraceutical and pharmaceutical industries.

In response to environmental concerns regarding the value of by-products, the fruit processing industry is often confronted with several solutions:

- Animal feed: it is the oldest direction of use of fruit residues;
- But most often it involves investments in a technology to provide a healthy by-product and good nutritional value;
- Spreading, composting;
- Energy production: by incineration or by biogas production;
- Recovery of different constituents that can be incorporated into new agri-food, cosmetic or pharmaceutical products [10, 6, 7] (Figure1).

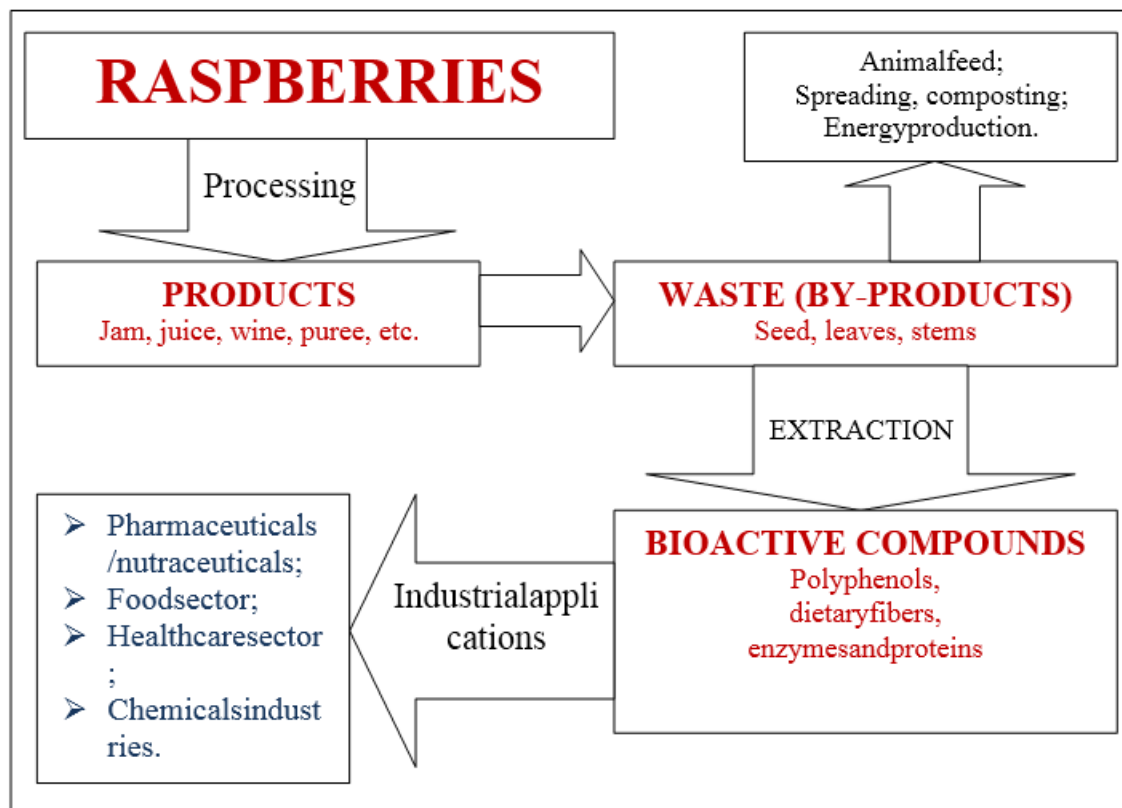


Figure 1: Graphical illustration of the fate of raspberry wastes.

Following the principles of waste management hierarchy, food industry can improve its environmental performance and also its cost-efficiency. Based on the waste management hierarchy, priority is given to the prevention of waste. On the second place stands the reduction of the amount of waste at source, which can be achieved through decreasing material losses and improving the efficiency of process. This waste management strategy not only avoids residues generation but uses both economic and environmental friendly technologies [17].

Furthermore, creating by-products there is an increased interest to explore novel food processing technologies to minimize the quality losses of berries and extend their shelf-life as well. A number of novel non-thermal processing techniques, such as high pressure processing, pulsed electric field, ultrasound and ultraviolet light (UV) irradiation have been introduced for processing of fruits in order to obtain high quality and long shelf-life products [18].

Pap et al. (2004) [19] focused on waste minimization and best eco-innovative practices in berry juice processing. The optimisation included the reduced utilization of raw materials, less energy and water use, while, as a result, less process waste and effluent was generated. Supercritical fluid extraction (SFE) with natural CO₂ was deemed the most promising technology for the recovery of valuable compounds in light of being the least expensive and more environmentally friendly solvent-free extraction method [5].

The bioactive compounds can be extracted by using both conventional and non-conventional technologies, each having their own advantages and disadvantages. However, in the recent years, green extraction technology, also known as non-conventional technology, has become the recent area of research. Owing to the high yield, reduced process time, high-quality products and less waste generation, these green technologies have replaced the traditional conventional technologies [19, 20].

Various green technologies based on enzyme (enzyme assisted extraction), pressurized liquid (pressurized liquid extraction), microwave (microwave-assisted extraction), ultrasound (ultrasound-assisted extraction), pulsed electric field (pulsed electric field assisted extraction) and supercritical fluid (supercritical fluid extraction) have been explored for the extraction of bioactive compounds. The effectiveness of these techniques varies with the properties of the source matrix, its chemical structure and process parameters like solvent, pressure, time and temperature [21].

Bioactive Compounds in Raspberries

Worldwide raspberry production could be increasing due to the numerous reports of their health benefits. Antioxidants, which help prevent free radical-induced oxidative stress that is associated with several toxic cellular processes, come mainly from total phenolics, which include anthocyanins and flavonoids [22]. Ellagitannins, as well as some flavonoids have also been detected in raspberry leaves [23].

The feature that makes berry fruit very popular among consumers is their contents of anthocyanins, phenolics and

flavonoids, as they exhibit antioxidant activity [24-26, 13, 39] in biological systems. Classification of berry fruit phenolic components is shown in (Figure 2) [28].

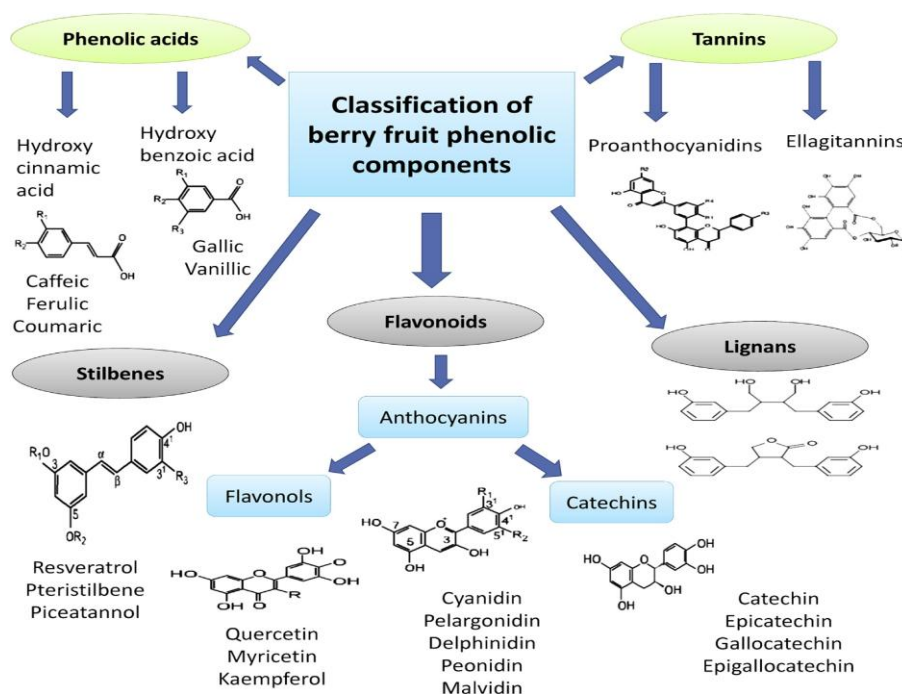


Figure 2: Classification of berry fruit phenolic components.

The raspberry fruit is rich in phenolic compounds such as phenolic acids (ellagic acid and hydrolysable tannins - ellagic acid derivatives), flavonoids (flavan-3-ols and their oligomers - mainly dimmers, quercetin) and anthocyanins (cyanidin-3-sophoroside, cyanidin-3-(2-glucosylrutinoside), cyanidin-3-glucoside, pelargonidin-3-sophoroside, cyanidin-3-rutinoside, pelargonidin - 3 - (2 - glucosylrutinoside), pelargonidin-3-glucoside, pelargonidin-3-rutinoside). Anthocyanins constitute the main group of phenolic compounds in raspberry. In this fruit, the content of ellagic acid is reported to be high, but not higher than of antocyanins [29-32].

Numerous epidemiological studies have shown a link between raspberries consumption and the evolution of various diseases [33, 34, 28, 27]. They show that a diet rich in fruits can reduce the risk of occurrence and improve the effects of diseases such as cardiovascular, diabetes, different types of cancer [35- 38] etc.

This evolution explains why in recent years, researchers have shown a real interest in the study of different fruit components (beneficial for human health) and in particular for understanding their mode of action to better understand the benefits and the possible disadvantages conferred by the consumption of fruits in different forms.

In many cases, the raspberry seeds are the waste products of technological processes, hence their re-using as the antioxidant source, could bring measurable economical profits and contribute to reduction of pollutions introduced by fruit

and vegetable industries into the environment. Perspectives of utilization of fruits and vegetables wastes-originated antioxidants are relatively big, but up to now little recognized. It should be stressed that raspberry seeds can be considered as a potential source of different antioxidant components, which are not exploited at the moment, but could find practical application in many industrial branches. It is necessary to consider both environmental (waste management, protection against pollution) and economical aspects (extraction profitability). Novel scientific and alternative technologies should be used to extract the optimum levels of bio-active compounds as well as other compounds of economic importance from the raspberry wastes. Medicine has long recognized the healing effects of this berry component and recommends its use not only in daily use, but also in treating, helping to manage or prevent various human diseases such as cancer, diabetes, neurodegenerative disorders, cardiovascular, heart disease.

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