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Mini Review

Asparagus Cultivation Co-Products: From Waste to Chance

Viera-Alcaide I[1], Hamdi A[2], Rodríguez-Arcos R[1], Guillén-Bejarano R[1] and Jiménez-Araujo A[1]*

[1]*Instituto de la Grasa, Consejo Superior de Investigaciones Científicas (CSIC), Pablo de Olavide Universitary Campus, Seville, Spain*

[2]*Unité de Physiologie et de Biochimie de la Réponse del Plantes aux Contraintes Abiotiques, FST, Campus Universitaire, Tunisia*

Abstract

Asparagus cultivation produces enormous amounts of biomass (leaves, stems, fruits, roots and rhizomes) that currently lacks of economic value at the time that implies an environmental challenge. From the bioeconomy point of view an added-value must be given to these co-products to shift their consideration from waste to chance. They are rich in phytochemicals, such as flavonoids, fructans and saponins, which can be easily extracted and purified by green and environmental friendly processes. Those bioactive extracts are of great interest for several industrial sectors. The exploitation of this biomass will represent an increase in the incomes of asparagus growers and life standard enhancement of rural areas.

Keywords: Asparagus cultivation co-products; Bioeconomy; Flavonoids; Fructans; Saponins

Introduction

Asparagus cultivation, both white and green, has increased in recent decades. In the year 2000, about $1x10^6$ ha were dedicated worldwide to its cultivation, while in 2017 the figure increased to $1.6x10^6$ ha [1]. The world's leading asparagus producer is China with more than 85% of total production.

Both aerial (stems, leaves and fruits) and underground (roots and rhizomes) parts are produced as co-products of asparagus farming. Annually, around 6 Tm/ha of aerial parts are discarded. It used to be done by controlled burnings in autumn. However, nowadays this practice has been banned by environmental regulations oriented towards CO_2 reduction. Besides, a plantation becomes less productive after 8-10 years of exploitation and, at that moment, they are abandoned. Usually the roots and rhizomes (30-40 Tm/ha) are left in the field. This can have important effects in the dissemination of allelopathic substances [2] and in the development of fungal infections, especially by *Fusarium* spp. and therefore in the problem of asparagus decay [3]. This could be the reason why asparagus cannot be re-cultivated in the same field until at least 5 or 6 years later. New cropping approaches have to be designed from the perspective of bioeconomy where these two co-products are turned into feedstock for new and sustainable processes, thus giving added-value to these awkward wastes.

Asparagus spears are very appreciated by consumers due to their low calories and high fiber contents, characteristic flavour and the presence of several phytochemicals (vitamins, fructans, flavonoids, cinnamic acids and saponins) [4-8], responsible for most of healthy properties of asparagus spear consumption. These same phytochemicals can be found both in the aerial and underground parts, but in different amounts than in shoots. Flavonoids, saponins and fructans are the most abundant bioactive compounds in roots, fruits, leaves and stems [9,10]. These compounds could be the key for the valorization of asparagus cultivation co-products.

Flavonoids from Asparagus Leaves and Stems

Asparagus spears are among the plant products with the highest antioxidant capacity, which is mainly due to their flavonoid content [4,6]. They constitute one of the most abundant groups of antioxidant compounds within the plant kingdom and are usually found as glycosylated derivatives. In asparagus shoots, flavonoids are mainly derived from three aglycones, quercetin, kaempferol and isorhamnetin [11-13]. These same compounds can be found in the basal portions of spears, discarded prior canning, in a quantity near 3g/Kg dry co-product [14]. Amounts six and three times higher have been found in *Asparagus albus* [10] and *Asparagus racemosus* [15] aerial parts, respectively. These results suggest that the amount of leaf flavonoids in different species depends of genetic and environmental factors, as it has been also shown for spears [4,12].

Since global market is eager for natural antioxidants with great potential as ingredients in the food industry, the amount of flavonoids described for asparagus leaves makes them valuable for flavonoid extraction and purification. In recent years, this market has generated sales of more than 2 billion dollars per year and forecasts indicate that it will reach 3.25 billion in 2020 [16]. Among the antioxidants, those of natural origin constitute a growing sector because of the escalating number of consumers who demand natural foods and ingredients. But the potentiality of asparagus flavonoids goes further than food industry because they are also promising agents for cancer therapy [17-19] and they have also proved antifungal activity [20].

***Corresponding author:** Jiménez-Araujo A, Instituto de la Grasa, Consejo Superior de Investigaciones Científicas (CSIC), Pablo de Olavide Universitary Campus, Seville, Spain, Tel: +34 954611550; E-mail: araujo@cica.es

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Fructans from Asparagus Roots and Rhizome

Fructans are oligo- or polysaccharides whose fundamental component is fructose with a glucose unit at its initial end. They are widely distributed throughout the plant kingdom in both monocots and dicots, as well as in green algae. They can be classified by their molecular weight in fructooligosaccharides, of polymerization degree up to 12 units of fructose and inulin of up to 200 units.

It is widely known health benefits from fructans and their wide application in the formulation of foods [21]. These polymers are considered as dietary fiber and have a prebiotic character as they favor the growth of bifidobacteria and lactobacilli by decreasing that of bacteroides and clostridia in the intestine. It is also widely demonstrated that they improve calcium and magnesium absorption, decrease the level of blood triglycerides and increase immune responses [22]. Fructans have been recognized as GRAS (Generally Recognized as Safe) in the USA and as FOSHU (Food of Specified Health Use) in Japan.

Asparagus spears are commonly known as a prebiotic food [23]. In the asparagus edible portion, the content of fructans depends on the variety, ranging from 0.5 to 2% (dry weight), being similar in canning co-products (0.2-1.5%) [24]. However, in *Asparagus* genus, fructans are reserve polysaccharides that accumulate in the roots, where it represents about 25% of the fresh weight, although this content varies throughout the vegetative cycle of the plant [25]. The main industrial source of commercial inulin is chicory root (*Cichorium intybus* L.), the content of which in fructan is very similar to that of asparagus roots (23%) [26].

From this data, it is easy to conclude that asparagus roots are a frontline feedstock for fructan industrial production and, what is more, asparagus can be considered at the same level of chicory as fructan source.

Saponins from Asparagus Plants

Saponins are a group of phytochemicals, present in numerous plant species, which are classified as triterpenic or steroidal according to the structure of their constituent aglycone [27]. The *Asparagus* genus is one of the few plant foods containing steroidal saponins that are distributed throughout different organs of the plant, including leaves, stems, fruits and roots [10]. They are also present in asparagus spears and in canning coproducts, but their amount and chemical structure vary depending on genetic, environmental and physiological factors [5,14].

The complexity of the saponin structure (and thereby their diversity of biological activities) depends on the variability of the aglycone structure and the nature and attachment position of the glycosidic moieties. This structural variability is of great interest because little differences could lead to bioactivity modifications [28,29]. For a long time, many plant extracts rich in saponins have been used as foaming agents and emulsifiers in the food industry. However, in recent years, the interest for saponins has increased radically due to the growing evidence of their possible health benefits, mainly due to its hypoglycemic, hypocholesterolemic, anticancer and antifungal activities [10,30-33].

As commented above, saponins are present in different concentrations in the different plant parts of asparagus plant. Hamdi et al. [10], showed that saponins are concentrated in the rhizomes and fruits of *A. albus* with levels of more than 50g/Kg dry weight. In *A. racemosus* the quantified amount was 12g/Kg dry roots [34] and in *Asparagus adscendens* the concentration varied between 4.5-52g/Kg dry roots [35]. Taking into account the important and varied bioactive functions of these compounds, asparagus roots could become a valuable agricultural co-product. In fact, saponins can be easily extracted and purified from the basal portions of spears (canning co-products) by an environment friendly process [36]. By this patented procedure, both flavonoid and saponin fractions can be effectively separated by adsorption resins. Asparagus roots, being richer in saponins than the studied co-product and lacking in flavonoids, could also be subjected to that process to obtain a more concentrated saponin extract to be applied in different sectors of pharmaceutical and food industries.

Conclusion

Asparagus cultivation co-products must be considered as excellent sources of a range of bioactive compounds of great interest for several industrial sectors. Flavonoids, natural antioxidants, can be isolated from leaves and stems; fructans, widely known as prebiotics, are the main component in asparagus roots and rhizomes; and saponins, with important and varied functional properties, are present in the different plant parts, but especially in roots and fruits. Thanks to this knowledge, the left over biomass from asparagus can swap its present consideration as environmental and soil health challenge for another one, more promising, as feedstock for new industrial activities. This approach could broaden the business opportunities for asparagus spear growers, opening up new opportunities to improve the quality of life in rural areas and preventing depopulation of these endangered regions.

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Conflict of Interest

The authors declare no conflict of interest.

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