Chapter

Sustainable and Healthy Food Ingredients: Characterization and Application in Functional Products

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Abstract

Nowadays, and considering the increasing pieces of evidence of health-promoting abilities of numerous food classes, a pronounced market pressure has been observed both in agricultural and biotechnological industries. Thus, while the development of functional foods seems to be conceived as an interesting trend with large market potential, the increasing demand and interest of sustainable food ingredients seems also promissory. In order to contribute to this approach, the proposal chapter will provides a comprehensive overview of the healthy and sustainable ingredients as edible mushrooms, legumes and bison emphasizing the characterization and application of those as natural ingredients in functional food products.

Keywords: bison, functional and healthy foods, legumes, mushrooms, sustainable ingredients

1. Introduction

The growing demand for nutritious, healthy, sustainable but at the same time attractive food products drives the future of food processing to be multipurpose and more sophisticated. For this reason it became very challenging to develop novel food and/or functional food products, considering that it has to fulfill the consumer's expectations for products that are simultaneously palatable and healthy. Compared to conventional foods, the development of functional components requires technological solutions that can be demanding and expensive, and needs to establish a dynamic equilibrium between research and business. In addition it is important to consider the fact that functional food markets are continuously changing [1]. Food industry innovation is focused on scientific and technical approaches in food processing, along with the introduction of novel and functional foods. In order to promote and sustain healthy eating, food manufacturers need to offer suitable and attractive options on the market for consumers to choose from. There are two main factors that stimulate the interest among food manufacturers to apply these approaches. From one side there is a constant pressure from the public sector to produce "healthier" food products which is accompanied by increased consumer attention to healthy eating. According to the literature, the achievement of food

sustainability is not easy, even more if it is linked to an environmentally friendly diet which is a challenge for even the most dedicated eco-warriors. Concerning human nutrition, agriculture is one of the most important drivers of these changes, since innovation brought by the Green Revolution has completely modified process sustainability, leading to an irreversible tendency to adopt conventional and intensive practices [2].

Sustainable foods are defined as types of foods that are obtained in a manner that minimizes their negative impact on both the environment and the communities that produce them. It is mandatory that sustainable foods meet several criteria among which the most important inquire that there production be environmentally friendly that minimize greenhouse gas emissions, lowering the carbon footprint of the process, and use resources as sustainably as possible. According to the Food and Agriculture Organization of the United Nations (FAO) sustainable food production is the "method of production using processes and systems that are non-polluting, conserve non-renewable energy and natural resources, are economically efficient, are safe for workers, communities and consumers, and do not compromise the needs of future generations".

Besides environmental factors, sustainable eating also pays careful attention to the lifecycle of animals involving their raise and slaughter and how farmers are treated and paid. Therefore, foods must be sustainable considering the future trend of global population increase and limited amount of resources (land, water, and the food itself) that we have. In view of the above, the current section focuses on the presentation and discussion of important aspects related to the characterization of healthy and sustainable ingredients and the application of these natural ingredients in functional foods.

2. Foods with potential sustainability, functionality and healthy

Based on the literatures date, it is very clear to the scientific community together with food manufactures what is the main framework of a sustainable food and farming system even though, at the moment, there is no legal definition of 'sustainable food'. This is clearly reflected in many well known good accreditation schemes which are clearly defined examples, like those certifying 'organic' and 'Fairtrade' food.

Recently it can be noticed that there is keen interest for plant-based foods which more specifically by nutrition is playing an important factor in the definition of sustainable foods. These foods tend to have a greater emphasis on whole foods and fewer processed ingredients. Moreover, there is a growing affinity of the consumers to sustainable wild food products that are grown and produced in uncontaminated wild areas offering high quality food that is viewed in a completely different way as enriched ones with beneficial bioactive compounds [3, 4]. There are large numbers of wild edible food categories including annual and perennial herbs, forbs, ferns, as well as mushrooms, algae and lichens, vines, sedges and rushes, grasses, broad-leaved and needle-like or scale-like leaved shrubs, trees [5].

2.1 Mountain food products: wild edible mushrooms

Mountain Food Products have received an increasing interest in the last years due to the fact that these food products have numerous beneficial and unique qualities that are significantly more accentuated or it cannot be found in other products. It was also found that their quality is strongly influenced by the specific environmental and processing conditions of their mountainous regions of production

and transformation [3]. Mountain foods include a wide variety of products, such as dairy and meat products, fruits, olive oil, pastries, mineral waters, medicinal plants, mushrooms etc. In fact, increasing evidence have confirmed that mountain produced foods present a high level of health-promoting micronutrients, apart from having vestigial or even null amounts of toxins at same time that safe-guards environment.

Many studies reported in the literature pointed put the potential beneficial applications of mushrooms in human dietary, considering that they possess unique nutritional and chemical properties [6–9]. Researchers revealed that wild edible mushrooms provide an important amount of fiber and proteins together with other valuable components like essential amino acids but in comparison to other food products they have a low fat content and do not contain cholesterol [10–14]. In addition, wild edible mushrooms are recognized as a delicacy, due to their specific flavor and texture, especially in mountain areas where they are widely collected considering that many studies emphasized their important nutritional value and the fact that amino acids found in mushrooms are comparable with those of animal origin [15]. For this reasons, many studies have been performed in order to use wild edible mushrooms as raw materials for the production of functional foods considering the identified and extractable bioactive compounds, like terpenoids, unsaturated fatty acids and carotenoids, etc. Also, their exceptional chemical characteristics can be valorized in the fabrication of nutraceuticals or pharmaceutical products, exploring the synergies of the large group of bioactive compounds [5, 16–19]. **Figure 1** gives a summary of the range of beneficial properties of wild edible mushrooms, such as antioxidative, antibacterial, antiviral, anticancer, and anti-inflammatory properties, strengthening the immune system as well as the ability to improve the functioning of the cardiovascular system [14, 20, 21]. This explains why wild edible mushrooms are becoming more and more important in the definition of a balanced diet for humans all over the world, achieving exploitation of the health benefits and functioning mechanisms of mushrooms which give good results in the prevention of major diseases, such as cancer, heart and nervous problems [22, 23].

Mushrooms contain a number of chemical compounds of nutraceutical importance, such as terpenes, bioactive proteins and antioxidants, which make them a therapeutically stronger foodstuff in the battle against various degenerative diseases [7]. Mushrooms have a wide variety of compounds operating in their natural environment, but they can be used to ensure or promote human health in the form of nutraceuticals, additives, functional foods and others. Thus, the creation of a research-oriented field of study for the scientific and novel use of edible or medicinal

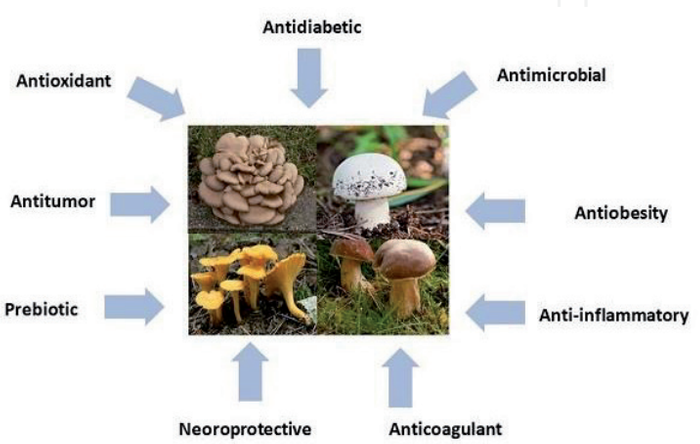

Figure 1.
Beneficial properties of wild edible mushrooms.

Aspect	Species	Habitat	Health benefits	References
	Cantharellus cibarius	Beech and Conifer forests	Excellent source of polysaccharides like chitin and chitosan, reduce inflammation and lower the risk of developing certain cancers	[24]
	Agaricus bisporus	Grassy areas following rain or forest	Hepatoprotective, immuno-stimulatory and antitumor activities Anti-aging activity, protect hepatic and nephric by improving serum, enzyme activities, biochemical levels, lipid contents and antioxidant status	[22, 25, 26]
	Lentinula edodes	Grows in groups on the decaying wood of deciduous trees, particularly shii and other chinquapins, chestnut, oak, maple, beech, sweetgum, poplar, hornbeam, ironwood, and mulberry.	Immuneregulator activity and anticancer potential Lung protection activity, regulate the antioxidant and inflammation status, Antitumor activity	[27]

Aspect	Species	Habitat	Health benefits	References
	Pleurotus ostreatus	On trunks of deciduous species	Cardiovascular, hypertensive, hypercholesterolemia antioxidant and antimicrobial activities, antidiabetic activity	[28–30]
	Boletus edulis	Conifer forests	Antiviral, antiinflammatory, antimicrobial, antioxidant	[31]
	Armillariella mellea	Grows solitary or in groups, on trunks of oak and beech but also on conifer trunks, roots, rotten logs	Meniere's Syndrome, vertigo, epilepsy, neurasthenia and hypertension, antioxidant, antimicrobial properties	[31]

Aspect	Species	Habitat	Health benefits	References
	Macrolepiota procera	Open woods and pastures as well as besides the paths in the forests (e.g. oak and beech or coniferous)	Antioxidant properties, Anti-tumor activity	[31, 32]
	Tuber indicum (truffle)	Conifer forests	Antitumor activity, inhibit the proliferation of hepatoma and human breast cancer cell lines	[22]
	Volvariella volvacea	Beech and Conifer forests	Reducing free radicals, Strengthening bones, Prevent Anemia	[33]

Aspect	Species	Habitat	Health benefits	References
	Flammulina velutipes	growing on dead or living wood or roots of deciduous trees, rarely on conifers	Regulation of the immune system, cancer immunotherapy, antioxidant Immunomodulating activity	[31, 34]

Table 1.
Health benefits of wild edible mushrooms.

mushrooms, the exploitation, and promotion of their full use is necessary. Some of the major properties of the mushroom are described and summarized in **Table 1**.

2.2 Legumes

Legumes and pulses have an important contribution to both human and animal dietary worldwide. The most significant ones are alfalfa, clover, beans, peas, chick-peas, lentils, soy and peanuts. These have long been a part of Western diets and agri-cultural management regimes, but they only recently gain the attention of researchers in the domain of in agri-food research. Promoted for their agronomic, nutritional and environmental benefits [35], legumes have been framed as plant-based solutions to an array of problems in the modern food system; becoming vegetable vessels that express the hopes and dreams of diverse researchers, marketeers and other food futurologists [36]. Moreover, research results concluded that legume consumption reduces the risk of numerous chronic diseases [37] but at the same time provide a range of essential macro, micronutrients and bioactive metabolites with synergic effect against inflammation, which plays a role in disease onset or progression [38]. The identification of resistant cultivars against abiotic and biotic stresses and development of sustainable field management practices, could address both nutri-tion and environmental concerns of modern society [2, 38]. These plants are viewed as a key component in many international research programs for the promotion of environmental sustainability development and the accomplishment of zero hunger. The concrete transition to a more sustainable diet rich in legumes requires a substan-tial change of the typical "western" dietary habits, and food choices (also supported by industrial stakeholders) as well as the suitable strategies to enhance legumes cultivation, distribution and consumption. It is well known that legumes show many environmental sustainability advantages such as the ones presented in **Figure 2**.

The healthy impact of legumes on human organism is based on the presence of The bioactive molecules [39] among which phenolic compounds, saponins, pep-tides and small proteins are the most significant [40]. Some of these are ubiquitous in the family, while others are typical of some genera or species and their synthesis

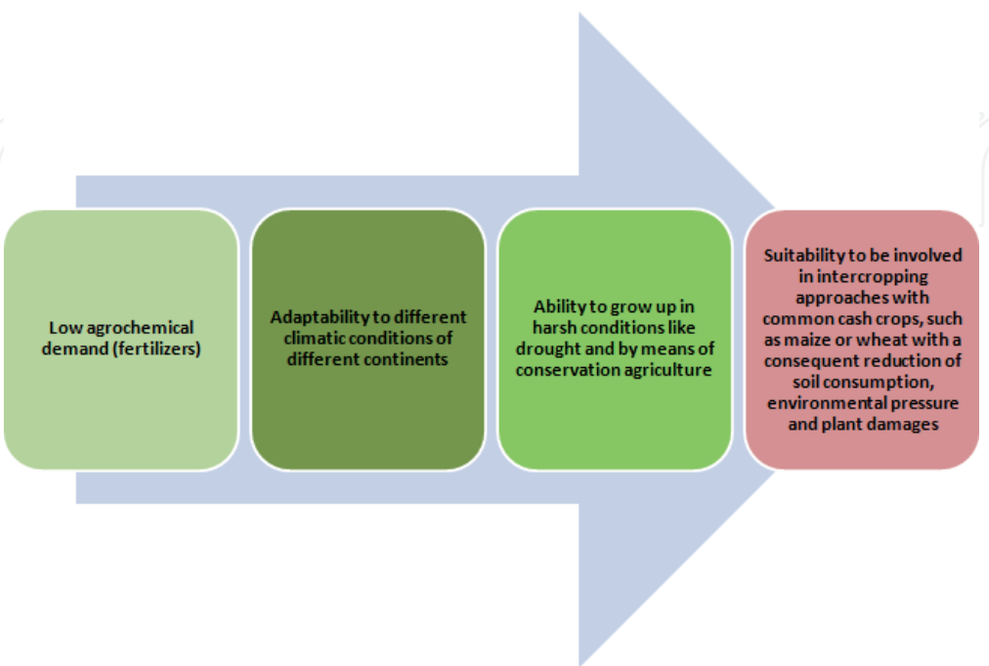

Figure 2.
Environmental sustainability advantages of legumes.

	Species	Health benefits	References
	*Phaseolus vulgaris* L.	Anti-diabetes, anti-hypertensive, antioxidant, prevention of cardiovascular disease, Hypocholesterolemic, prebiotic and fermentation modulator	[44–47]
	*Pisum sativum* L.	Protease inhibition, modulation of intestinal bacteria, glucose metabolism modulation, body weight regulation and anti-diabetes	[48, 49]
	Lupinus spp.	Anticancer, anti-inflammatory	[50]
	Arachis hypogea L.	Hypolipidemic, antioxidant and antimicrobial	[51, 52]
	*Cicer arietinum* L.	Antioxidant, hypoglycemic and anti-diabetes, antimicrobial, glucose metabolism modulation, body weight regulation and anti-diabetes	[53–55]
	*Lens culinaris* L.	Prebiotic, hypocholesterolemic, fecal bile acids and SCFAs enhancer, Anticancer potential	[56–58]

	Species	Health benefits	References
	*Glycine max* L.	Inhibition of proliferation, anti-inflammatory, osteoporosis prevention	[59]

Table 2.
The most common legume species and their health properties.

is highly dependent on plant growing conditions (e.g., development stage, amount of light, and water availability) [41]. Besides polyphenols, legumes proved to be an excellent source of peptides and small proteins that present many biological activities applicable as nutraceuticals and/or therapeutic agents [42, 43]. As a result, these small proteins have been subjected to many studies both in vitro and in vivo in order to quantify their beneficial properties and their potential role in prevention of chronic degenerative diseases. An important category of well-studied legume proteins are lectins which are adequate as carriers for target drug delivery considering their peculiar binding ability. Such an application is the use of lectins for the transportation and release of anticancer drugs during the different stages of tumor progression taking advantage of the well known fact that carbohydrates present on the cancer cell membrane are involved in recognition processes.

In order to highlight the health benefits of legumes, some of the most common legume species and their health impact are listed in **Table 2** based on the scientific literature. According to the data shown in **Table 2** it is obvious that these plants represent an important source for both diet and new nutraceuticals, considering the large number of bioactiv compounds and properties.

2.3 Bison

In the recent years, bison as an alternate meat variety is becoming more and more well-liked in North America [60]. One of the major advantages of bison meat is the fact that it is a sustainable and healthful alternative to cow beef and its production does not face so many environmental and ethical questions. In contrast to cattle which prefer to move around near water sources, bison cover more land leading to the preservation of the sensible ecosystems in the vicinity streams and ponds. Another important fact about bison is that they promote biodiversity considering that by going first for grasses and leaving patches where other plants can fill in. Their hoof prints leave depressions that collect water and their dung serves as a powerful fertilizer: both assist in seedling germination and establishment. Results reported in the literature indicate that in comparison to beef, bison meat presents a lowers energy and fat content and according to the feedback of consumers it seems that bison meat is also healthier than beef. However, the nutrient composition of bison and other meats are strongly influenced by a series of factors like age, type of feed, maturity, gender, type of cut, genetics and season [61]. It is also important to note that bison not only contains less fat than beef but in addition proved to offer an advantageable fatty acid profile, making bison meat a healthy red meat source [62, 63]. Many studies confirmed that bison meat has an hihg ratio of polyunsaturated fatty acids (PUFA) to saturated fatty acids (SFA) [62–64], 3 to 4 times more anti-inflammatory omega-3 PUFA and

is particularly high in alpha linolenic acid [63]. In addition, ruminants such as bison are a major contributors of conjugated linoleic acid (CLA) to the human diet [65, 66], providing significantly more CLA than other non-ruminant meat sources such as pork, fish, chicken, and turkey. The dietary inclusion of a specifically rich source of CLA may be advantageous as CLA is believed to have anti-inflammatory properties [67] and may have an important role in the prevention of cardiovascular disease.

3. Application of sustainable healthy ingredients in functional foods

The recent tendency of functional food development had determined the orientation of the scientific community to attractive sustainable and healthy ingredients which can be used in the production. This demarche aims to valorize some of the

	Sustainable ingredients	Application	References
Mushrooms			
1	*Shiitake* powder	Frankfurter	[68]
2	Mixt of *Lentinula edodes*, *Pleurotus eryngii* and *Flammulina velutipes*	Yogurt	[69]
3	*Suillus luteus*	Cottage cheese	[69]
4	*Tremella fuciformis*	Pork patties	[70]
5	*Pleurotus eryngii*	Pork sausages	[71]
6	*Boletus edulis*	Frankfurter Bread	[72, 73]
7	*Cantharellus cibarius*	Frankfurter	[72]
8	*Agaricus bisporus*	Meat emulsion Beef patties Smoke sausages	[74–76]
9	*Flamulina velutipes*	Emulsiontype sausage Ham Chicken sausage	[77–79]
10	*Agaricus bisporus*	Snacks White bread Sponge cake	[80, 81]
11	*Pleurotus ostreatus*	Noodles	[82]
12	*Cordyceps militaris*	Extruded product	[83]
Legumes			
13	*Phaseolus vulgaris* L.	Tortilla Bakery product	[84, 85]
14	*Pisum sativum* L.	Cookies	[86]
15	Arachis hypogea L.	Bakery products	[86]
16	*Cicer arietinum* L.	Pasta, snacks	[87]
17	*Lens culinaris* L.	Bread, cake, crackers, pasta, snacks, dressings, soups, dairy and meat products	[88]
18	*Glycine max* L.	Noodle, meat product	[89]

Table 3.
Applications of different types of sustainable ingredients.

Figure 3.
Application of sustainable healthy ingredients in functional foods.

most important characteristics of sustainable and healthy ingredients such as easily digestible protein, healthy fat, and repertoire of various essential micronutrients for billions across the globe. In recent years, these ingredients were used in the different sector of the food industry being incorporated in various food products to obtain fortified functional foods (**Figure 3**) such as bakery and meat products, food supplements, pharmaceutical products, food additives, cosmetic products.

According to the data presented in **Table 3**, the benefits of sustainable and healthy ingredient are well known but their application in the elaboration of food products is quite recent mainly as meat, fat, phosphates, salt, flour, and nitrite replacer. As a result, many research teams are focusing on the assessment of efficient incorporation of the bioactivities of sustainable and healthy ingredients into newly developed food products. Despite the progress made there are several issues that need to be solved in the future such as the demonstration of the correlation between the functional activities and mechanisms, as well as their safety evaluation and safe range of intake.

4. Conclusions

Nowadays, sustainable ingredients gain more and more attention due to the beneficial and unique characteristics which make them an attractive source of high added-value compounds that could be utilized to fortify different products such as cosmetics and functional foods. Based on the result provided by several studies it can be concluded that healthy sustainable products provide protein, fat, minerals and vitamins in a very precise form and adequate content being recognized as a delicacy and therefore preferred by big part over the globe. It is important to note that literature data show an increasing demand to foods that has low calories, low fat and low cholesterol content and functional foods, which are defined as foods that have positive effects on human health. As an overall conclusion it can be stated that the studied and presented sustainable ingredients have great potential to be used as a natural source of bioactive compounds for the production of functional foods.

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Conflict of interest

"The authors declare no conflict of interest."

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