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Lupin in Foods

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Background

Currently, epidemiological studies have shown that plant-based diets reduce the risks of developing chronic diseases. In this sense, legumes are one of the most important food categories. They have been widely cultivated and used as staple food sources to cover protein and energy needs throughout human history. Legume seeds are used as a source of protein, lipids and dietary food in human and animal food and are also used as a source of protein, lipids and dietary foods and are also adapted to marginal soils and climates. In many regions of the world, legumes are the only source of dietary protein and have been used as an effective substitute for animal protein at a lower cost.

In addition, legumes have been shown to contain a large number of bioactive compounds with potential health benefits such as the prevention of coronary heart disease, cancer and diabetes. These compounds include oligosaccharides, phenols and alkaloids. The interest in these compounds is due to their possible beneficial applications as metabolic, hormonal and digestive system regulators, as well as prebiotics, therefore it is of great interest to know legumes as functional foods and the importance of their bioactive compounds.

Keywords: lupin, foods, epidemiological, plant-based, diets

1. What is lupin?

Lupin (*Lupinus polyphyllus*) is a herbaceous plant in the legume family, Fabaceae, which also includes peas. Lupin is a plant cultivated in the Mediterranean basin as food or as an ornamental flower. It is found on the North and South American continents, as well as in the European and African areas of the Mediterranean [1]. Lupin is a plant that is grown for fodder and green manure. Of the more than 200 species, in addition to all wild varieties, there are also species cultivated for human consumption, others for ornamental value, and most as animal feed. The progress of genetics in the 20th century contributed to the complete domestication of lupin species, by hybridizing those with low alkaloid content and those with soft seeds, giving rise to new, sweet varieties, much more suitable for human consumption [2]. Certain varieties of lupin (*Lupinus albus* - white lupin, *Lupinus luteus* - yellow lupin, *Lupinus angustifolius* - blue lupin) are used in food, especially in the Mediterranean area [3].

The seeds of several lupin species have been consumed for at least 3000 years in Europe and over 6000 years in the alpine areas of the Andes [4]. However, until relatively recently, lupin – in the form of various species bearing this generic name – remained wild or semi-domesticated, due to low interest and little information among farmers, although its value as a rotational crop has been noted since Antiquity. The ancient Egyptians cultivated and consumed it, as did the pre-Inca populations of pre-Columbian America. The Romans wrote about it, because they used lupin crops to improve the quality of the soils. In fact, today's botanical name, used in most languages, has been preserved from the Latin language [4].

It was only in the 18th century that it was brought back to the cultures of the continent - following the ancient Roman method - being cultivated to increase the fertility of poor soils [3]. These lupin species were rich in alkaloids, which made them bitter and unpleasant for digestion, so they were mainly used for animal feed.

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But the progress of genetics in the 20th century definitely contributed to the complete domestication of lupin species, by hybridizing those with low alkaloid content and those with soft seeds, giving rise to new, sweet varieties, much more suitable for human consumption [5].

Figure 1. Lupin seeds and lupin flour (original)

2. Chemical composition of lupin seeds

In relation to their nutritional properties, the protein content of lupin seeds is similar to that of soybean, with an acceptable content of essential amino acids. In addition, the presence of prolamins and low glutein content make lupin proteins desirable for the preparation of low-gluten foods [5]. A low gluten diet is one that excludes most grains and is recommended for people who have celiac disease or gluten sensitivity. For other people, however, eating gluten-free can be unhealthy. The benefits and risks of a gluten-free diet must be carefully weighed, especially if the person starting the new diet does not really need to restrict their gluten intake. Lupin have a rich vegetable protein content, four times higher than wheat grains [6]. They also have one of the highest concentrations of fiber. They do not contain cholesterol, gluten or gastric irritants, unlike soy, which has a fairly large amount of saponins. They are probiotics, helping the development of good bacteria in the body. They contain appreciable amounts of essential aminoacids [7]. Lupin flour has many nutritional properties and is a rich source of the best quality protein [8].

The nutritional value of lupin seeds includes: water (71.08 mg/100g), proteins (32.2g/100g), lipids (5.95 g/100g), fibers (16.2g/100g), carbohydrates (5.82g/100g), saturated fatty acids (13.5%), monounsaturated fatty acids (55.4%), polyunsatured fatty acids (31.1). Vitamins: thiamin (3.9 mg/kg), riboflavin (2.3mg/kg), niacin (39 mg/kg) [9]. Macro and microelements: calcium (51 mg/100g), iron (1.20 mg/100g), magnesium (54 mg/100g), potassium (245 mg/100g), zinc (1.38 mg/100g), phosphorus (128 mg/100g) and phytosterols [10].

Lupin seeds are an important source of nutritionally important lipids. The content of essential fatty acids such as linoleic acid (18:2) is higher in *L. luteus* than in the other species. However, *L.albus* has a higher content of linolenic acid (18:3). Similarly, the fatty acid composition of *L. angustifolius* seeds is excellent due to the high content of palmitic acid and stearic acid, which makes it an attractive ingredient for food and nutraceutical products [11].

Lupinus angustifolius is a rich source of dietary fibres (41.5%), of which 11% is soluble and 30.5% is insoluble [12]. In *L. albus*, a content of 50.4% of total diets was reported, with 2.0% soluble and 48.4% insoluble. Dietary fiber may benefit intestinal functions and fecal parameters by reducing the risk of colon cancer and promoting a healthy digestive system [13].

Lupin seeds are a good source of minerals such as calcium, phosphorus and iron, among others, which are important for various body functions and are part of many tissue structures. The most important minerals in human nutrition are calcium, phosphorus, iron, iodine, fluorine and zinc. Compared to other legumes, lupins have a low level of calcium (Ca) and phosphorus (P), but a similar content of trace elements, such as iron (Fe), zinc (Zn) and copper (Cu) [14]. *Lupinus angustifolius* shows a higher Ca content, while L. luteus var. 4492 contains more Mg, P, Cu, Fe and Zn [15].

Another advantage for which lupin flour is recommended is the lowering of cholesterol. Lupin is rich in soluble fiber and therefore lowers total cholesterol without affecting the good HDL cholesterol [16].

Lupin is one of the best natural sources of aminoacids - arginine, which improves the performance of blood vessels helping to lower blood pressure. Recent studies have shown that eating lupin improves intestinal health: foods like lupin reduce transit time, lower the pH in the colon and act as a "pre-biotic" [17].

Germination increased the amount of bioactive compounds in the lupin seeds as genistein and main cinnamic acids derivatives (ferulic, caffeic, rosmarinic, and coumaric acids) [18] and potentiates the antioxidant, anticarcinogenic, antimicrobial and anti-inflammatory activities [19-21].

3. Lupin and the functional diet

Many studies have highlighted the beneficial effects of lupin on glucose metabolism. Most of the studies were performed on experimental animals with induced diabetes or on cell cultures, testing the effect of lupine derivatives on insulin secretion [22-26]. The replacing up to half of the wheat flour with lupine flour will result in much healthier baked goods. The glycemic index of the products decreases by 50%, the fiber content increases by 200% and the vegetable protein intake by 100% [27].

The acute effects of soy and lupin based beverages on glucose and insulin responses in patients with type 2 diabetes were studied [28].

In addition, lupins contain bioactive compounds such as oligosaccharides, phenolic compounds and alkaloids, some of the main biomolecules that can prevent and protect against chronic diseases such as cancer, diabetes and neurodegenerative and cardiovascular diseases [29, 30].

The benefit of these compounds depends on their chemical structures, concentrations, exposure time, interactions with other compounds and, in particular, their bio availabilities [31, 32]. These compounds are considered to be anti nutrients and/or pro nutrients with negative and/or positive health effects [29,33]. Thus, it is important to know the amount and type of compounds in food and to understand how the body works.

Lupin is a valid substitute for wheat flour in bakery recipes, used to increase the protein fraction and essential amino acids found in insufficient quantities in wheat flour. Also, the phytochemical content and antioxidant activity of food products is enhanced by addition of lupin flour [34, 35]. Previous studies have highlighted the importance of lupin flour as a fortification matrix of wheat flour in bakery [36-38], biscuit technology [39-41], pastry products [42] or protein bars [43].

The use in dietary food technology of lupin seeds refers to fermented probiotic products [44]. The use of *Lupinus mutabilis* from four different cultivars in fermented beverage using *Saccaromyces cerevisae* and *Rhizopus oligosporus* as inoculum improved the nutritional, functional and sensory characteristics of foods [45].

Dove ER et al., 2011 looked at the acute effects of soy and lupin based beverages on glucose and insulin responses in patients with type 2 diabetes [46]. Responses to glucose and C-peptides showed no significant differences between lupin and soybeans, but lupine was found to have a lower insulin response compared to soybeans [47]. Adding lupin or soy to carbohydrate-rich beverages reduces blood sugar in patients with type 2 diabetes, playing a beneficial role in the management of this disease [47].

Conclusions

The increased interest in functional and dietary products has determined food processors to find new matrices to ensure nutritional needs, rich in active principles and with optimal technological behaviors. The use of lupine-type legumes in food represents a healthy, sustainable and viable alternative for the food industry in order to develop functional and innovative products

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