

Castanea sativa Mill. Chemical Composition

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The European chestnut (*Castanea sativa* Mill.), is an environmentally and economically important species in Europe, mainly for fruit production. The chestnut fruit is well-known for its nutritional properties, namely its high concentration of carbohydrates (starch) and its low-fat content, as well as being one of the few fruits that do not contain gluten. Due to its chemical and nutritional characteristics beneficial to health, the sweet chestnut is a food recommended at different levels.

Keywords: sweet chestnuts ; chemical composition ; flavor ; health benefits

1. Introduction

The chestnut tree belongs to the genus *Castanea* and family *Fagaceae*, the same family as the oaks (*Quercus*) and the beeches (*Fagus*) [1][2][3][4]. This family is widely distributed in the forests of the Northern Hemisphere's temperate regions. The different species of the genus *Castanea* can be found in China (*Castanea mollissima* BL. and *Castanea seguinii* Dode.), Japan (*Castanea crenata* Sieb. & Zucc.), North America (*Castanea dentata* (Marsh.) Brokh), and Europe (*Castanea sativa* Mill.) [1]. The chestnut tree derives from the presence and influence of humans from prehistoric times to the present day. Thus, there is a long history of culture and tradition around chestnuts, especially those from Southern Europe [5]. In the Middle Ages, chestnut was used as the main ingredient in bread production [6], and in periods of food crisis with a scarcity of food resources, the chestnut was fundamental in the food supply [7][8], especially in the 18th century, which is said to have been the worst famine century in history [9][10].

The chestnut tree is a species of great interest in multifunctionality, associated with several agricultural and forestry crops. It presents remarkable biodiversity and a capacity to adapt to different ecosystems [10]. The *Castanea sativa* Mill. is one of the most important fruits in the world and is traditional in the European Mediterranean countries [4][11]. Chestnut production has been increasing worldwide over the last few years, as has the area occupied by chestnut trees, and their productivity. This increased interest in the planting of chestnut trees is largely a result of the increased knowledge of tastemakers about the nutritional qualities of the chestnut and its potential health benefits [4][7]. In addition, there is a growing concern in the chestnut sector, namely in the implementation of the plantation of new chestnut areas. Considering climate change, the new chestnut plantations aim to use plants resistant to diseases that cause high mortality in chestnut groves, such as the disease (*Phytophthora cinnamomi*) and the use of smart irrigation systems installed [12][13]. In 2021, Portugal was the main producer in Europe and represented about 35.7 % of the European production. Indeed, the production in Portugal reached 50.37 thousand tons that year [14]; see **Figure 1**.

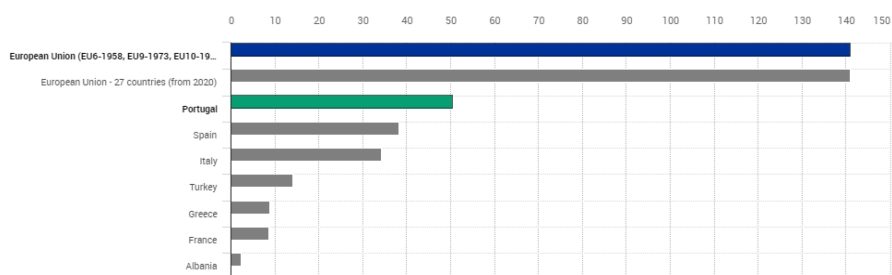


Figure 1. Crop production in EU standard humidity. Chestnut annual area (cultivation/harvested/production) (1000 ha). Source: Eurostat. Adapted from Statistics|Eurostat (eurostat.eu) [14].

Chestnut (*C. sativa*) is an important resource in Europe due to its economic value associated with fruit, wood, and tannin production, and indirectly with honey production, but also due to its cultural value [4]. Even more, the chestnut tree is known as “tree bread” since its nuts, with elliptical shape, bright reddish-brown color with long dark lines, and intense flavor [7], contain essential nutrients in the human diet, such as starch, sugar, and protein [15].

2. Chestnut Chemical Composition

Chestnuts have played an essential role in human nutrition since ancient times ^[16]. Nowadays, their integration into the human diet is highly recommended ^[17]. The main compound of the chestnut is water, where the moisture content ranges from 40 and 64 g/100 g fresh weight ^[18]. Studies conducted on chestnuts' chemical and nutritional composition confirm that this fruit is low in fat, cholesterol-free, and gluten-free. On the other hand, it is a rich source of starch (carbohydrates), protein, dietary fiber, vitamins, minerals (such as potassium, phosphorous, and magnesium), lipids, and nutrients. Furthermore, it is a good source of antioxidants such as *L*-ascorbic acid, carotenoids, and phenolic compounds such as gallic and ellagic acids ^{[2][15][16][17][18][19]}. Due to the mentioned characteristics, the chestnut may have beneficial health effects, arousing consumer interest. Consumer awareness will require the development of reliable methods to select high-quality foods, both nutritionally and sensorily ^[19]. The nut's nutritional value depends on its chemical composition, and this is the result of the interaction of the cultivar (genotype), environmental conditions (climatic factors, temperature, and radiation), and production practices (soil mineral composition, nutrient availability, diseases, and pest) ^{[16][17][20][21]}.

Nutritionally, chestnuts have interesting characteristics, containing significant amounts of dietary fiber but small amounts of crude protein (2–4%) and low levels of crude fat (predominated by unsaturated fatty acids) (2–5%) compared to typical walnuts (walnuts, almonds, hazelnuts), thus being a good source of energy with multiple health-beneficial effects ^[4]. On a dry-matter basis, the main components of the chestnut are carbohydrates (75–91%), most notably starch (39–82%), followed by sucrose ^{[18][22]}. These polysaccharides, together with glucose, fructose, and raffinose—which are also found in significant quantities—can contribute to the identification of a specific chestnut cultivar ^{[11][16][20][23][24][25]}. Researchers argue that starch is partially hydrolyzed into glucose during storage, giving chestnuts a higher sweetness ^[18]. Moreover, chestnuts with a higher starch content are more suitable for flour production ^[16]. The content and composition of these sugars are influenced by various conditions such as storage temperature, relative humidity, harvest time, oxygen level, and even the packaging itself ^[20]. Chestnuts with lower moisture content may have a longer shelf life after harvest because they are likely to have a less favorable environment for the development of microorganisms ^[26]. As previously referred, the chestnuts are also low in fat, thus helping to decrease cholesterol levels. Additionally, they are rich in vitamin C, macro- (K, P, Mg, Ca, Na), and micronutrients (Mn, Fe, Zn, and Cu) ^{[4][27]}. The mineral content found in chestnut trees is associated not only with the genotype and the climatic conditions but also with the mineral composition of the soil where the chestnut trees were grown ^[21]. Chestnuts also have a significant antioxidant activity associated with polyphenolic and organic contents ^[4]. The composition of chestnuts, in different processing, estimated by the United States Department of Agriculture ^[28], confirmed that chestnuts are rich in starch, minerals, vitamins, and phytonutrients, and low in calories and fat (**Table 1**). Borges ^[26] studied the chemical composition of eight sweet chestnut cultivars (Aveleira, Reborda, Trigueira, Zeive, Demanda, Longal, Martainha, and Judia) from three protected designation of origin (PDO) areas located in the Trás-os-Montes region of Portugal. The results once again proved that chestnuts contain high levels of starch (43 g/100 g dry matter) and low fat (3 g/100 g dry matter). In addition, they are a good source of minerals, containing potassium (≈750 mg/100 g dry matter), phosphorus (≈120 mg/100 g dry matter), and magnesium (≈75 mg/100 g dry matter); and amino acids (6–9 g/100 g dry matter) ^[26]. Additionally, there are differences depending on the type of processing the chestnut is subjected to, **Table 1**. The way chestnuts are processed—roasting or cooking—has effects on their primary and secondary metabolic composition. In roasted chestnuts, there is a higher protein, insoluble, and total dietary fiber content ^[21]. When the chestnut is cooked, significant changes occur in the macromolecular structure of the starch (important polysaccharide), modifying its digestibility and making it more bioavailable. In addition, cooked chestnuts are a good source of phenolic compounds and organic acids and are low in fat, properties that are associated with positive health benefits ^{[21][29]}.

Table 1. Nutritional value of 100 g of European chestnut; Source: National Nutrient Database for Standard Reference, United States Department of Agriculture; Retrieved from FoodData Central ([usda.gov](https://www.ars.usda.gov/fooddata)) ^[28].

	Nutrient Value		
	Raw	Roasted	Boiled
Energy (Kcal)	196	245	131
General composition (g)			
Water	52	40.5	68.2
Protein	1.63	3.17	2
Total lipid (fat)	1.25	2.2	1.38
Fatty acids, total saturated	0.235	0.414	0.26

	Nutrient Value		
	Raw	Roasted	Boiled
Fatty acids, total monounsaturated	0.43	0.759	0.476
Fatty acids, total polyunsaturated	0.493	0.869	0.545
Carbohydrates	44.2	53	27.8
Fiber, total dietary		5.1	
Sugars, total including NLEA ¹		10.6	
Vitamins			
Folates (µg)	58	70	38
Niacin (mg)	1.1	1.34	0.731
Pantothenic acid (mg)	0.476	0.554	0.316
Riboflavin (mg)	0.016	0.175	0.104
Thiamin (mg)	0.144	0.243	0.148
Vitamin A (IU)	26	24	17
Vitamin C (mg)	40.2	26	26.7
Electrolytes (mg)			
Sodium	2	2	27
Potassium	484	592	715
Minerals (mg)			
Calcium	19	29	46
Cooper	0.418	0.507	0.472
Iron, Fe	0.94	0.91	1.73
Magnesium	30	33	54
Manganese	0.336	1.18	0.854
Phosphorus	38	107	99
Zinc	0.49	0.57	0.25

¹ Total sugar on the Nutrition Labelling and Education Act (NLEA).

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