Biochemical Properties of Using Active Principles of Chestnuts in Animal Feed

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Abstract

Chestnuts (*Castanea sativa*) are traditionally ingredients of different food and feed, being used in human and animal diet – due to its valuable active principles. The products used are chestnuts (fruits) and also by-products from chestnuts industry like shell, skin, bark, leaves or even flowers. Chestnuts are ingredients with protein – but gluten-free, with low lipid content, high carbohydrates, with hydro-soluble vitamins (A, B_1, B_2, B_3, B_6, B_{12}, C) and minerals (Ca, Fe, Mg, P, K, Na, Zn). Also, in chestnut products are present different antioxidants which could be extracted and used in processing of food and feed products. Thus, various extraction techniques and solvents are used to obtain good yield of substances that are used in animal feeding (for broiler chicken, pigs, rabbits).

Key words: active principles, animal feed, chestnuts

1. Introduction

Due to the fact that the world population is looking for novel food and feed, researchers try to use food ingredients or food with no or poor history, which are easy to found and meet the nutritional requirements. Thus, the nutritionists have in view novel carbohydrates and proteins which avoid some digestibility medical problems (like celiac disease, lactose intolerance and others). Chestnuts could be considered as a novel food due to the fact that it is not so much used in food and feeding plan, it is cultivated around the world, being a fruit that even was easy to found it was not usually consumed by humans and animals.

The chestnuts are fruits of a tree belong to the *Fagaceae* family which is found in temperate regions. The European sweet chestnut is known as *Castanea sativa* Mill. Some populations – mostly in the rural area, used chestnuts as sustainable food resources being cheap and rich in nourishment nutrients.

There are more varieties of chestnuts tree which are distributed around the world: *Castanea crenata*, *Castanea mollissima* and *Castanea dentata* – in Asia, America and South Europe, but sweet chestnut (*Castanea sativa*) is characteristic of Europe. The variety of chestnuts also influences the biochemical and nutritional properties of the fruits [1, 2].

The European chestnut is native to the forests around the Black Sea. History has led us to believe that the name of chestnuts comes from the city that bears the name of Kastanis – located on the territory of Georgia now, on the eastern side of the Black Sea. Also the Persian word "kastana" and the Arabic word "kastanat" have their origin in the Sanskrit word "kashta" which means tree [3].

Due to the composition of chestnuts and the use in the diet of some population – these were also named as "bread tree" [4]. In history there are proves that Homer mentioned in his writings about chestnuts named them "marronia", and also

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Hippocrates, the Prophet Isaia, the historian Xenophon wrote about the benefits of chestnuts in the diet [5].

Chestnuts are considered valuable fruits being rich in carbohydrates, minerals and vitamins; good source of proteins – but free of gluten; and low in lipids. The composition of chestnuts is different depending on the species and on the biological part, but usually fresh chestnuts contain higher concentration of vitamins, roasted chestnuts are higher in protein and dietary (insoluble and total) fiber content, while boiled chestnuts have higher lipid and lower protein content compared to roasted chestnuts [6, 7]. Also, the roasted fruits represent a very good natural source for organic acids and phenolic compounds – which increase the biologic active properties for consumption.

The biochemical properties of the chestnuts are related to the chemical composition which it was demonstrated that is different depending also on the geographical characteristics, but also on chestnut types and cultivars. Turkey is one of the countries which annually produces about 50 000 tons of chestnuts - being a leader in the world.

The biochemical properties of these nutritional valuable fruits made the chestnuts to be used in the human and animal diet, to adjust the chemical composition of the basic food/feed ingredients. Chestnuts can be used in human and animal feeding plan as raw, roasted, fried, boiled or steamed or as flour – depending on the nutritional purpose [8].

2. Biochemical composition of chestnuts

Composition of chestnuts in carbohydrates, proteins, lipids, minerals, and vitamins depends on the species, on hybrid cultivars, on the type of chestnut (fresh, roast, boiled) and of course of the anatomical part of the chestnuts used in analysis. The composition of chestnuts in major nutrients is presented in Table 1 – taking in consideration three literature published data between 2006 and 2011 [4, 9, 10].

Table 2 presents the composition of chestnuts in some vitamins and fatty acids and table 3 presents some amino acid content of chestnuts [10].

Table 1. The composition of chestnuts in nutrients (ns – not specified)

Specification	Unit measure [UM]	Quantity variation according to		
		USDA (2011) [raw, peeled]	Ylldiz et al. (2009) [wild, raw, peeled]	Ertürk et al. (2006) [dry matter]
Carbohydrates (total)		*44.17*	*11.21*	*75.32 ÷ 86.31*
- total sugar		ns	ns	10.32 ÷ 22.79
- invert sugar		ns	ns	0.08 ÷ 1.25
- starch		ns	ns	54.45 ÷ 69.70
- sucrose	g/100g dry matter]	ns	ns	8.86 ÷ 21.28
- crude cellulose		ns	ns	3.58 ÷ 5.96
- crude fibers		ns	3.92	ns
Lipids		*1.25 (total)*	*2.24 (crude)*	*0.49 ÷ 2.01*
Proteins		*1.63 (total)*	*8.93 (crude)*	*4.88 ÷ 10.87*
Minerals content		*0.96 (as ash)*	*2.078 (as ash)*	ns
- iron (Fe)		0.94	0.381	0.4 ÷ 5.7
- copper (Cu)		0.418	0.012	0.6 ÷ 3.8
- manganese (Mn)		0.336	ns	0.7 ÷ 5.5
- sodium (Na)		2	ns	6 ÷ 40
- zinc (Zn)	[mg/100g dry matter]	0.49	ns	1.8 ÷ 9.1
- calcium (Ca)		19	ns	43 ÷ 230
- magnesium (Mg)		30	ns	70 ÷ 160
- phosphorus (P)		38	ns	107 ÷ 191
- potassium (K)		484	ns	761 ÷ 1271
Moisture	g/100g dry matter]	*52*	*54.84*	ns
Dry matter		*48*	*45.16*	ns

* Note: ns–not specified

Table 2. Vitamins and fatty acids presented in chestnuts

Specification	Unit measure [UM]	Quantity variation [raw, peeled]
Vitamins		
- acid ascorbic (total vitamin C)		40.2
- thiamine (vitamin B1)		0.144
- riboflavin (vitamin B2)	[mg/100g]	0.016
- niacin (vitamin B3)		1.102
- pantothenic acid (vitamin B5)		0.476
- pyridoxine (vitamin B6)		0.352
- folate (total vitamin B9)	[microg/100g]	58
- retinols (vitamine A)	IU	26
Fatty acids		
- *total saturated*		*0.235*
- myristic acid (14:0)		0.005
- palmitic acid (16:0)		0.212
- stearic acid (18:0)		0.012
- *total monounsturated*	[g/100g]	*0.430*
- palmitoleic acid (16:1)		0.012
- oleic acid (18:1)		0.413
- gadoleic acid (20:1)		0.005
- *total polyunsaturated*		*0.493*
- linoleic acid (18:2)		0.440
- linolenic acid (18:3)		0.053

The most representative vitamins from chestnuts are hydro-soluble vitamins and very low quantities of lipid-soluble vitamins (γ-tocopherol) due to the very low quantity of lipids presented in chestnut fruits. Also, important natural carotenoids (as xanthophylls) like lutein and lutein esterified with fatty acids were found in significant quantities in chestnuts which could be a valuable ingredient of feed formulas [11]. Even if low concentration of lipids characterized these fruits, the lipid content is represented by biological valuable fatty acids – especially monounsaturated fatty acids and polyunsaturated fatty acids like linoleic and linolenic acids – which are essential fatty acids for animals and humans.

Table 3. Amino acid s presented in chestnuts

Specification	Unit measure [UM]	Quantity variation [raw, peeled]
Amino acids		
- tryptophan		0.018
- threonine		0.058
- isoleucine		0.064
- leucine		0.096
- lysine		0.096
- methionine		0.038
- cysteine		0.052
- phenylalanine		0.069
- tyrosine	[g/100g]	0.045
- valine		0.091
- arginine		0.116
- histidine		0.045
- alanine		0.109
- aspartic acid		0.281
- glutamic acid		0.210
- glycine		0.084
- proline		0.086
- serine		0.081

In an experimental study, Ertürk and his collaborators in 2006 made a complex analysis and evaluated the composition of chestnuts depending on cultivars. Thus, the carbohydrates, proteins, lipids, and minerals varied between chestnuts cultivars [4].
According to the nutritional characterization of chestnuts by USDA the energy of 100g edible raw, peeled chestnuts is about 196Kcal (820kJ), and for fresh fruit Barreira and his collaborators reported an energy of 195Kcal/100g [10, 12].

3. Chestnuts, active principles and feeding plan

Lately, the chestnuts are more and more used in the preparation of different feeding plan, especially due to its nutritional quality is given by the composition in carbohydrates - starch (50 to 60%) and dietary fibers (4 to 10%), essential amino acids (rage between 4 to 7%), lipids (2 to 4%), and also vitamins (especially B vitamins), minerals and compounds with antioxidants properties [11, 13].
Chestnuts are very important ingredients for people with celiac problems being free of gluten.
Ribeiro characterized the chestnuts composition in some organic acids such as ascorbic acid, oxalic acid, citric acid, cis-aconitic acid, malic acid, fumaric acid, quinic acid [14]. Ascorbic acid is a very good antioxidant and protects the organism of oxidative processes which can lead to free radicals formation. The oxalic, citric, malic, fumaric and cis-aconitic acids are involved in the Krebs Cycle – which is an integrative metabolic pathway and a very important source of energy.
Chestnuts are also good sources of phenols with antioxidant protection and tannins, and the most efficient extraction solvent was when it was used acetone: water in a ratio of 70: 30 at 20^{o}C [14]. The phenols found in chestnut pericarp were represented by gallic, ellagic, protocatechuic, syringic, vanilic, ferulic, and acids, and from the total tannins the most significant quantities were ellagitannins such as acutissimin A and B, castalagin, vescalagin [11, 15]. The total flavonoid content – as catechin equivalent of seeds was 0.39% (vanillin assay), of brown shell was 2.78%, of new chestnut bark was 3.91%, old chestnut bark 0.76%, while the total condensed tannins (butanol assay) content of seeds was 0.88%, of brown seed shell 1.67%, of new chestnut bark 1.89%, and old chestnut bark 0.58% [16, 17].
Studies of the antioxidant properties of leaf extract demonstrated high activity compared to quercitin and tocopherols [18]. Also, the lyophilized extract of chestnuts presented high antioxidant activity on some reactive oxygen species (superoxide radical, peroxyl radical, singlet oxygen, hydrogen peroxide, and reactive nitrogen species) [19, 20].
Natural products are more and more used in nutrition – as ingredients of food for humans or feed for animals, and also in medicine – in prevention and treatment. Antioxidant properties of natural products are preferred compared to pharmaceutical products, and chestnut, fenugreek, black cumin, colostrum [21-26].

4. Chestnuts and traditional medicine

Ellagic acid is a natural carcinogenesis inhibitor present in chestnut fruits and barks. Concentration of ellagic acid registered variations between 0.71mg/g and 21.6mg/g dry matter in non-hydrolyzed samples and between 2.83 mg/g and 18.4mg/g dry matter in hydrolyzed samples [27].
Experimental results demonstrated that chestnuts extract – due to the presence of xylans, 4-o-methylglucuronoxylan and homoxylan compounds – inhibits the proliferation, migration and invasion of human epidermoid carcinoma cells [28].
Tested topical application of chestnut extract formulation with glycerin showed very good antioxidant activity and prevention of skin photoaging and oxidative-stress-mediated diseases [29].
A dietary supplement based on chestnut wood and *Saccharomyces boulardii* was successfully tested on guinea pig for spasmolytic effect of ileum and proximal colon. So, tannins from chestnut and S. *boulardii* could be used on treatment of diarrhea, having also antibacterial, antispasmodic and antiviral properties [30].
Leaves tea, infusions, or bark infusions were used with very good results in cough and diarrhea, as expectorant, tonic, astringent, anti-inflammatory, rheumatism, back pain, muscle and joints stiff and contractions. Also, leaves infusions were successfully used in homeopathic therapy of fatigue and depression [8].
Oil extracts from *Castanea sativa* Mill. bark has good medicinal activity, being rich in some phenols and polyphenols, tannins, lipid-soluble vitamins, mono- and polyunsaturated fatty acids and esters [31].

Pieroni and Price cited a traditional recipe of chestnuts boiled in red wine as traditional remedies used by independent populations for anti-inflammatory pain, digestive and respiratory problems and for joints and muscle pain [5].

4. Conclusions

Chestnuts are fruit of *Castanea* sativa Mill. tree, spread around the world, being known since ancient. Fruits are rich in carbohydrates, good sources of essential amino acids and high valuable biologic activity proteins, low quantity but important unsaturated fatty acids, good source of hydro-soluble vitamins, dietary fibers, poly-phenols and tannins. Chestnuts could be used in the food and feeding plan raw, boiled, and roasted, as flour or extracts which increase the nutritive value of the meal. Also good results were reported by different authors after their experimental studies which showed very good results in prevention or treatment of different medical problems.

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