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Review

Brazil nuts: Nutritional composition, health benefits and safety aspects

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ABSTRACT

Brazil nuts are among the richest selenium food sources, and studies have considered this Amazonian nut as an alternative for selenium supplementation. Besides selenium, Brazil nuts present relevant content of other micronutrients such as magnesium, copper, and zinc. The nutritional composition of nuts, also characterized by adequate fatty acid profile and high content of protein and bioactive compounds, has many health benefits. In the present review, we examine the nutritional composition of Brazil nuts, comparing it with other nuts, and describe the relevance of possible contaminants and metal toxicants observed in this nut for human health. Furthermore, we report different trials available in the literature, which demonstrate positive outcomes such as modulation of the lipid serum profile, enhancement of the antioxidant system and improvement of anti-inflammatory response. These effects have been assessed under different conditions, such as cognitive impairment, dyslipidemia, cancer, and renal failure.

1. Introduction

Nuts are energy-dense foods, mainly due to their high fat content. These foods are low in saturated fatty acids (SFAs) and high in unsaturated fatty acids (Venkatachalam & Sathe, 2006). In addition, nuts contain considerable amounts of fiber, folate, minerals, and antioxidant compounds (Kornsteiner, Wagner, & Elmadfa, 2006; Ros, Tapsell, & Sabate, 2010). Due to their nutritional composition, extensive research has been carried out on nuts and health outcomes, such as decreased risk of cardiovascular disease (Mozaffarian, 2016; Ros, 2015) and associated risk factors like oxidative stress and inflammation (Lopez-Uriarte, Bullo, Casas-Agustench, Babio, & Salas-Salvado, 2009), high cholesterol levels (Del Gobbo, Falk, Feldman, Lewis, & Mozaffarian, 2015; Ros, 2015) and diabetes (Asghari, Ghorbani, Mirmiran, & Azizi, 2017; Estruch et al., 2006). In light of the observed benefits of nut consumption on cardiovascular health, the US Food and Drug Administration (FDA) released a health claim recognizing that these foods may reduce the risk of heart disease (US Food and Drug Administration, 2003). Since then, nuts have been incorporated into guidelines for healthy eating in several countries (Kromhout, Spaaij, de Goede, & Weggemans, 2016; National Health and Medical Research Council, 2013; US Dietary Guidelines Advisory Committee, 2015).

Tree nuts are defined as dry fruits with one seed in which the ovary wall becomes hard at maturity. Besides Brazil nuts (*Bertholletia excelsa*), other popular tree nuts are almonds (*Prunus amigdalis*), walnuts (*Juglans regia*), pistachios (*Pistachia vera*), cashews (*Anacardium occidentale*), and macadamias (*Macadamia integrifolia*). Peanuts (*Arachis hypogea*), although botanically classified as groundnuts or legumes, have a similar nutrient profile to tree nuts, and thus are usually included in this group (Ros, 2010). The most frequently studied nuts are almonds, hazelnuts, walnuts, pistachios, macadamias, and cashews; comparatively few studies have assessed the health effects of Brazil nuts (*Bertholletia excelsa*). This nut is considered the main selenium food source and has been used as a strategy to supply this micronutrient in a selenium deficient diet (Thomson, Chisholm, McLachlan, & Campbell, 2008). Selenium is an essential micronutrient with antioxidant capacity that aids in different physiological processes such as immune system modulation, heavy metal and xenobiotic detoxification, and thyroid hormone regulation (Roman, Jitaru, & Barbante, 2014). Such roles have associated selenium with health benefits, for instance decreased risk of cancer (Meplan & Hesketh, 2014) and neurodegenerative diseases (Cardoso, Roberts, Bush, & Hare, 2015) and modulation of the thyroid function (de Farias et al., 2015; Kohrle, 2015).

The present review examines the nutritional composition of Brazil nut as well as the possible contaminants observed in this nut, and it reports on clinical evidence supporting the health benefits of Brazil nut consumption.

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2. Production

Brazil nut (*Bertholletia excelsa*, H.B.K.) is an Amazonian native species, which is part of the Lecythidaceae family. In botanical terms, the edible Brazil nuts are the seeds of a fruit that takes ~14 months to mature and has a hard and woody shell, weighs up to two kilograms and contains eight to 24 triangular seeds that are up to 2 cm wide and 5 cm long.

Brazil nuts are harvested by forest-based pickers who are usually local people, and the commercialization of this nut provides one of the major sources of income for many Amazonian indigenous and riverine communities (Ribeiro et al., 2014). Brazil nut production does not require the chemical products that are used to control pests and weeds, and thus it is considered organic. Brazil nut trees are colossal; they may grow up to 60 m high and 100–180 cm in diameter and are usually found in groves of between 50 and 100 individuals, known as *castanhais* (Portuguese), *manchales* or *castañales* (Spanish) (Rockwell et al., 2015). The groves occupy over 320 million ha distributed among Brazil, Bolivia, and Peru. Although Brazil has the largest area, Bolivia is currently the leading producer of Brazil nuts worldwide (41.6% of the total production), followed by Brazil (35.4%) and Peru. Recently countries in West Africa have become more noticeable due to Brazil nut production, although they still represent a small percentage of the global market (IndexBox, 2016).

3. Nutritional composition of Brazil nut

3.1. Macronutrients

Nuts in general have high fat and protein content, which contributes for high energy density. However, macronutrients profile leads to high satiety levels (Tan & Mattes, 2013; Zaveri & Drummond, 2009), and thus nuts intake is not associated with body weight increase (Flores-Mateo, Rojas-Rueda, Basora, Ros, & Salas-Salvado, 2013; Shang et al., 2016). Brazil nuts have ~2928 kJ 100 g^{-1} (700 kcal 100 g^{-1}) and present lower carbohydrate content than other nuts. Brazil nuts present similar fiber content as walnuts (7.7 g 100 g^{-1} and 7.2 g 100 g^{-1}, respectively), but smaller compared with almonds (11.5 g 100 g^{-1}) and pistachio (13.1 g 100 g^{-1}) (Table 1). Non-bioaccessible material from nuts, for instance polymerized polyphenols and polysaccharides, are believed to play prebiotic role. However, characterization of these compounds in Brazil nuts remains to be performed (Lamuel-Raventos & Onge, 2017).

Brazil nuts present lower protein content than peanuts, almonds, and cashews and higher protein:fat ratio (1:4) when compared with these nuts. This ratio in Brazil nuts is similar to walnuts and lower than in macadamias (1:8), which present the lowest protein content. Protein intake from plant foods as nuts, legumes, and grains was associated with decreased risk of metabolic syndrome (Shang et al., 2016) and type 2 diabetes (Malik, Li, Tobias, Pan, & Hu, 2016), which corroborates with positive health outcomes resulted from nuts intake. Table 1 shows the average composition of different nuts in macronutrients.

Table 2
Fatty acid composition in Brazil nut.
Adapted from Colpo et al., 2014.

Fatty acid	g 100 g^{-1} of total lipid	mg 5 g^{-1} [a]
C14:0	0.07	2.0
C16:0	16.74	544.0
C16:1	0.43	14.0
C17:0	0.14	4.6
C18:0	9.97	324.0
C18:1n9	28.52	926.9
C18:2n6	36.04	1171.3
C20:0	0.17	5.25
C20:1n9	0.09	2.92
C18:3n3	0.11	3.57

[a] Average Brazil nut weight.

Nuts are good sources of lipids and are considered beneficial for health due the high content of monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) and low concentration of SFAs (Ros & Mataix, 2006; Yang, 2009). Brazil nuts contain on average 15% of SFAs – a higher concentration than other nuts such as macadamia, peanuts, cashews, walnuts, pistachios, and almonds – 25% of MUFAs and 21% of PUFAs. Importantly, the α-linolenic acid (omega-3 fatty acid) contributes to 7% of total fats (Yang, 2009). The PUFAs content in Brazil nuts is similar to other nuts except for walnuts, which stand out when compared to all nuts (Universidade Estadual de Campinas, 2011; Universidade de São Paulo, 1998; Ros, 2010). Table 2 shows the fatty acid composition in Brazil nuts.

3.2. Micronutrients

Nuts contain a wide range of trace elements in significant amounts; their effects are related to health benefits and can contribute to the prevention of nutritional deficiencies (Table 3). Like cashews, Brazil nuts have higher concentrations of magnesium, copper, and zinc when compared with other nuts, although they have low concentration of iron (~2.5 mg 100 g^{-1}). The content of these micronutrients may vary according to climate and soil characteristics, such as fertilization, which influence nutrients uptake levels by the plant (de Lima & de Souza, 2014; Silva, Ascheri, & Souza, 2010). Studies have associated nuts intake with better nutrient adequacy and higher diet quality. Consumers of tree nuts have more favourable intake of vitamins A and C, folate, calcium, iron, magnesium, and zinc (O'Neil, Keast, Nicklas, & Fulgoni, 2012; O'Neil, Nicklas, & Fulgoni, 2015). Indeed, food pattern modeling used to assess the nutritional impact of replacing between-meal snacks with tree nuts revealed that the replacement of solid snacks with tree nuts decreases empty calories, promotes more favourable fat profile

Table 1
Energy density and macronutrient contents of selected nuts.

Nuts	Energy (kJ 100 g^{-1})		Energy (kcal 100 g^{-1})		Protein (g 100 g^{-1})		Carbohydrate (g 100 g^{-1})		Lipid (g 100 g^{-1})		Fiber (g 100 g^{-1})	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Brazil nut[a,c,d,e]	2901.8	2759.1–2992.7	693.10	659.0–714.8	15.52	14.32–16.2	12.36	10.9–15.9	66.16	64.9–67.3	7.7	7.5–7.9
Cashew nut[a,b,c]	2397.7	2315.3–2491.2	572.7	553.0–595.0	18.4	18.2–18.6	28.6	26.7–30.2	46.4	43.8–49.1	4.6	3.3–6.9
Peanut, roasted, salted[a,b,c]	2396.1	2277.6–2537.0	572.3	544.0–606.0	25.2	22.5–27.2	18.4	16.1–20.3	49.0	43.9–54.0	7.0	4.4–8.5
Pistachio[b,c]	2076.7	1817.1–2344.6	496.0	434.0–560.0	15.2	10.2–20.1	24.5	21.8–27.2	54.7	45.3–64.2	13.1	10.6–15.5
Macadamias[b,c]	3102.4	3006.1–3198.7	741.0	718.0–764.0	8.7	7.9–9.5	11.8	9.8–13.8	76.0	75.8–76.3	8.6	8.6
Almond, roasted, salted[a,b,c]	2477.3	2424.2–2574.9	591.7	579.0–615.0	20.8	18.6–22.6	24.6	21.6–29.5	51.3	47.3–56.7	11.5	10.5–12.5
Walnuts[a,c]	2643.9	2595.8–2692.1	631.5	620.0–643.0	14.1	14.0–14.2	18.1	17.9–18.4	60.1	59.4–60.7	7.2	7.1–7.2

Data are compiled from: [a]Universidade Estadual de Campinas, 2011; [b]Universidade de São Paulo, 1998; [c]USDA, 2015; [d]Rocha et al., 2014; [e]Cardoso et al., 2016.