Recent analysis of the composition of Brazil nut *Bertholletia excelsa*

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An in-depth analysis of the composition of Brazil nuts revealed that the nutritional value of this product is not solely due to its high lipid content, including linoleic acid—an unsaturated fatty acid. This nut also has a substantial mineral content, especially magnesium and phosphorus. Its high selenium content, however, is its most valuable feature, indicating that it could become a “new nutraceutical product”.

Atmospheric drying of thin nut layers. Lima, Peru.
Photo D. Pioch.

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RÉSUMÉ

ANALYSES RÉCENTES DE LA COMPOSITION DE LA NOIX DU BRÉSIL *BERTHOLLETIA EXCELSA*

La noix du Brésil, *Bertholletia excelsa,* a une teneur importante en biomolécules que nous avons dosées finement. Son huile, ses protéines et ses minéraux ont été analysés en détail. La composition en acides gras, stérols, tocophérols, phospholipides de l'huile est précisée. Le tourteau résultant de l'extraction de l'huile est particulièrement riche en sélénium (126 ppm) qui est connu pour ses capacités anti-oxydantes et anti-radicalaires. Le facteur de conversion azote/protéine a été recalculé à 6,97, en tenant compte de la composition en acides aminés des protéines. La teneur élevée en sélénium de la noix du Brésil et de ses dérivés fait de ces produits une base pour la création d'aliments à propriétés anti-radicalaires.

Mots-clés : noix du Brésil, huile, protéine, acide gras essentiel, stérol, sélénium.

ABSTRACT

RECENT ANALYSIS OF THE COMPOSITION OF BRAZIL NUT *BERTHOLLETIA EXCELSA*

Brazil nut *Bertholletia excelsa* contains many biomolecules, which we analyzed in detail, especially the oil, protein and mineral contents. The fatty acid, sterol, tocopherol and phospholipid composition of the oil was determined. The cake resulting from oil extraction is particularly rich in selenium (126 ppm), which is famous for its anti-oxidative and anti-radicalizing capacities. The nitrogen/protein conversion factor was recomputed at 6.97 according to the protein amino-acid composition. The high selenium contents of Brazil nut and derivative products could be utilized as a basis for novel anti-radicalizing healthy foods.

Keywords: Brazil nut, oil, protein, fatty acid, sterol, selenium.

RESUMEN

ANÁLISIS RECIENTES DE LA COMPOSICIÓN DE LA NUEZ DE BRASIL *BERTHOLLETIA EXCELSA*

La nuez de Brasil, *Bertholletia excelsa*, tiene un contenido importante de biomoléculas que dosificamos finamente. Se analizó detalladamente su aceite, proteínas y minerales. Se proporciona la composición de ácidos grasos, esteroles, tocoferoles, y fosfolípidos del aceite. La torta que se obtiene tras extracción de aceite es especialmente rica en selenio (126 ppm), conocido por sus capacidades antioxidantes y antirradicalarias. El factor de conversión nitrógeno/proteína se recalculó en 6,97, teniendo en cuenta la composición de aminoácidos de las proteínas. El alto contenido de selenio de la nuez de Brasil y sus derivados hace de estos productos una base para la creación de alimentos con propiedades antirradicalarias.

Palabras clave: nuez de Brasil, aceite, proteína, ácido graso, esterol, selenio.

Whole Brazil nut *Bertholletia excelsa.*

Brazil nut producing tree.

Introduction

Brazil nuts, or *Castana*, are produced by a large tropical forest tree (*Bertholletia excelsa* and *B. nobilis*), Lecythidacea family, that grows throughout the Amazon Basin. Brazil nut is an angular nut with a very hard hull. The almond is very white, with dark brown tegument. A tree may produce more than 150 kg of nuts/year. The species is propagated naturally. The fruit is mature in November but only harvested from wild trees in January. Amazonians prefer to wait until the nuts fall because it seems that the quality of the almond is better then. As the trees are very high, gathering is always dangerous since the fruits weigh approximately 3 kg.

Bolivia, Brazil and Peru produce all of the 20 000 t of Brazil nuts sold on the world market. Bolivia is the top producer, with 10 000 t, and the other half of the production is shared between Peru 2 200 t and Brazil 7 800 t (Collinson *et al.*, 2000). Bolivia is also the top exporting country, accounting for 75% of the sales. Brazil nuts are generally marketed in their hulls or peeled and consumed raw, roasted, salted, mixed with dairy ice creams, in chocolates, pastry and confectionery products. They are an important source of income for local people.

Because of its high selenium content, i.e. up to 30 µg/g, this nut is considered to be a beneficial anti-radicalizing or anti-cancer product. Brazil nuts compete with many other nuts on the world market (Table I). Hazelnuts, groundnuts, almonds and cashew nuts dominate the market, followed by coconut, walnuts and pecan nuts. Brazil nut is thus a minor player on the world market, accounting for only 1.62% of the overall trade volume.

Although there is a considerable amount of descriptive literature available on the Brazil nut tree and fruit, little has been written about the biochemical composition of the nut and its nutritional benefits.

The goal of this study was to gain further insight into the biochemical composition of Brazil nuts, particularly concerning minerals, oil, proteins and carbohydrate fractions.

Manual sorting of Brazil nuts for pastry-confectionary uses. Lima, Peru.
Photo D. Pioch.

Oil production. Handmade hydraulic press (batch pressing). Laranjal do Jari, Brazil.
Photo D. Pioch.

Three categories of Brazil nuts (left to right): whole-partially dehulled, whole-dehulled (the only category eligible for export), chipped or broken (for oil production). Lima, Peru.
Photo D. Pioch.

Oil production. Loading a hydraulic press (batch pressing). Laranjal do Jari, Brazil. Photo D. Pioch.

Table I.
Nuts on the world market.

Nuts	Principal producing countries	Volume (t)
Hazelnut	Turkey, Italy	136 000
Peanuts	United States, India, Argentina	731 000
Almond	United States, Spain	123 000
Cashew nut	India, Brazil	59 000
Walnut	United States, China	61 000
Coconut	Philippines, Sri Lanka	106 000
Brazil nut	Brazil, Bolivia, Peru	20 000

Sources: Dominguez, 1991;
Man Producten (Rotterdam, Netherlands), 1999.

Table II.
Summary chart of the composition of the defatted Brazil nut cake compared with that of the whole Brazil nut (Peroxide Index in milliequivalent active oxygen/kg of oil, acidity in g of oleic acid/100g of oil. The values are given on a dry matter basis).

Components	Brazil nut cake	Whole Brazil nut (*calculated)
Ash	7.0	2.0*
Selenium (ppm)	126	40*
Oil	5.0	72.5
Unsaturated fatty acids (% of oil)	75.6	75.6
Sterols (mg/g)	1.4	
Tocopherols (mg/g)	0.2	
Phospholipids (µg P/g oil)	377	
Peroxyde Index	9.8	
Acidity	0.6	
Density	0.975	
Unsaponifiable (% of oil)	0.7	
Protein	67.9	19.7*
Fibers	13.0	3.8*
Soluble sugars	7.1	2.1*
Glucose	0.2	
Fructose	1.0	
Sucrose	5.9	

Results and Discussion

Brazil nuts were collected in the northeastern part of the Amazon Basin. They were provided by the company JB Agroconcept (France). All of the analyses were carried out in 3 months. Nut samples were stored in a cabinet at room temperature (20-25°C) from the beginning of the analysis in April 2000. Some analyses were conducted on whole nuts, others on defatted cake.

Water content and mineral composition

At an a_w (water activity) of 0.5, at 23°C, the water content of Brazil nuts is 2.75 ± 0.2%, which is a common value for an oily nut. Sorption isotherms conducted at CIRAD in 1998 showed that the critical water content is 6% (W/W wet base) when the nut is at equilibrium under 65% relative humidity and 20°C environmental conditions. It will thus be microbiologically stable during conservation if packed or stored in an environment at low relative humidity (< 65%).

Ash determination of cake containing 5% lipids revealed a high mineral content of 7.0 ± 0.1%. The calcium content is low, i.e. around 600 mg/100 g, but the magnesium and phosphorous contents are very high, i.e. respectively 1 400 and 2 400 mg/100 g of cake.

The selenium content varies substantially between regions and also among nuts from the same tree. The nuts analyzed in this study showed contents ranging from 0.4 to 12.7 mg/100 g. For the highest concentration analyzed, this means that only 0.5 g of nut covers the recommended daily mineral intake.

Oil cake designated for livestock feed. Riberalta, Bolivia.
Photo D. Pioch.

Carbohydrates

The total sugar content (glucose + fructose + sucrose) of Brazil nut defatted cake was 7.1%. By taking into account the water and oil contents, the sugar content of whole nuts was 2.1% (Table II). This content is equivalent to that of pecan nuts (2.1%), macadamia (4.2%), almond (3.6%) (Fourie, Basson, 1990), but lower than that of sunflower cake (6.3%) (Vioque *et al.*, 2000).

Elements and nutritional value

Fatty acids

The distinction between saturated, mono-unsaturated or poly-unsaturated corresponds to the presence of zero, one or more double bonds or "unsaturations" in the fatty acid (FA) structure. In nature, all fatty substances contain the three types of FA in variable amounts. A saturated lipid mainly but not exclusively consists of saturated FA. Certain fatty acids are known to be "essential", because the human body cannot synthesize them alone. It must thus obtain them from food or supplements. These poly-unsaturated FA are involved in important processes such as the constitution and integrity of cellular membranes, operations of the cardiovascular system, brain and hormonal system, as well as regulation of inflammatory processes.
Essential FA belong to omega-3 and omega-6 families. In the ω-3 family, alpha linolenic acid (C18:3) is essential. It should represent about 1% of ingested energy, i.e. 1-2 g/day. In the ω-6 family, linoleic acid (C18:2) is essential. It should represent 4-16 g/day, depending on the authors.

Sterols

Sterols are naturally occurring substances found in plants. Plant sterols, called phytosterols, which occur in oils may reduce blood cholesterol levels. Phytosterols are similar in structure to cholesterol but are not produced by the human body. Phytosterols can reduce total cholesterol and LDL cholesterol. Reducing total and LDL could contribute to the prevention of cardiovascular disease.

Tocopherols

Four tocopherols and four tocotrienols (α, β, γ, δ) are classified with vitamin E. They are minor but predominant components in cellular membranes. Their primary task is to prevent damage caused by free radicals on tissues by giving a hydrogen atom to a peroxyde radical resulting from unsaturated lipid degradation. Dietary vitamin E supplementation is associated with a reduction in cardiovascular diseases.
The basic structure of tocopherols includes two cycles and a C16 side chain. In tocopherols, this side chain is saturated and it contains three double bonds in tocotrienols. Anti-oxidant activity decreases from α to δ tocopherols. Tocotrienols are the most effective anti-oxidants because of their unsaturation. The daily recommended intake is 3-15 mg.

Amino acids

Amino acids (AA) are the molecular units that make proteins. All of them have a COOH group and an amino or amido group. All proteins have various compositions of twenty specific naturally occurring amino acids. Among them, eight are considered critical because they are not synthesized by humans. The daily recommended protein intake is around 0.7 g/kg body mass. A quality index has been established by FAO/WHO. It is based on the ability of a protein to supply essential AA relative to estimated human needs. Reference profiles (mg AA/g protein) have been proposed to define the needs of each AA. These needs are periodically revised. For instance, in 1991, FAO/WHO proposed: lysine, 58; sulfured amino acids, 25; threonin, 34; tryptophane, 11.

Minerals

Minerals are essential to life. They represent 4% of the body mass.
The recommended daily intake of calcium is 600-1 000 mg. It is one of the major constituents of bones, but it also intervenes in blood coagulation, body and cardiac muscle contraction.
Magnesium is involved in numerous cell biology phenomena. It should be ingested at a 1:2 ratio with calcium in order to be efficient. The recommended daily intake of magnesium is around 300 mg.
The recommended daily intake of phosphorus is around 1 000 mg. It is involved in the constitution of bones and teeth.

Selenium

Selenium belongs to the oligoelement category. The principal functions of selenium in the body were summarized by Dr. Clarke of Arizona University (http://www.selenium.arizona.edu/). Selenium is found in the active site of many enzymes such as thioredoxin reductase, which catalyzes oxidation/reduction reactions. Glutathion peroxidase, an enzyme that helps to prevent the oxidation process, needs selenium for its formation. Selenium seems to improve the immune system and its response to infections. There are indications that it supports the natural death of cells, which destroys infectious bacteria. P450 enzymes, which help to detoxify some pro-cancerous substances, can be induced by selenium. Selenium inhibits the action of prostaglandins which are responsible for inflammatory reactions in the body. Male fertility can be increased by selenium, which improves spermatozoid mobility. At high amounts, selenium can decrease the growth rate of the tumoral cells.
The United States National Research Council suggests a human requirement of approximately 60-120 µg Se/day with toxicity occurring after prolonged ingestion of 2 400-3 000 µg Se/day (Food and Nutrition Board, 1976). Few toxicity cases have been related to selenium in food, although in Brazil nut producing areas, because of the high nut consumption rates, selenium intakes can sometimes be much higher than the DRI.

Table III.
Amino acid composition (%) of *Bertholletia excelsa* protein compared with Cambodia nut defatted flour (Bandelier *et al.*, 2002).

Amino acids	Brazil nut (%)	Cambodia nut (%)
Aspartic acid	8.4	8.5
Glutamic acid	17.7	19.4
Serine	5.7	6.8
Glycine	8.8	8.4
Histidine	1.8	1.9
Arginine	11.8	6.9
Threonine	4.3	5.3
Alanine	6.2	6.9
Proline	5.0	4.9
Tyrosine	2.4	2.8
Valine	6.3	5.4
Methionine	2.4	1.4
Cysteine	1.0	1.7
Isoleucine	4.0	4.4
Leucine	7.9	7.2
Phenylalanine	3.8	3.2
Lysine	2.5	4.9

equivalent to that of pecan nut (2.0%) and twofold lower than that of macadamia (4.1%) and almond (3.4 %). Other sugars are present at a lower level: the fructose (0.02%) and glucose (0.06%) contents of Brazil nut are in the same range as in pecan, macadamia and almond.

The total fiber content of the cake is 13.0%, i.e. 3.8% for whole nuts. These values are similar to those of Grenoble walnut (6.7%) (dietobio.com, 2003) and those reported by Favier *et al.* (1995), means of 4-8% for Brazil nuts. Bandelier *et al.* (2002) noted 7.5% fiber contents in the whole Cambodia nuts.

Protein fraction

In order to improve the calculation of protein contents in Brazil nut, we calculated the nitrogen/protein conversion factor by taking the amino-acid analysis results into account. The nitrogen content obtained by total carbonization of the defatted cake was 9.74%. The conversion factor thus obtained was 6.97 (Chunhieng *et al.*, 2003). The defatted cake contained 97.47 mg/g of nitrogen, which means that there was a protein content of 67.9% in the equivalent to that of Grenoble walnut (15.2%) (Dietobio, 2003) and almond (19%) (almondsarein.com, 2003).

The amino-acid composition of *Bertholletia excelsa* proteins is similar to that of Cambodia nuts (Bandelier *et al.*, 2002) (Table III). The lysine content is low (3.3%) and the sulfur amino acid content as methionine (6.3 %) and cystine (2.2 %) are high.

Lipid fraction

The oil content of fresh Brazil nut is 72.5%, which is much higher than that of almond (53%) and Grenoble walnut (55%). Brazil nut oil was solid at –18°C and then reliquified at –10°C, after 1.5 min of exposure at room temperature, showing a high level of unsaturation.

The fatty acid composition analysis confirmed this point, as 75.6% of the oil consists of mono- and poly-unsaturated fatty acids (Table IV). This is lower than olive (83.3%), almond (87.0%) and walnut (83.0%) oils. The sum of unsaturated fatty acids C18:1 (39.3%) and C18:2 (36.1%) is close to 75%. The linoleic acid content (18:2%) is very high in comparison to almond or olive oils. Linolenic acid is absent. The high unsaturation of fatty acids and the high amount of linoleic acid give this oil some interesting dietary health properties.

Brazil nut oil is rich in β-tocopherol (88.3% of total tocopherols) (Chunhieng, 2003), whereas olive oil (Kamal-Eldin, Andersson, 1997) is characterized by a high α-tocopherol content (84.2%).

Brazil nut oil has a similar sterol composition as olive oil (Jiménez de Blas, Gonzalez, 1996). Its β-sitosterol content (76% of total sterols) is comparable to that of olive oil (81%) and almond oil (77%) (Itoh *et al.*, 1974). A small quantity of cholesterol is present (2%) in Brazil nut oil, as in other comparable vegetable oils.

Table IV.
Fatty acid composition (%) of Brazil nut oil determined by gas-liquid chromatography in comparison with almond, walnut, and olive oils.

Fatty acids	Almond (%)	Walnut (%)	Olive (%)	Brazil nut (%)
C 12:0				0.2
C 14:0				0.2
C 16:0	9	9	13.9	13.0
C 16:1			1.5	0.2
C 18:0		3	2.8	11.0
C 18:1	73	19	71.8	39.3
C 18:2	14	64	9.0	36.1
C 18:3			1.0	
Unsaturated FFA[1]	87.0	83.0	83.3	75.6

[1] FFA: free fatty acids.

Conclusion

Brazil nut can be classified as an oilseed because of its very high oil content. Its high linoleic acid content can contribute to the equilibrium of essential fatty acid. It is also rich in minerals, and could provide significant amounts of magnesium and phosphorus.

However, the main benefit of Brazil nut is the particularly high selenium level (126 ppm of selenium in the cake). This characteristic was studied by Chunhieng *et al.* (2003) and the results indicated that this nut could be of major interest for the development of a new nutraceutical product. A standardized defatted cake powder could be used as a natural selenium source in nutraceutic preparations. The extracted oil could also have potential as an exotic speciality table oil.

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Storing oil in 200 l barrels, in an inert atmosphere, prior to export. Lima, Peru.
Photo D. Pioch.

Screw press (continuous) oil cake output. Lima, Peru.
Photo D. Pioch.

Loading a preheating module prior to a continuous oil pressing operation. Lima, Peru.
Photo D. Pioch.

Screw press (continuous) with oil output. Lima, Peru.
Photo D. Pioch.

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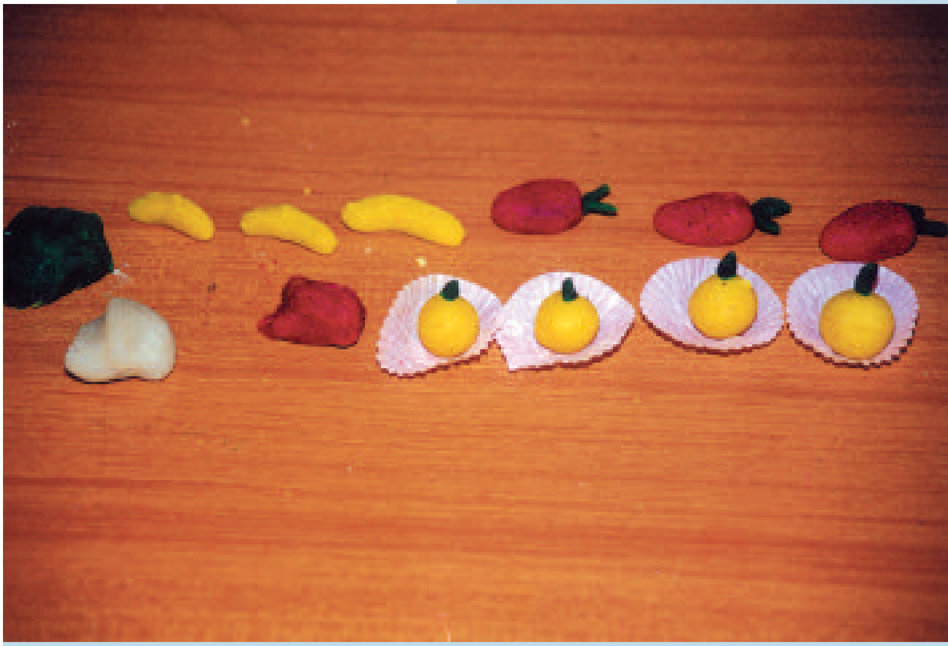
Brazil nut biscuits. Iratapuru, Brazil.
Photo D. Pioch.



Brazil nut paste, a Peruvian specialty. Lima, Peru.
Photo D. Pioch.