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Nutritional quality and protein value of exotic almonds and nut from the Brazilian Savanna compared to peanut

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ABSTRACT

The aim of this study was to determine the nutritional quality and protein value of the baru almond, pequi almond, and cerrado cashew nut compared to the peanut. We determined the proximate chemical composition, mineral content, and amino acid profile. A biological assay was carried out to assess the protein value, by net protein ratio (NPR), relative net protein ratio (RNPR), and protein digestibility-corrected amino acid score (PDCAAS) indexes. We found that the exotic almonds and the nut are rich in proteins (22.7–29.9 g/100 g), lipids (41.9–50.0 g/100 g), fibres (baru and pequi almonds, around 10.0 g/100 g), iron and zinc (4.3–7.4 mg/100 g). Baru almond's protein did not show deficiency in essential amino acids and lysine was the first limiting amino acid in the proteins of the pequi almond and cerrado cashew nut. The baru almond showed a RNPR of 86%, similar to that of the cerrado cashew nut (78%), but higher than that of the peanut (72%) and of the pequi almond (54%). The PDCAAS value of the baru almond (91%) was the highest and cerrado cashew nut and peanut presented similar values of this index (82%), which were higher than that of the pequi almond (55%). The baru almond has the highest protein quality, but the cerrado cashew nut and peanut are sources of good quality protein, too. We recommend the inclusion of these exotic foods in healthy diets and in food industry, and the baru almond and cerrado cashew nut as sources of complementary protein.

1. Introduction

A true nut is a dry fruit often covered by a shell with thorns that protects the seed. The most popular nuts across the world are the Brazil nut, cashew nut, pistachio, walnut, macadamia, nut, and chestnut. In addition to the true nuts, there exist other seeds with similar morphological and sensory qualities but with a different botanical classification, such as the peanut (Judd, Campbell, Kellogg, Stevens, & Donoghue, 2002; Venkatachalan & Sathe, 2006).

Several tree species flourish in the native flora of the Cerrado region of central Brazil (Savanna). These include the 'baru' tree (*Dipteryx alata* Vog.), the 'pequi' tree (*Caryocar brasiliense* Camb.), and the 'caju-do-cerrado' tree (*Anacardium othonianum* Rizz.). All these 3 species give exotic-tasting fruits: the baru, pequi, and cerrado cashew, respectively.

The baru tree (Fabaceae family) produces fruits from August to October. The brown fruits contain a single edible oleaginous seed, commonly named almond (Fig. 1). The baru almond contains high levels of lipids (around 40%) and proteins (approximately 30%) with good digestibility and amino acid profile (Fernandes, Freitas, Czeder, & Naves, 2010). Moreover, the baru almond has a high content of minerals, particularly calcium, iron, magnesium, potassium, and zinc (Freitas & Naves, 2010; Takemoto, Okada, Garbelotti, Tavares, & Aued-Pimentel, 2001).

The pequi tree is common in the Cerrado regions (Savanna) and its fruit consists of a greenish or greenish-brown exocarpus or pericarpus, an external mesocarpus (white pulp), and an internal yellow-dark orange mesocarpus (the fruit's edible part). Furthermore, a thorny endocarpus protects the edible seed, also named almond (Melo Júnior, Carvalho, Póvoa, & Bearzoti, 2004) (Fig. 1). The energy value of almond is high (approximately 600 kcal/100 g), with considerably high lipid (about 50%) and protein contents (over 20%) (Lima, Silva, Trindade, Torres, & Mancini-Filho, 2007).

The 'cerrado cashew nut' is an important Brazilian cashew specie native from the Savanna biome of the Goiás state. The mature pseudo-fruit (fleshy peduncle) has a colour that varies from yellowish to bright red and is widely used in juices, sweets, and liqueurs. In turn, the true fruit or nut (weight 4–13 g) is rarely consumed, and its nutritional value is not yet known (Correia, Naves, Rocha, Chaves, & Borges, 2008) (Fig. 1).

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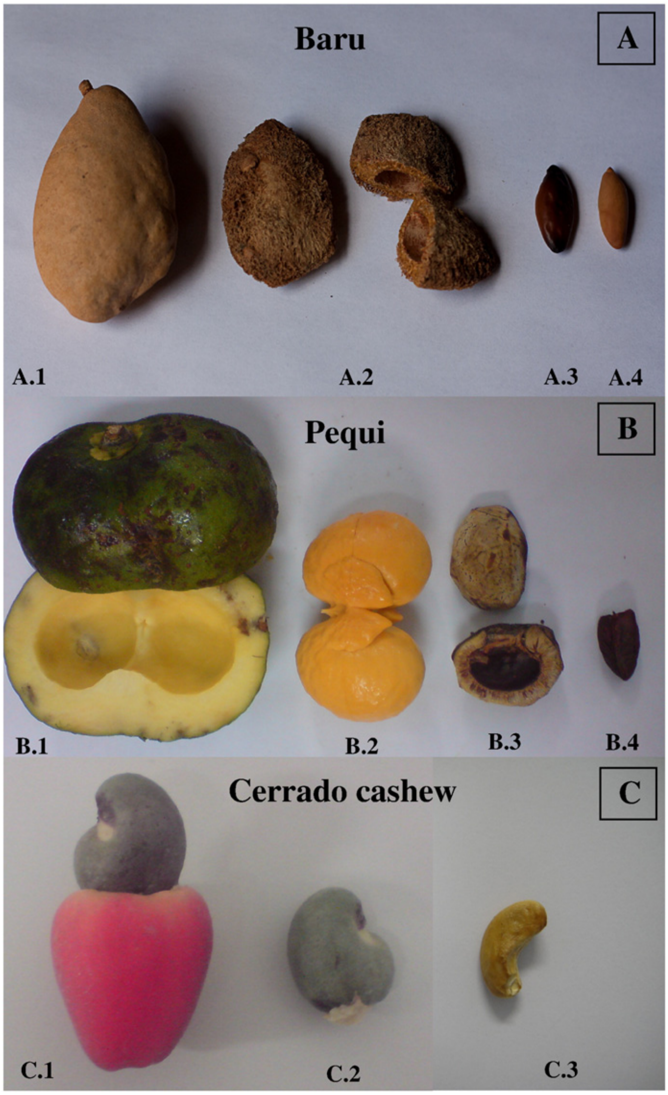

Fig. 1. Exotic almonds and nut from the Brazilian Savanna (fruits and almonds/nut). A: Baru fruit; A.1: Whole baru fruit (ripe); A.2: Woody endocarp; A.3: Baru edible seed, also called baru almond; A.4: baru edible seed without the dark brown peel (usual form of consumption). B: Pequi fruit; B.1: Pequi greenish-brown exocarpus and external mesocarpus (white pulp); B.2: Pequi internal mesocarpus (yellow pulp); B.3: Pequi thorny endocarpus (without the internal mesocarpus) containing the edible seed; B.4: Pequi edible seed, also called pequi almond. C: Cerrado cashew fruit; C.1: True fruit and ripe pseudo-fruit (fleshy peduncle); C.2: Cashew true fruit containing the cashew nut; C.3: Cerrado cashew nut.

The peanut (*Arachis hypogaea* L.), also known as groundnut, earthnut, monkeynut or ground bean, is the world's third most important source of vegetable protein, yet lysine-deficient (Fernandes et al., 2010; Singh & Singh, 1991; Venkatachalam & Sathe, 2006). The peanut has considerably high amounts of lipids and proteins, which are similar to those of the baru and pequi almonds (Fernandes et al., 2010; Lima et al., 2007; Venkatachalam & Sathe, 2006).

True nuts and edible seeds are widely consumed as sources of health-promoting substances and of functional or biological active compounds (Freitas & Naves, 2010; López-Uriarte, Bulló, Casas-Agustench, Babio, & Salas-Salvado, 2009). In addition to biological active compounds, these foods have high amounts of protein. However, few studies have determined the protein value of nuts and almonds, especially of the exotic ones. Therefore, research is necessary to generate comprehensive knowledge about the protein value of native almonds and nuts.

The protein value of food is usually determined by net protein ratio (NPR) and protein digestibility-corrected amino acid score (PDCAAS) indexes. NPR is a biological method that assesses the efficiency of protein utilisation by using growing rats (Pellett & Young, 1980). This method often underestimates the protein quality of plant foods, since growing rats require higher amounts of certain essential amino acids than humans. PDCAAS is a method recommended by FAO (1991) and IOM (2005) to evaluate the protein quality considering both essential amino acid profile (in comparison with the human requirement pattern) and protein digestibility. It has been previously shown that the PDCAAS values of foods are generally higher than those evaluated by biological indices. Thus, it is important to evaluate the protein quality by both methods — NPR, to establish the relative protein quality among different food sources, and PDCAAS, to estimate more reliably the protein value of food for human consumption (Friedman, 1996; Shaafsma, 2000).

The study of the protein and nutritive value of native fruits from the Savanna biome contributes to the sustainable use, conservation, and selection of the promising species as well as to the economic importance of these foods. Thus, the purpose of this study was to determine the nutritional quality and protein value of 2 native edible seeds (the baru and pequi almonds) and of cerrado cashew nut and to compare these values to those of the peanut, which is widely consumed worldwide.

2. Material and methods

2.1. Fruit collection

Baru and pequi fruits were collected from representative regions of their productivity in the Brazilian Savanna. The cerrado cashew fruit was collected in only one region (Northwest) of the Goiás state (Brazil) because this region had the highest productivity in the year of collection. Peanuts (variety HPS) were purchased from the local market of Goiânia, Goiás state, Brazil.

2.2. Sample preparation procedures

After maturation period, the pequi fruits were pulped and dried in an oven at 60 °C for 30 h. The baru and pequi almonds (Fig. 1) were extracted using a guillotine. The cerrado cashew nut (Fig. 1) was extracted manually, as follows: the fruit of the cerrado cashew was directly exposed to fire in a perforated steel container to remove the corrosive liquid of the cashew nut; subsequently, the cerrado cashew nut was decorticated using a stainless steel knife. The baru and pequi almonds and the cerrado cashew nut were roasted to inactivate the possible anti-nutritional factors (Togashi & Sgarbieri, 1994) and to investigate the nutritional quality of the almonds and of the nut as usually consumed. The baru almond and the peanuts were roasted at 140 °C for 30 min (Fernandes et al., 2010) and the pequi almond and cerrado cashew nut at 130 °C for 30 min (Rabêlo, Torres, Geraldine, & Silveira, 2008) in an electric oven. Thereafter, the almonds and the nut were milled with a blender and sieved through a 60-mesh for chemical analysis and for use in the experimental diets.

2.3. Chemical characterization of the exotic almonds and the nut

2.3.1. Chemical composition

The following chemical composition parameters were determined in triplicate: moisture (AOAC, 1990); nitrogen content by the micro-Kjeldahl method (AOAC, 1990) by using a conversion factor of 6.25 (FAO, 1970); total lipids by extraction with chloroform and methanol (Bligh & Dyer, 1959); ash at 550 °C (AOAC, 1990); and total dietary fibres (soluble and insoluble), according to the enzymatic-gravimetric technique (Prosky, Asp, Schweizer, Devries, & Furda, 1988). The carbohydrate content was estimated by subtracting from 100 the values obtained for moisture, protein, lipid, ash, and total dietary fibre

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contents. The energy value was estimated by using Atwater conversion factors of 4 kcal (proteins and carbohydrates), and 9 kcal (lipids) (Merril & Watt, 1973).

2.3.2. Minerals

Minerals (Ca, Fe, K, Mg, Na, P, and Zn) were characterised and quantified, in triplicate, by atomic absorption spectrophotometry (Perkin Elmer Analyst-200 spectrometer). Samples (30 g) were incinerated and then dissolved with concentrated hydrochloric acid (analytical grade). Specific instrumental parameters (lamp, wavelength, lamp current, and slit width) were used for each mineral (AOAC, 1990). Selenium was analysed by atomic absorption spectrophotometry (HITACHI®, model Z-5000, Tokyo) with generation of hydrides in a quartz tube.

2.3.3. Amino acid profile

The amino acid profile analysis of the exotic almonds and the nut were performed in duplicate. The quantification of amino acids (with the exception of tryptophan) was performed by acid hydrolysis of proteins and peptides (Moore, Spackman, & Stein, 1958). Tryptophan was quantified in samples treated by alkaline hydrolysis (Lucas & Sotelo, 1980). Then, samples were placed in an automatic amino acid analyser (Nicolas V, Protein Chemistry Centre, University of São Paulo, Ribeirão Preto, Brazil). After elution in the column and reaction with ninhydrin, the amino acids were quantified by a colorimetric assay.

The results of this analysis were used to estimate the amino acid score (AAS) by using the following formula (WHO, 2007): (mg of amino acid in 1 g of test protein/mg of amino acid in requirement pattern) × 100.

2.4. Evaluation of the protein value

2.4.1. Biological assay

The experiment was carried out with 42 weaned male Wistar rats (21–23 days old) from Bioagri Laboratories (Planaltina, Federal District, Brazil). The rats were randomly divided into 7 groups of 6 animals each, and kept in individual cages under standard environmental conditions (temperature 23 ± 2 °C, relative humidity 50–60%, 12/12 h light/dark cycle). All procedures with animals were conducted in accordance with the Guide for the Care and Use of Laboratory Animals (NRC, 1996) and were approved by the Research Ethics Committee of the Federal University of Goiás (Protocol no. 53/2008).

The animals were fed for 17 days (3 days of acclimatisation and 14 days of experiment) with experimental diets. The diets were formulated on the basis of AIN-93G formula (Reeves, Nielsen, & Fahey, 1993) with modification in the protein content (10%). The experimental groups were divided into 2 casein diets (casein diet with 7% lipids [reference group] and casein diet with 15% lipids [control group]), 4 experimental diets (baru almond, pequi almond, cerrado cashew nut, and peanut, with approximately 15% lipids), and a protein-free diet. The milled almond and nut used in the diets were not defatted in order to preserve their natural characteristics. The ingredients and chemical composition of these diets are shown in Table 1.

The body weight and food intake (food offered–food wasted) in all experimental groups were monitored on alternate days. Potable water was provided *ad libitum*. At the end of the experiment, the animals were weighed and euthanized with ethyl ether in a closed container.

2.4.2. Estimative of biological indexes

The protein values of the native fruits and of the peanut were estimated using the net protein ratio (NPR) and the protein digestibility-corrected amino acid score (PDCAAS) indexes. NPR and RNPR (relative NPR) were calculated as follows: NPR = [weight gain of test group (g) + weight loss of protein-free group (g)]/protein intake of test group (g); RNPR = [NPR test group/NPR reference group × 100] (Pellett & Young, 1980). True protein digestibility (%) was determined as recommended by the Food and Agriculture Organization (FAO) (FAO, 1991) for *in vivo* test. Faeces were marked and collected during the second week of the experiment, and ground for nitrogen analysis. The amount of nitrogen consumed by the animals (I), the amount of nitrogen excreted in the faeces of animals fed with a protein diet (F), and the amount of nitrogen excreted in the faeces of animals fed with a protein-free diet (endogenous nitrogen — Fk) were determined. True digestibility was calculated using the formula: $[I - (F - Fk)/I] \times 100$. PDCAAS was estimated as follows: [AAS of test protein (%) × true digestibility of test protein (%)]/100 (FAO, 1991).

2.5. Statistical analysis

The data are presented as mean ± standard deviation. Analysis of variance and Tukey's mean comparison test were used to compare the data about chemical composition and data from the biological assay. STATISTICA version 7.0 (StatSoft, Inc., Tulsa, OK, USA, 2004) was used for statistical analyses. Differences were considered significant when the P value was <0.05.

Table 1
Ingredients and chemical composition of diets used in the biological assay.

Component (g/100 g of diet)	Diet[a]						
	Reference	Control	Baru almond	Pequi almond	Cerrado cashew nut	Peanut	Protein-free
Casein	13.27	13.27	–	–	–	–	–
Baru almond	–	–	33.42	–	–	–	–
Pequi almond	–	–	–	33.73	–	–	–
Cerrado cashew nut	–	–	–	–	44.12	–	–
Peanut	–	–	–	–	–	33.79	–
L-Cystine	0.20	0.20	–	–	–	–	–
Soybean oil	6.58	14.58	–	–	–	–	7.00
Cellulose	5.00	5.00	0.52	4.26	3.37	2.30	5.00
Mineral mix	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Vitamin mix	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Choline bitartrate	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Corn starch	70.20	62.20	61.31	57.26	47.76	59.16	83.25
Protein (g/100 g)	10.39	10.67	9.24	9.94	9.93	10.95	0.45
Lipids (g/100 g)	6.70	14.89	14.36	17.24	21.31	15.60	6.94
Energy value (kcal/100 g)	412.50	452.50	452.00	459.10	485.40	458.20	–

Reference: casein with 7% lipids; control: casein with 15% lipids.
[a] Feed formulation according to the AIN-93G diet (Reeves et al., 1993), with reduction of protein levels to 10% (w/w).

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Table 2
Chemical composition and energy value of exotic almonds and nut compared to those of peanut.

Component (g/100 g)*	Exotic almonds and nut			Peanut
	Baru almond	Pequi almond	Cerrado cashew nut	
Moisture	3.49 ± 0.08[b,c]	4.97 ± 0.09[a]	3.16 ± 0.11[c]	3.53 ± 0.15[b]
Proteins (N × 6.25)	29.92 ± 0.37[a]	29.65 ± 0.55[a]	22.67 ± 0.20[b]	29.59 ± 0.05[a]
Total lipids	41.95 ± 0.44[d]	50.00 ± 0.66[a]	47.79 ± 0.31[b]	46.35 ± 0.26[c]
Carbohydrates	12.25	0.40	19.86	13.06
Total dietary fibres	9.21 ± 0.21[b]	10.44 ± 0.09[a]	3.92 ± 0.05[d]	5.20 ± 0.11[c]
Soluble fibres	2.03 ± 0.00[b]	3.62 ± 0.13[a]	1.17 ± 0.05[d]	1.36 ± 0.02[c]
Insoluble fibres	7.18 ± 0.21[a]	6.82 ± 0.21[b]	2.76 ± 0.05[d]	3.84 ± 0.09[c]
Ash	3.18 ± 0.01[b]	4.54 ± 0.02[a]	2.60 ± 0.01[c]	2.27 ± 0.01[d]
Energy value (kcal/100 g)	546.23	570.20	600.23	587.75

[a–d] Values marked with the same letter in the same row are not significantly different ($P > 0.05$ by Tukey's test).
* Data are mean ± standard deviation of 3 replicates, except carbohydrates, which were calculated by subtracting the values of the other components from 100.

3. Results and discussion

The chemical composition and the energy values of the exotic almonds and nut (baru almond, pequi almond, and cerrado cashew nut) and peanuts are shown in Table 2. We found that the baru almond, pequi almond, and peanut have high protein contents. The exotic almonds and the nut contain high lipid content (40–50 g/100 g) and elevated energy value. In addition, these fruits contained high amounts of dietary fibres (>5 g/100 g), except the cerrado cashew nut (Table 2).

The protein and lipid contents and the energy value of the roasted baru almond are similar to those reported in the literature (26 g/100 g, 42 g/100 g and 535 kcal/100 g, respectively) (Fernandes et al., 2010). This edible seed presented a high content of dietary fibres (mainly insoluble dietary fibres), in accordance with the literature (13.4 g/100 g) (Takemoto et al., 2001). The roasted pequi almond showed the highest lipid content (50%), similar to that reported in the literature (51%) (Lima et al., 2007). It also presented the highest level of total dietary fibres, soluble fibres and ash. Cerrado cashew nut presented the highest energy density (about 600 kcal/100 g). There is no study in the literature about the chemical composition of the cerrado cashew nut. However, its chemical composition and energy value were similar to those of the traditional cashew nut (Venkatachalam & Sathe, 2006). The peanut showed similar chemical composition and energy value (Table 2) to those reported in the literature for this edible seed (Fernandes et al., 2010; Venkatachalam & Sathe, 2006).

The exotic almonds and the nut showed high concentrations of iron, potassium, magnesium and zinc (Table 3). On the other hand, these foods had low sodium content. Notably, the roasted baru almond showed the highest concentrations of calcium, and the other exotic fruits presented greater levels of calcium than that of the peanut. The roasted pequi almond showed the highest concentrations of magnesium, selenium, and zinc, the latter meeting 67% of the dietary reference intake for adults (IOM, 2006). The amount of zinc present in the roasted pequi almond was higher than that in any almond or nut reported in the literature (Freitas & Naves, 2010). Considering the nutritional importance of this mineral as an antioxidant, and its limited content in plant foods, the pequi almond can be considered as a good source of zinc. Peanut had the highest selenium content compared to the other exotic fruits (Table 3). There is no published data about the selenium content of the exotic almonds and nut (Freitas & Naves, 2010). The amount of selenium in cerrado cashew nut (Table 3) is comparable to that in the traditional cashew nut (3.0 µg/100 g) (Fagbemi, 2008).

A deeper knowledge of the mineral composition and bioavailability of the exotic almonds and nuts native to the Brazilian Savanna is useful for the prevention of mineral deficiencies, especially for communities with limited access to quality diet.

The amino acid composition of the baru almond, pequi almond, cerrado cashew nut and peanut are shown in Table 4. In general, cerrado cashew nut and exotic almonds have higher concentrations of sulphur amino acids than those of the common bean (FAO, 1991), a staple food of the Brazilian diet. According to the requirement pattern of essential amino acids (WHO, 2007), the proteins of the baru almond met 100% of the nutritional requirements. Therefore, the baru almond studied has more sulphur-containing amino acids (Table 4) than that of reported in the literature (22 mg amino acid/g protein) (Fernandes et al., 2010).

The limiting amino acids of the pequi almond were lysine (first limiting amino acid), isoleucine, and threonine (Table 4). Lysine was the limiting amino acid of the cerrado cashew nut, in agreement to what's reported in the literature for the traditional cashew nut (Venkatachalan & Sathe, 2006). According to literature, lysine is the first limiting amino acid in some other nuts such as the Brazil nuts, traditional cashew nuts, hazelnuts, pistachios, almonds, and macadamia nuts (Ruggeri, Cappelloni, Gambelli, & Carnovale, 1998; Venkatachalan & Sathe, 2006). There are no reports on the amino acid profile of pequi almond and cerrado cashew nut. Peanut showed valine as the first, and lysine as the second limiting amino acid (Table 4), as previously reported (Venkatachalan & Sathe, 2006).

Table 3
Mineral composition of exotic almonds and nut compared to that of peanut.

Minerals* (mg/100 g)	Exotic almonds and nut			Peanut
	Baru almond	Pequi almond	Cerrado cashew nut	
Ca	110.94 ± 1.36[a]	90.12 ± 0.71[b]	64.05 ± 1.61[c]	32.65 ± 1.20[d]
Fe	3.57 ± 0.09[a]	2.28 ± 0.13[b]	3.89 ± 0.48[a]	1.89 ± 0.24[b]
K	980.35 ± 5.31[a]	835.66 ± 15.46[b]	556.16 ± 13.40[d]	668.11 ± 3.73[c]
Na	7.46 ± 1.51[b]	5.68 ± 4.23[b]	3.08 ± 1.14[b]	19.47 ± 1.77[a]
Mg	164.81 ± 1.29[c]	452.11 ± 62.10[a]	277.09 ± 2.90[b]	190.47 ± 6.76[c]
P	832.80 ± 2.66[c]	2214.46 ± 1.85[a]	1101.04 ± 10.87[b]	856.29 ± 2.18[c]
Se (µg/100 g)	0.37 ± 0.06[d]	1.40 ± 0.01[b]	1.02 ± 0.00[c]	2.51 ± 0.00[a]
Zn	4.29 ± 0.16[b]	7.38 ± 0.78[a]	4.98 ± 0.21[b]	4.33 ± 1.03[b]

[a–d] Values marked by the same letter in the same row are not significantly different ($P > 0.05$ by Tukey's test).
* Data are mean ± standard deviation of 2 replicates.

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Table 4
Amino acid composition and amino acid score (AAS), according to the WHO/FAO/UNU requirement pattern, of exotic almonds and nut compared to those of peanut.

Amino acid (mg amino acid/g protein)	Requirement pattern[a]	Exotic almonds and nut[b]			
		Baru almond	Pequi almond	Cerrado cashew nut	Peanut
Indispensable (essential)					
His	16.0	23.4	28.4	23.3	26.8
Ile	31.0	32.5	27.7	41.9	32.7
Leu	61.0	74.4	64.5	73.1	67.1
Lys	48.0	66.4	**30.3**	**44.6**	43.8
Met + Cys	24.0	29.8	62.0	35.6	27.2
Phe + Tyr	41.0	88.5	67.1	86.7	102.3
Thr	25.0	55.3	21.7	36.0	31.8
Trp	6.6	11.2	10.0	16.5	7.1
Val	40.0	55.6	40.4	53.8	**35.5**
Total	292.6	437.1	352.1	411.5	374.3
AAS (%)	100	105	63	93	89
Dispensable (non-essential)					
Asp	–	91.4	79.9	78.9	115.3
Glu	–	176.9	182.2	173.0	180.6
Ala	–	42.6	36.3	35.1	38.1
Arg	–	151.4	223.7	172.8	136.7
Gly	–	41.7	56.8	56.2	47.0
Pro	–	3.8	33.6	21.9	53.1
Ser	–	58.4	45.5	50.5	55.1
Total		566.2	658.0	588.4	625.9

[a] WHO (2007).
[b] Data are means of 2 replicates. Bold values indicate the first limiting amino acid.

The total essential amino acid content of baru almond was higher than those of the other fruits, including the peanut. In turn, pequi almond showed the lowest level of essential amino acids, mainly because of its low lysine content (Table 4).

The body weight profiles of the experimental groups are shown in Fig. 2. The body-weight gain of rats fed with the baru almond and cerrado cashew diets was similar to that of the peanut diet-fed rats, but lower than that of the casein diet-fed rats (Fig. 2, Table 5). All groups of animals, except protein-free group, showed a positive linear trend of body weight evolution over time, yet the animals fed with pequi almond diet showed more moderate weight gain ($P<0.05$; Fig. 2). The growth rates of the animals are represented by the 'b' value in the linear regression equation, and there are no significant differences among baru almond, cerrado cashew nut, and peanut groups ('b' values around 3, $P>0.05$). Despite the different energy values of these diets, the growth rate of the 2 groups of animals fed with casein diets was similar ('b' values around 5, $P>0.05$), probably because the control group showed a compensatory reduction in its food intake in comparison with the reference group (Table 5).

The food and protein intakes of the animals are shown in Table 5. Food intakes of the rats fed with the baru almond, cerrado cashew nut, and peanut diets were similar. Food intake of the pequi almond group was lower than that of the other groups. It should be pointed that the essential amino acid composition of a diet influences the food intake, mainly because of an imbalance in the essential amino acid content (Harper, Benevenga, & Wohlhueter, 1970). Furthermore, the pequi almond has a strongly marked flavour, which can also be contributed to the low food intake of this group. The protein intake of the rats fed with the baru and peanut diets were similar to that of the cerrado cashew nut group, and the pequi almond group presented the lowest protein intake, because of its lowest food intake (Table 5).

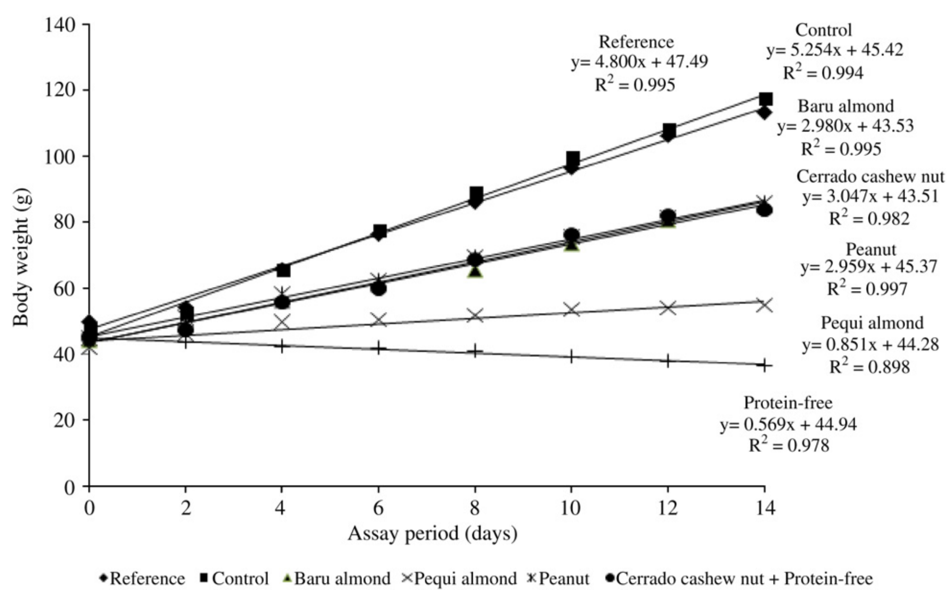

Fig. 2. Body weight of rats fed with different experimental diets for 14 days.

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Table 5
Food and protein intakes and protein value indexes of rats fed with different experimental diets.

Parameter[a]	Diet*					
	Reference	Control	Baru almond	Pequi almond	Cerrado cashew nut	Peanut
Total food intake (g)	181.18 ± 15.32[a]	168.57 ± 11.28[a,b]	150.98 ± 10.95[b]	97.02 ± 14.22[c]	147.88 ± 4.85[b]	154.08 ± 13.45[b]
Total protein intake (g)	18.82 ± 1.74[a]	17.99 ± 1.32[a]	13.95 ± 1.01[c]	9.64 ± 1.55[d]	14.68 ± 0.53[b,c]	16.87 ± 1.61[a,b]
Weight gain (g)	63.53 ± 10.67[a]	69.93 ± 4.60[a]	40.87 ± 4.32[b]	13.10 ± 4.56[c]	38.38 ± 4.35[b]	41.00 ± 5.70[b]
NPR	3.81 ± 0.49[a,b]	4.36 ± 0.41[a]	3.53 ± 0.35[b,c]	2.19 ± 0.29[e]	3.17 ± 0.23[c,d]	2.91 ± 0.20[d]
RNPR (%)	100[a]	100[a]	86.44 ± 8.62[b]	53.66 ± 7.09[d]	77.63 ± 5.70[b,c]	71.70 ± 4.87[c]
True digestibility (%)	95.48 ± 2.25[a,b]	96.85 ± 0.68[a]	86.38 ± 0.75[c]	88.11 ± 1.82[c]	88.07 ± 1.21[c]	92.74 ± 1.10[b]
PDCAAS (%)	–	–	90.70 ± 0.79[a]	55.51 ± 1.15[c]	81.91 ± 1.13[b]	82.54 ± 0.98[b]

[a–d] Values marked with the same letter in the same row are not significantly different ($P > 0.05$ by Tukey's test).
* Reference diet: casein with 7% lipids; Control diet: casein with 15% lipids. Data are mean ± standard deviation of six animals.
[a] NPR: Net Protein Ratio (values were calculated considering the weight loss of rats fed with the protein-free diet: 8.20 ± 0.77 g); RNPR: Relative NPR; PDCAAS: protein digestibility-corrected amino acid score.

The proteins of the exotic fruits had similar true digestibility (Table 5). The peanut's protein showed the highest true digestibility among the experimental groups. This value was in agreement with a previous report (92%) (Fernandes et al., 2010). On the other hand, the true digestibility of the baru almond's protein was higher than the values previously reported, of 80% (Fernandes et al., 2010) and 66% (Togashi & Sgarbieri, 1995). There are no reports on the protein digestibility of the pequi almond and of the cerrado cashew nut. According to the FAO (1970), the digestibility of the protein of the traditional cashew nut is 85%, comparable to the digestibility of the cerrado cashew nut's protein (Table 5).

According to the RNPR values, the baru almond presented protein value similar to that of the cerrado cashew nut and higher than that of the peanut (Table 5). Besides, the baru almond showed the highest PDCAAS among the experimental groups, which was higher than the value of 73%, reported in the literature (Fernandes et al., 2010). The PDCAAS of the peanut was very close to that observed for the cerrado cashew nut (Table 5). In turn, the RNPR and PDCAAS of the pequi almond were lower than the other groups, probably because of its poor amino acid profile (Table 4). These results indicate that these exotic fruits, except the pequi almond, contain good quality proteins (PDCAAS around 85%). The data of this study reinforce that the NPR index is more sensible to evince slightly differences in protein quality than PDCAAS index (Table 5), but the PDCAAS method is the most appropriate to estimate the food protein value for humans (Friedman, 1996; IOM, 2005; Schaafsma, 2000).

Our findings contribute to public awareness of the health benefits of exotic fruits consumption. Beside, the protein values of the pequi almond and cerrado cashew nut have not been determined so far, and these information can be useful to the preservation of these exotic species (Fig. 1). The study of exotic edible seeds is necessary because these foods have nutritional values similar to that of the true nuts (Freitas & Naves, 2010; Venkatachalan & Sathe, 2006). Therefore, exotic edible seeds, either alone or with other nuts, are potential functional foods for healthy diets and food industry. Our study, in particular, contributes to the development of strategies for the conservation and sustainable use of these species as well as for the promotion of healthy diet, not only in Brazil but also in other countries where the nuts are appreciated (Jenab et al., 2006).

4. Conclusions

The baru almond, pequi almond, and cerrado cashew nut from the Brazilian Savanna, as well as the peanut, are foods with high nutritional (proteic and lipidic) content and energy value. In addition, these foods have an appreciable mineral content, mainly calcium, iron, and zinc, and baru and pequi almonds also have high contents of fibres. The baru almond and the cerrado cashew nut have a good amino acid profile and protein quality, and the protein value of baru almond is better than that of the peanut. On the other hand, the protein of the pequi almond is limited in lysine. We recommend the inclusion of these exotic foods in healthy diets and in food industry, and the baru almond and cerrado cashew nut as sources of complementary protein.

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