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Mixed water-soluble nut-based plant extracts to produce vegan ice creams

Utilização de extrato vegetal hidrossolúvel misto a base de castanhas para elaboração de sorvetes veganos

Uso de extracto vegetal hidrosoluble mixto a base de castañas para la elaboración de helados veganos

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Abstract

The demand for plant-based foods to meet the vegan public and/or individuals allergic to milk protein has increased, leading to the development of new products for this market. This work aimed to use mixed plant extracts to produce peanut-flavored and cocoa-flavored vegan ice creams. A mixed water-soluble plant extract (EHMBC) was prepared using water-soluble plant extracts of baru nuts (EHCB) and cashew nuts (EHCC) at a 60:40 v/v ratio. Then, the mixed extract was used to produce (i) cocoa-flavored and (ii) peanut-flavored vegan ice cream formulations. The peanut-flavored ice cream showed higher lipids (16.16%) and proteins (9.85%) levels, and lower moisture (54.24%) and carbohydrates (18.28%) levels when compared to the cocoa-flavored ice cream. No significant difference ($p>0.05$) was observed for the parameter ash between the ice creams. After 90 minutes of melting, the cocoa-flavored ice cream exhibited a higher melting rate and overrun when compared to the peanut-flavored ice cream, with values of 90.90 and 21.97 %, and 56.82 and 18.62%, respectively. The peanut-flavored ice cream was characterized for the fatty acid profile, and 9 different types were identified, with a greater proportion for the oleic acid. Therefore, the use of plant extracts in the manufacture of vegan products may be an effective approach, but further studies are required to evaluate the consumers' acceptance of the product.

Keywords: Plant milk; Gelato; Allergic; Baru nut; Cashew nut.

Resumo

A demanda por alimentos para o público vegano e/ou alérgicos a proteína do leite cresceu e, com isso, é necessário desenvolver novos produtos para este mercado. Este trabalho teve como objetivo a utilização de extrato vegetal misto para elaboração de dois sorvetes veganos, sendo um sabor amendoim e outro cacau. Inicialmente, foi elaborado um extrato vegetal hidrossolúvel misto (EHMBC) na proporção de 60:40 v/v, a partir da mistura do extrato vegetal hidrossolúvel simples de castanha de baru (EHCB) e de caju (EHCC). Posteriormente, o extrato misto foi utilizado para elaborar dois tipos de sorvete vegano, sendo um (i) sabor cacau e outro (ii) sabor amendoim. O sorvete de amendoim apresentou valores maiores de lipídeos (16,16%) e proteínas (9,85%), menores de umidade (54,24%) e carboidratos (18,28%) em relação ao sorvete de cacau. O único parâmetro que não foi observado diferenças ($p>0,05$)

entre os sorvetes foi cinzas. O grau de derretimento do sorvete sabor cacau (90,90%) foi superior ao de sabor amendoim (56,82%) após 90 minutos. O *overrun* do sorvete sabor cacau (21,97%) foi maior que do sabor amendoim (18,62%). O sorvete de amendoim foi caracterizado quanto ao perfil de ácido graxos, sendo encontrados 9 diferentes tipos, com o ácido oleico em maior proporção. Com base nos resultados obtidos foi possível concluir que a utilização de extrato vegetal na elaboração de produtos veganos é possível e interessante, porém estudos complementares devem ser realizados para avaliar a aceitação do produto desenvolvido.
Palavras-chave: Leite vegetal; Gelato; Alérgicos; Castanha de baru; Castanha de caju.

Resumen
La demanda de alimentos para el público vegano y/o alérgico a la proteína de la leche ha crecido y, por tanto, es necesario desarrollar nuevos productos para este mercado. Este trabajo se basó en el uso de extracto vegetal mixto para elaborar dos helados veganos, siendo uno de ellos sabor a cacahuete y el otro sabor a cacao. Inicialmente, se elaboró un extracto vegetal hidrosoluble mixto (EHMBC) en la proporción de 60:40 v/v, a partir de la mezcla del extracto vegetal hidrosoluble simple de nuez de barú (EHCB) y de anacardo (EHCC). Posteriormente, el extracto mezclado se utilizó para preparar dos tipos de helado vegano, siendo uno (i) con sabor a cacao y el otro (ii) con sabor a cacahuete. El helado de cacahuete presentó valores más altos de lípidos (16,16%) y proteínas (9,85%), y más bajos de humedad (54,24%) y carbohidratos (18,28%) en relación con el helado de cacao. El único parámetro en el que no se observaron diferencias (p>0,05) entre los helados fue la ceniza. El grado de fusión del helado con sabor a cacao (90,90%) fue superior al del sabor a cacahuete (56,82%) después de 90 minutos. El rebasamiento del helado con sabor a cacao (21,97%) fue mayor que el del sabor a cacahuete (18,62%). El helado de cacahuete se caracterizó en cuanto al perfil de ácidos grasos, y se encontraron 9 tipos diferentes, con el ácido oleico en mayor proporción. En base a los resultados obtenidos se pudo concluir que el uso de extracto vegetal en la elaboración de productos veganos es posible e interesante, pero se deben realizar más estudios para evaluar la aceptación del producto desarrollado.
Palabras clave: Leche vegetal; Helado; Alérgico; Castaña barú; Castaña de cajón.

1. Introduction

The dietary profile of consumers has shown a growing trend toward plant-based diets (Väkeväinen et al, 2020; Mosso et al, 2020, Cardillo-Diniz et al, 2020). The reasons for these changes include the growth of individuals with some physiological restrictions, such as milk protein allergies (APLV) (α-lactalbumin, β-lactoglobulin, and casein) and/or lactose intolerance (Vanga and Raghavan, 2018), as well as the growth of the vegan population.

Food allergy is more common in children and affects approximately 6% of children under 3 years old, and 3.5% of adults (Moore et al., 2017). Studies have shown that about 3.4% of the United States population is vegetarian or vegan and about 36% eat at least one or more vegetarian or vegan meals per week (Stahler, 2009). According to the Brazilian Institute of Opinion and Statistics (IBOPE, 2018), 14% of the Brazilians are self-declared vegetarians, while in 2012 they were 8% of the population. This scenario has led to an increase in studies to evaluate the effects of the adoption of the vegan pattern in the population's diet (Craig, 2009; Baines et al., 2007; Larsson and Johansson, 2002).

In this context, raw material alternatives, such as water-soluble plant extracts, have been used to develop products to meet this demand. Research and Markets (2017) reported that sales of plant-based extracts in the U.S. retail market were approximately $6 billion in 2017, which is estimated to be $28 billion by 2021. It is worth noting that although the plant extracts are often used directly, i.e., as a cow's milk substitute, they can also be used as an ingredient for other food formulations, such as ice cream.

According to the Brazilian law Resolution 267, September 1999, ice cream is defined as a food product obtained from fat and protein emulsion, with or without the addition of other raw materials and substances, or a mixture of water, sugars, and other ingredients, which have been subjected to freezing to ensure the product’s preservation in the frozen or partially frozen state, during storage, transportation, marketing, and delivery to consumption (Brasil, 2003).

Ice cream is a tropical product widely consumed in Brazil, satisfying the most varied preferences of different age groups and social classes. It is characterized by a sweet, smooth, and creamy texture, which attracts consumers, with a market with high growth potential (Salgado, 2013). However, individuals with milk protein allergy and/or lactose intolerance and vegan individuals are prevented from consuming the product, once milk is the basis of its composition in the vast majority of formulations. Thus, the use of raw materials of plant origin for the development of ice cream may be an interesting alternative to meet this demand (Su & Lannes, 2012; Perreira et al., 2012).

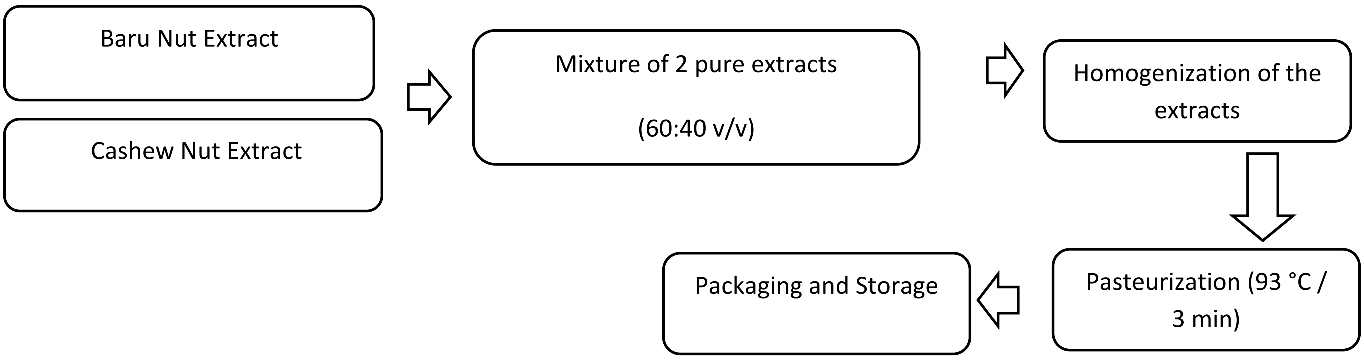
Almeida et al, (2019) produced vegan ice cream based on yam, evaporated milk, soy cream, 100% cocoa powder, and flaxseed gel. The authors made two ice cream formulations, with (SGL) and without the addition of flaxseed gel (SSG), which were compared to a commercial formulation (SC). The authors reported no differences in the sensory attributes aroma and flavor, with excellent acceptability by the consumer. Beltran et al. (2020) produced two chocolate-flavored vegan ice creams, based on coconut milk and sweet potato using stabilizing and emulsifying agents (Emustab), and different percentages of sweet potato, 200 g (ice cream A) and 400 g (ice cream B). The ice creams were subjected to sensory evaluation, with no differences observed between them. Therefore, both ice creams exhibited commercial feasibility and consumer acceptance and can be an alternative for the public with food restrictions or even as a food option. Thus, the objective of this study was to study the feasibility of using water-soluble plant extracts based on baru and cashew nuts in the manufacture of vegan ice creams.

2. Methodology

2.1 Production of Mixed Water-Soluble Plant Extracts of Baru and Cashew Nuts (EHMBC)

The methodology proposed by Felberg et al. (2005) was used to produce the HBMC, with modifications, as shown in Figure 1. Initially, pure water-soluble baru nuts extract (EHCB) was prepared. For that, baru nuts were peeled, sanitized with sodium hypochlorite at 200 ppm for 15 minutes, washed with water, and subjected to heat treatment at 95 ºC for 5 minutes at a ratio of 1:6 w/w (kernel: water). Then, they were triturated in an industrial blender for 3 minutes and filtered twice with the aid of a 1 mm sieve and filter cloth. Afterwards, the other ingredients were added, as follows: 0.5% inulin, 0.2% xanthan gum, 0.1% salt, and 0.03% potassium sorbate.

Figure 1. Flowchart of the procedures used to produce the mixed water-soluble plant extract of baru and cashew nuts (EHMBC).



Source: From the authors.

A pure water-soluble cashew nut extract (EHCC) was also produced, using nuts previously sanitized with sodium hypochlorite at 200 ppm for 15 minutes and washed with water, followed by soaking in water (nut to water ratio of 1: 2) for 24 hours. Then, the nuts were macerated in water at 95 °C for 5 minutes and ground with water for 3 minutes in an industrial blender. The extract was filtered twice with the aid of a 1 mm sieve and filter cloth, and the other ingredients were added, as follows: 0.05% xanthan gum, 2% sucrose, 0.1% salt, 0.03% sorbate, and 0.25% inulin.

The mixed extract (Figure 1) was made using the EHCB and the EHCC in the proportion of 60:40 v/v, which were homogenized and subjected to pasteurization at 93°C for 3 minutes and filling at 70°C.

2.2 Manufacture of Vegan Ice Creams

The formulations in Table 1 were used for the manufacture of two vegan ice creams using the mixed water-soluble plant extract of baru and cashew nuts (EHMBC). First, the ingredients were weighed and homogenized in the mixer for approximately 10 minutes. Then, the mixture was subjected to agitation and cooled around -30 ºC for 40 minutes in an ice cream maker (Tramontina by Breville Express). The ice cream was then packaged and stored at -18 ºC.

Table 1. Vegan ice cream formulations made with mixed water-soluble plant extracts.

Ingredients	Vegan ice cream	
	Peanut flavor	Cocoa flavor
Mixed water-soluble plant extract of baru and cashew nuts (EHMBC) (mL)	150	150
Peanut paste (g)	75	-------
Cocoa powder 50% (g)	-------	25
Sugarcane syrup (g)	25	25
Xanthan Gum (g)	0.15	0.15
Water (mL)	-------	35
Emulsifying agent/Emustab (g)	2	2
Stabilizing agent (g)	2	2

Source: From the authors.

2.3 Characterization of the Mixed Water-Soluble Pant Extract of Baru and Cashew Nuts (EHMBC) and Vegan Ice Creams

2.3.1 Proximate Composition

The proximate characterization of the samples was determined in the laboratory of analytical chemistry and food analysis of the UFFS, Campus Laranjeiras do Sul according to the methodologies of the Institute Adolfo Lutz (Zenebon et al., 2008) as follows: moisture (method 012/IV), ash (method 018/IV), total lipids (method 321/IV, with adaptations), crude protein (method 036/IV, with adaptations). The total carbohydrates were calculated by the difference method, using the following equation: g/100g carbohydrates=100 - (moisture + lipids + crude protein + ash + crude fiber).

2.3.2 Melting Rate of Vegan Ice Creams

The melting rate was determined as described by Granger et al. (2005) and Correia et al. (2008), with modifications. The ice cream samples were removed from the freezer and 100 grams were placed on a support with a 0.5 cm opening screen with a beaker, using a semi-analytical balance to record the weight as a function of the melting behavior. The weight was recorded every 10 minutes, for 90 minutes.

2.3.3 Overrun of Vegan Ice Creams

The overrun was calculated as reported by Muse and Hartel (2004), using the following equation:

$$overrun\ (\%): \frac{\rho\ mixture - \rho\ ice\ cream}{\rho\ ice\ cream}\ X\ 100$$

where ρ = grams of 250 Ml

2.3.4 Fatty Acids Profile Analysis

The fatty acid profile of peanut-flavored vegan ice cream was analyzed using a gas chromatograph coupled to a mass spectrometer, Shimadzu, model GCMS-QP2010 Ultra, equipped with a DB 5 ms (5% diphenyl, 95% dimethylpolysiloxane) 30 m fused silica capillary column with an internal diameter of 0.25 mm and film thickness of 0.25 µm. Helium was used as carrier gas at a linear velocity of 43 cm s^{-1}. The operating conditions were: injector in Split mode (1:5) at 280 °C; interface at 280 °C; column temperature set to 50 °C maintained for 1 min, heating at a rate of 15 °C min^{-1} to 175 °C, heating at a rate of 2 °C min^{-1} to 230 °C; 3 °C min^{-1} to 260 °C; 10 °C min^{-1} to 280 °C, and maintained at this temperature for 5 min. The mass spectrometer was set for scanning from 35 to 500 m/z and 2 µL of solution was manually injected. The fatty acids were identified by comparing the mass spectrum and retention index of the fatty acid methyl esters using the NIST11 and NIST11 libraries. The retention index was calculated using the software after analysis of the standard C8 - C40 n-alkanes (40147-U Supelco).

The Bligh-Dyer method (Zenebon et al., 2008) was used to extract lipids from the samples, with modifications. The lipids were esterified using the standard procedure of IUPAC (1987). The solutions containing the fatty acid esters were properly diluted with n-hexane and three repetitions of each sample were injected into the chromatograph.

2.4 Statistical analysis

Data were analyzed by analysis of variance ANOVA and the comparison of means was performed by Tukey's test.

3. Results and Discussion

Table 2 shows the results of the proximate composition of the mixed water-soluble plant extract of baru and cashew nuts (EHMBC) and the peanut-flavored and cocoa-flavored vegan ice creams. Figure 2 shows the visual appearance of the ice creams. The EHMBC presented 6.23% lipids, 1.51% protein, 0.30% ash, 87.96% moisture, and 3.94% carbohydrates. Schmitz (2018) produced water-soluble plant extracts based on cashew and baru nuts and reported 1.03 and 0.32 % ash, 4.86 and 4.10% lipids, 2.82 and 2.28% protein, 80.97 and 87.11 % moisture, and 10.53 and 6.45% carbohydrates for baru nut and cashew nut extracts, respectively.

Figure 2. Cocoa-flavored and peanut-flavored vegan ice creams made with water-soluble plant extract of baru and cashew nuts.

Source: From the authors.

Significant differences ($p<0.05$) were observed between the ice cream formulations, except for the ash contents ($p>0.05$). The peanut-flavored ice cream showed higher lipids (16.16%) and proteins (9.85%) levels and lower moisture (54.24%) and carbohydrates (18.28%) levels when compared to the cocoa-flavored ice cream. The difference observed in the lipids and protein contents between the formulations was probably due to the use of peanut paste in the manufacture of the peanut-flavored ice cream, which contains higher fat and protein contents when compared to cocoa powder. According to the manufacturer's information on the label of the peanut paste and cocoa powder, they contained 5.8 and 2.3g of protein and 11 and 1.3g of fat in 20g of product, respectively.

Table 2. Characterization of the mixed water-soluble plant extract of baru and cashew nuts (EHMBC) and the cocoa-flavored and peanut-flavored vegan ice creams.

Parameters	EHMBC 60:40 (v/v)	Vegan ice creams	
		Peanut flavor	Cocoa flavor
Lipids (%)	6.23 ± 0.01	16.16 ± 0.30^a	9.84 ± 1.10^b
Proteins (%)	1.51 ± 0.03	9.85 ± 0.20^a	3.04 ± 0.01^b
Ash (%)	0.30 ± 0.01	0.95 ± 0.10^a	0.98 ± 0.07^a
Moisture (%)	87.96 ± 0.01	54.24 ± 0.05^b	64.91 ± 0.09^a
Carbohydrates (%)	3.94 ± 0.06	18.28 ± 0.30^b	21.07 ± 1.20^a

* Results expressed as mean ± standard deviation. Averages with equal low case letters, in the same row (vegan ice cream), do not differ at $p > 0.05$ by Tukey's test at a 95% confidence level. **EHMBC: mixed plant water-soluble extract of baru and cashew nuts. Source: From the authors.

The cocoa-flavored ice cream showed higher moisture content (21.07%) when compared to the peanut-flavored ice cream. During the manufacture of the cocoa-flavored formulation, an additional amount of water (35 mL) was added to facilitate the solubilization of cocoa powder, which may have led to an increase in moisture. Regarding the carbohydrate contents, the peanut-flavored ice cream had a lower value, due to its higher protein and fat contents, once the carbohydrates content is calculated by difference using the percentages of these parameters.

Da Silva et al. (2022) studied the effect of the addition of prebiotic ingredients (inulin HP, inulin GR, oligofructose, or polydextrose 5g/100g) on the characteristics of passion fruit-flavored ice cream made with water-soluble extracts of rice flour and found 60.53-64.27% moisture; 0.07-0.10% ash; 0.60-0.76% proteins; 11.20-14.43% lipids; and 21.92-25.64% carbohydrates. Beltran et al. (2020) produced cocoa-flavored lactose-free ice cream based on coconut milk and found 17g of carbohydrates, 1.2g of proteins, and 6.1g of lipids per 100g. The results of the sensory evaluation showed that the ice cream was a valid alternative for the lactose-restricted audience or as a food choice. Marques et al. (2017) produced a functional chocolate ice cream using water-soluble soy extract and green banana biomass. The ice cream showed 72.03% moisture, 19.57% carbohydrates, 2.67% protein, 1.46% lipids, and 0.67% ash. According to Kassada et al. (2015), the great advantage of producing ice cream based on plant raw materials is to meet the needs of the population with lactose intolerance and allergy to cow's milk protein, as well as wheat protein. Thus, studied on alternative raw materials that provide a good protein and fatty acids profile may be an effective approach. The results of the present study are interesting from the point of view of protein and lipid contents when compared to other vegan ice creams.

Table 3 shows the physicochemical parameters of the vegan ice creams. A significant ($p<0.05$) higher melting rate was observed for the cocoa-flavored formulation (90.90%) when compared to the peanut-flavored formulation (56.86%), probably due to its higher moisture content. The peanut-flavored formulation showed melting from the first 40 minutes of analysis, probably due to its higher lipids content (16.16% - Table 2). Rodrigues et al. (2006) made 9 ice cream formulations from milk powder, whey, and milk cream, and different fat contents and reported that the formulation with a higher fat content showed a lower melting rate when compared to the formulations with lower fat content.

Table 3. Melting rates and overrun values of the peanut-flavored and cocoa-flavored vegan ice creams.

Parameters	**Vegan ice creams**	
	Peanut flavor	**Cocoa flavor**
Melting rate (%)	56.86 ± 0.06[b]	90.90 ± 0.09[a]
Overrun (%)	10.28 ± 1.41[b]	13.75 ± 2.03[a]

Source: From the authors.

The overrun (air incorporation) values of the cocoa-flavored and peanut-flavored ice creams (Table 3) were 13.75% and 10.28%, respectively. Therefore, the incorporation of peanut paste led to a reduction in overrun probably due to the creamy texture of the peanut paste, which altered the viscosity of the mixture. It is known that a higher mixture viscosity can delay the incorporation of air, with a consequent decrease in ice cream volume and overrun (Abo-Srea et al., 2017). In addition, during ice cream freezing, the incorporation of air is affected by several factors including the ingredients used in the formulations, and the processing conditions, such as freezing time and temperature (Whelan et al., 2008).

The peanut-flavored vegan ice cream had a higher lipid profile, thus a fatty acid profile analysis was performed (Table 4). The fatty acids found in the peanut-flavored vegan ice cream in descending order were oleic, palmitic, linoleic, stearic, 11-eicosenoic, behenic, lignoceric, eicosanoic, and cis-vaccenic acids. The study of fatty acid composition in food products is an interesting approach from a nutritional point of view. Nuts (cashew) and seeds (peanuts and baru kernels) are sources of nutrients and compounds with health claiming properties. Among these compounds, the fatty acid profile stands out, containing mainly oleic acids (Borges et al., 2007), which were found in higher concentrations in the ice cream of the present study.

Table 4. Fatty acid methyl ester profile of peanut-flavored vegan ice cream.

Compound	**Theoretical Retention Rate***	**Experimental Retention Rate**	**Fatty acid methyl ester profile as a function of the relative area**
Palmitic acid, methyl ester	1878	1921	8.9 ± 0.6
Linoleic acid, methy ester	2093	2089	5.3 ± 0.4
Oleic acid, methyl ester	2085	2101	77.7 ± 0.4
cis-Vaccenic acid, methyl ester	2085	2103	0.5 ± 0.1
Stearic acid, methyl ester	2077	2123	3.8 ± 0.2
cis-11-Eicosenoic acid, methyl ester	2284	2296	1.3 ± 0.2
Arachidic acid, methyl ester	2276	2324	0.7 ± 0.1
Behenic acid, methyl ester	2475	2527	1.2 ± 0.4
Lignoceric acid, methyl ester	2674	2728	0.7 ± 0.2

* Source: NIST11 and NIST11 libraries. Source: From the authors.

4. Conclusion

The new food choices due to health problems such as intolerance or allergy to animal products have led to further studies on the development of novel food formulations. In this context, nut extracts proved to be an effective alternative to replace cow's milk in the manufacture of vegan ice creams. Furthermore, the ice creams exhibited an interesting proximate composition; however, studies on the consumers' acceptance and texture of the products should be carried out.

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