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APPLICATION OF DIFFERENT METHODS FOR OBTAINING ANTIOXIDANT EXTRACTS AND DIETARY FIBER CONCENTRATES FROM GUAVA BY-PRODUCT

APLICAÇÃO DE DIFERENTES MÉTODOS PARA OBTENÇÃO DE EXTRATOS ANTIOXIDANTES E CONCENTRADOS DE FIBRAS ALIMENTARES A PARTIR DE SUBPRODUTO DE GOIABA

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ABSTRACT

The aim of this work was to produce and characterize aqueous extracts and dietary fiber concentrates obtained from guava by-product, using different processing conditions. After removing the pulp, the peels were subjected to drying and grinding. Aqueous extractions were performed in shaker (SH), ultrasound (US), microwave (MW), water-bath (WB) and homogenizer (HO). After centrifugation, the aqueous extracts were evaluated as total phenolic compounds (TPC) and antioxidant activity (AA). The precipitates were dried, ground, sieved and named dietary fiber concentrates (DFCs), being analyzed for composition and functional properties. The extracts obtained by MO and US showed the highest values of TPC and AA, respectively, and after these extractions, the DFCs produced had the highest contents of protein (9.71 g.100 g^{-1}; 10.78 g.100 g^{-1}) and dietary fiber (60.44 g.100 g^{-1}; 65.63 g.100 g^{-1}). The treatments applied to guava by-product reduced the content of total reducing sugars and increased the water absorption index of DFCs when compared to the control (without aqueous extraction). Thus, antioxidant extracts and DFCs can be obtained from guava waste, helping to enhance the productive chain, providing more sustainable destinations for the by-product generated in the industrial fruit processing, as a source of nutrients to enrich food products or to be used as supplements.

KEY WORDS

Psidium guajava L.; *Sustainable processing; Phenolic compounds; Functional properties.*

RESUMO

O objetivo deste trabalho foi produzir e caracterizar extratos aquosos e concentrados de fibras alimentares obtidos a partir do subproduto da goiaba, utilizando diferentes condições de processo. Após a remoção da polpa, as cascas foram submetidas a secagem e moagem. Este material passou por diferentes tipos de tratamentos em shaker (SH), ultrassom (US), micro-ondas (MO), banho-Maria (BM) e homogeneizador (HO). Após centrifugação, os extratos foram avaliados quanto ao teor de compostos fenólicos totais (CFT) e atividade antioxidante (AA). Os precipitados foram secos, triturados, peneirados, sendo denominados concentrados *fibrosos (CFs), os quais foram analisados quanto à composição e propriedades funcionais. Os resultados mostraram que os extratos obtidos em MO e US apresentaram o maior teor de CFT e AA, respectivamente, e que após estes tratamentos, os CFs produzidos continham os maiores teores de proteínas (9.71 g.100 g^{-1}; 10.78 g.100 g^{-1}) e de fibras alimentares (60.44 g.100 g^{-1}; 65.63 g.100 g^{-1}). Os tratamentos realizados permitiram reduzir o teor de açúcares redutores totais e aumentar o índice de absorção de água dos CFs quando comparado ao controle (sem extração aquosa). Assim, a obtenção de compostos antioxidantes e concentrados fibrosos são consideradas alternativas interessantes para valorizar a cadeia produtiva da goiaba, fornecendo destinos mais sustentáveis ao subproduto gerado no processamento industrial desta fruta, como uma fonte de nutrientes para enriquecimento de produtos alimentícios ou para ser utilizado como suplementos.*

PALAVRAS CHAVE

Psidium guajava L.; Processamento Sustentável; Compostos Fenólicos; Propriedades funcionais.

1. INTRODUCTION

Guava (*Psidium guajava* L.) belongs to the Myrtaceae family and grows predominantly in various countries tropical and subtropical regions of America, Asia, and Africa (Angulo-López et al., 2021; Laily et al., 2015). Guava fruits have medicinal properties such as laxative, hepatoprotective, antiallergic, antidiabetic, antimicrobial, anticancer, antihypertensive, antiplasmodial, antispasmodic, anti-inflammatory and antinociceptive (Kafle et al., 2018; Angulo-López et al., 2021).

The pink guava is the most popular cultivar for consumption in natura or processing because it has an intense aroma and color. It outshines other tropical fruits in productivity, hardness, adaptability and ensures higher economic returns to the grower with minimal inputs. Guava has high nutritional value due to the content of dietary fiber, lycopene, vitamin C and phenolic compounds (Nunes et al., 2016; Ninga et al., 2018). The intake of dietary fiber and antioxidant compounds has been correlated with many benefits such as low incidence of cardiovascular disease, cancer, aging and degenerative processes (Palafox-Carlos; Ayala-Zavala; González-Aguilar, 2011; Calvache et al., 2016).

Guava fruits can be used in the food industry to produce pulp, nectars, jams, jellies, and syrups (Narváez-cuenca et al., 2020). The processing generates high amounts of by-products (~30% of the total weight) constituted by peel and seeds. The use of these by-products can promote the valorization of productive chains, with the total use of the raw material, also reducing the costs of waste treatment (Sousa; Vieira; Lima, 2011; Uchoa et al., 2008). There is an increasing interest in applying fruit processing wastes as functional food ingredients since they are a source of dietary fibers and active compounds that can act as antioxidants (Balasundram; Sundram; Samman, 2006; Soquetta et al., 2016).

The antioxidant compounds extracted from by-products can be used in the development of foods or pharmaceutical and cosmetic products. The yield of the extraction depends on the type of solvents (polarity), extraction time and temperature, mass transfer rate, as well as the chemical composition and physical characteristics of the matrix. Green technologies have been used in recent years to provide higher yield, minimize processing time and reduce energy and solvent consumption, for example, ultrasound and microwave are considered sustainable methods to antioxidant extraction (Durovic et al., 2018; Kumar et al., 2021).

The ultrasound assisted extraction produces acoustic waves in the solvent with the formation of cavitation and agitation bubbles within the matrices (Chemat et al., 2019), which accelerates compounds released, enhancing mass transfer (Mason; Chemat; Vinatoru, 2011). The microwave assisted extraction generates high-energy electromagnetic waves that change the ionic mobility and solvent molecular rotation, causing friction and rapid migration of the compounds from the matrix to the solvent (Chemat et al., 2019).

The residual material of the by-products extraction, separated by filtration or centrifugation, can be used to produce dietary fiber concentrates (DFCs). According to the conditions applied to prepare DFCs, there are changes in the composition and functional properties, that have to be studied to direct their application (Peerajit; Chiewchan; Devahastin, 2012; Ma; Mu, 2016, Iwassa; Piai; Bolanho, 2019).

The use of green technologies and nontoxic solvents, to produce, simultaneously, extracts rich in antioxidants compounds and DFCs, can minimize the problems with incorrect disposal of guava by-products in the environment. The extracts and DFCs could be used for the development of food products with high nutritional value or as additives and supplements, helping to improve the health and well-being of consumers, as recommended by the third sustainable development goal. Thus, the aim of this work was to evaluate the effect of different processing conditions in the characteristics of antioxidant extracts and dietary fiber concentrates produced from guava by-product.

2. MATERIAL AND METHODS

2.1. Materials

The guava fruits were obtained in the local market from Teodoro Sampaio, São Paulo, Brazil. The following reagents were used in the determination of the proximal composition: boric acid (Anidrol), hydrochloric acid (Anidrol), sodium hydroxide (Anidrol), sulfuric acid (Anidrol), protease enzyme (Savinase, Novozymes), MES reagent (2-(N-Morpholino) ethanesulfonic acid) (Sigma-Aldrich Chemical), TRIS reagent (Tris(hydroxymethyl) aminomethane) (Sigma-Aldrich Chemical), ethanol (Anidrol), acetone (Anidrol). The chemicals used in the determination of total phenolic compounds and antioxidant activity were sodium carbonate (Anidrol), sodium acetate (Synth), acetic acid (Anidrol), ferric chloride (Dinâmica), ferric sulfate - $FeSO_4$ (Anidrol), chloridric acid - HCl (Synth), hydrogen peroxide - H_2O_2 (Synth); and, Folin-Ciocalteau reagent, gallic acid, DPPH (2,2-Diphenyl-1-picrylhydrazyl), Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid), TPTZ (2,4,6-tris(2-pyridyl)-s-triazine), salicylic acid and pyrogallol were purchased from Sigma-Aldrich Chemical.

2.2. Preparation of antioxidant extracts and dietary fiber concentrates

Guava fruits were washed; the peels were separated by cutting and ground (Cadence). This by-product was submitted to water extraction, in the proportion of 1:2 (m/v), for 30 min at 30 ºC, using different methods: horizontal agitation at 150 rpm in water bath type Dubnoff (Solab, SL 157) - WB, mechanical agitation at 150 rpm in a homogenizer (Marconi, MA 259) - HO, orbital agitation at 150 rpm in shaker (Marconi, MA 83/A) - SH, ultrasound by indirect contact (Q5.9/40A, Ultronique) at 150 W - US, and, microwave treatment (Monowave 450, Anton Paar) at 50 W - MW. A fraction of the guava by-product was not submitted to aqueous extraction and it was named control (CO).

After each treatment, the samples were centrifuged at 3000 x *g* to 10 min (Metroderm). The supernatant was removed and stored at -12 ºC until the moment of antioxidants analysis. The residues of centrifugation and the control sample were transferred to Petri dishes and dried at 50 ºC in a forced ventilation oven (Marconi MA 35/5) until reaching final moisture of 10±2%. The dried samples were ground in a knife grinder (Solab, SL 31) and passed through Tyler sieves (Bertel), from 20 to 100 mesh, in a mechanical stirrer (Marconi, MA 750) and the fraction retained in the 80-mesh sieve was named dietary fiber concentrate.

2.3. Extracts characterization

The methodology of Singleton; Orthofer; Lamuela-Raventós (1999) was used for the total phenolic compounds (TPC) analysis. Absorbance was measured in a spectrophotometer at 760 nm (Femto 700 plus). A calibration curve was prepared using gallic acid (0.1 – 0.5 mM), with a regression coefficient (R^2) of 0.99. The results were expressed as gallic acid equivalent (GAE) in mg per 100 g of sample.

Antioxidant activity was measured using the DPPH free radical scavenging method, according to Brand-Wiliams; Cuvelier; Berset (1995). After a 30 min incubation at room temperature, the absorbance was read at 515 nm. Antioxidant potential based on ferric reducing power (FRAP) was performed according to Benzie and Strain (1996). Test tubes were maintained at 37 °C for 30 min in a water bath, after, the absorbance was read at 593 nm. Trolox solutions (0.05 – 0.5 mM for DPPH and 0.25- 0.75 mM for FRAP) were used to generate analytical curves for both antioxidant activity methodologies (R^2 of 0.99) and the results were expressed in µmol of Trolox equivalent (TE) per g of sample.

The method of hydroxyl radical scavenging was carried out using 1.0 mL of sample, 1.0 mL of $FeSO_4$ (9 mM), 1.0 mL of Salicylic acid-ethanol (9 mM), and 1.0 mL of H_2O_2 (9 mM), respectively. The mixture was incubated at 37°C for 30 min, and the absorbance was measured against a blank (distilled water instead of sample and H_2O_2) at 510 nm. The scavenging of hydroxyl radical was calculated by the following Equation (1), where Ao was the absorbance of the blank (distilled water instead of the sample), Ai was the absorbance of the sample, and Aj was the absorbance of the control (distilled water instead of H_2O_2) (Liu et al., 2017).

$$E(Hydroxylradical\ scavenging\ rate/\%) = \frac{[A_0 - (A_i - A_j)]}{A_0} \times 100\% \quad (1)$$

To determine the superoxide radicals scavenging 1 mL of each sample (1.0 mg/mL) was mixed with 4.0 mL of Tris-HCl buffer (50 mM, pH 8.2) and 0.5 mL of pyrogallol solution (25 mM). The mixture was shaken slowly and incubated at 25 °C for 5 min. Finally, 0.5 mL of HCl solution (8 mM) was added and the absorbance of the mixture was measured against a blank (Tris-HCl instead of sample and pyrogallol solution) at 420 nm. The scavenging rate of superoxide radicals was calculated by the following Equation (2), where Ao was the absorbance of the blank (Tris–HCl instead of the sample), Ai was the absorbance of the sample, and Aj was the absorbance of the control (Tris–HCl instead of the pyrogallol solution) (Liu et al., 2017).

$$E(Superoxide\ scavenging\ rate/\%) = \frac{[A_0-(A_i-A_j)]}{A_0} \times 100\% \quad (2)$$

2.4. Composition and technological analysis of dietary fiber concentrates

The proximal composition was determined using AOAC methods: moisture (925.09), ashes (923.03), proteins (920.87), total reducing sugars (939.03) and dietary fiber (991.43) (Horwitz; Latimer, 2005).

The technological properties - water absorption index (WAI), oil absorption index (OAI), water solubility index (WSI) - were determined as described by Seibel and Beléia (2009). The results were expressed in g of water absorbed per g of sample (WAI), g of oil absorbed per g of sample (OAI), and g of dried solids per g of sample (WSI).

2.5. Data analyses

All the analyses were performed in triplicate and the results were expressed as mean values ± standard deviation in dry basis. Analysis of variance (ANOVA) and Tukey test were performed using Excel® 2010 software (with a 95% confidence interval)

RESULTS AND DISCUSSION

2.6. Total phenolic compounds and antioxidant activity of the extracts

Table 1 shows the results of extracts characterization. The highest content of total phenolic compounds was detected in the microwave assisted extraction (9.39 ± 0.96 mg GAE g^{-1}), followed by the ultrasonic method (6.29 ± 0.35 mg GAE g^{-1}). The other extraction techniques did not have differences for TPC values ($p>0.05$). The results obtained for TPC were similar to the value found by Arslan et al. (2017), 9.27 mg GAE g^{-1} in guava pulp powder, and higher than the one reported by Bertagnolli et al. (2014), 8.27 mg GAE g^{-1} in guava peel flour.

Table 1: Total phenolic compounds and antioxidant activity obtained by different methodologies from guava by-product.

Extracts	TPC (mg GAE g^{-1})	DPPH (µmol TEg^{-1})	FRAP (µmol TEg^{-1})	OH (%)	O$_2^-$ (%)
WB	3.52±0.63^{c}	1.67±0.12^{d}	2.64±0.23^{b}	77.07±4.89^{a}	68.04±2.34^{b}
HO	3.99±0.17^{c}	2.75±0.10^{b}	2.48±0.19^{b}	80.45±1.99^{a}	67.35±3.65^{b}
SH	3.73±0.64^{c}	1.71±0.09^{d}	1.39±0.05^{c}	81.95±6.15^{a}	67.83±3.42^{b}
US	6.29±0.35^{b}	3.37±0.01^{a}	5.92±0.59^{a}	77.82±7.14^{a}	84.26±3.50^{a}
MW	9.39±0.96^{a}	2.43±0.02^{c}	1.68±0.26^{c}	83.46±5.26^{a}	78.62±0.34^{a}

Different lowercase letters in the same column indicate that there is significant difference by the Tukey test at 5% of significance. WB - horizontal agitation in water bath, HO – mechanical agitation in homogenizer, SH – orbital agitation in shaker, US – ultrasound extraction, MW – microwave extraction, TPC – Total Phenolic Compounds), DPPH – scavenging activity of free radicals, FRAP – ferric reduction power, OH – hydroxyl radicals scavenging, O$_2^-$ – superoxide radicals scavenging, GAE – gallic acid equivalent, TE - Trolox equivalent.

Phenolic compounds are secondary metabolites of plants and they are characterized by the structure-activity relationship of the hydroxyl group and the nature of substituents on the aromatic ring (Amarowicz et al., 2004). According to Rojas-Garbanzo et al. (2017), the principal phenolic compound found in guava peel was cinnamoyl-glucoside. Besides this, the antioxidant activity and the phenol composition depend on the cultivar, growing conditions, and extraction method (Flores et al., 2015).

Based on their structure-activity relationship, there are several antioxidant mechanisms, such as free radicals scavenging through the donation of hydrogen atoms or electrons (Amarowicz et al., 2004). So, different assays of antioxidant activity were carried out in this work (Table 1).

In the DPPH method, the highest antioxidant potential was found in the extracts obtained by US (3.37 µmol of TE g^{-1}) followed by HO (2.75 µmol of TE g^{-1}) and MW (2.43 µmol of TE g^{-1}). Regarding FRAP assay, the highest value was observed in US extract (5.92 µmol of Trolox mL^{-1}). These results were similar to those found by Martínez et al. (2012) for ethanol extraction from the guava by-product - 3.3 µmol of Trolox g^{-1} and 6.0 µmol of TEg^{-1} for DPPH and FRAP assays, respectively. In the method of hydroxyl radicals scavenging, the extracts showed similar values ($p > 0.05$), ranging from 77.07% to 83.46%. For superoxide radical scavenging, the highest values were obtained in the extracts obtained by US (84.26%) and MW methods (78.62%).

The results obtained in this work showed that MW and US were the most effective methods to obtain the highest levels of TPC and antioxidant activity, respectively. Microwave-assisted extraction allows the solvent mixture to be heated by direct interaction with free molecules present in the system, which leads to the destruction of plant tissue, enhancing the mass transfer towards the solvent phase and the release of the components into a solvent (Taqi et al., 2020). Ultrasound assisted extraction induces cavitation, mechanical and thermal effects that disrupt cell walls and accelerate the release, diffusion, and dissolution of intracellular substances, increasing the yield of bioactive substances (Luo et al., 2018). These methods are considered sustainable alternatives to obtain functional products with high content of active compounds, with low energy and maintenance costs (Gouda et al., 2021; Kumar et al., 2021), and in this study, the use of water as solvent is another point to highlight in relation to organic solvents commonly used in extraction processes.

There is an increasing interest in the use of different biosources as effective antioxidants that could be used in the replacement of synthetic compounds due to its rejection by health-conscious consumers (Durovic et al., 2018). Thus, the use of guava by-product as a source of antioxidant compounds is an alternative to add value to the waste, and the extract could be widely used, for example, as a food additive.

3.2 Characterization of dietary fiber concentrates

The results for the proximal composition of dietary fiber concentrates obtained after the extraction of the antioxidant compounds by different methods, and of the control that did not undergo the extraction process are shown in Table 2.

Table 2: Composition of dietary fiber concentrates (DFCs) obtained by different methods from guava by-product

DFCs	Moisture (g.100 g^{-1})	Fat (g.100 g^{-1})	Ashes (g.100 g^{-1})	Proteins (g.100 g^{-1})	Sugars (g.100 g^{-1})	Dietary fiber (g.100 g^{-1})
CO	11.85 ± 0.07^{a}	1.43 ± 0.12^{a}	3.69 ± 0.13^{ab}	9.33 ± 0.22^{a}	12.44 ± 0.08^{a}	28.60 ± 0.82^{e}
WB	11.36 ± 0.12^{a}	1.61 ± 0.15^{a}	2.64 ± 0.16^{b}	3.99 ± 0.34^{c}	6.44 ± 0.18^{b}	44.42 ± 0.42^{c}
HO	11.29 ± 0.19^{a}	1.45 ± 0.07^{a}	2.42 ± 0.08^{b}	5.06 ± 0.38^{b}	5.82 ± 0.49^{b}	48.31 ± 0.65^{d}
SH	11.07 ± 0.04^{a}	1.25 ± 0.14^{a}	2.70 ± 0.26^{b}	4.59 ± 0.26^{bc}	6.34 ± 0.13^{b}	47.60 ± 0.46^{d}
US	9.30 ± 1.40^{a}	1.63 ± 0.11^{a}	3.20 ± 0.58^{ab}	10.78 ± 0.18^{a}	6.37 ± 0.18^{a}	65.63 ± 0.46^{a}
MW	9.49 ± 0.94^{a}	1.31 ± 0.10^{a}	3.46 ± 0.82^{a}	9.71 ± 0.63^{a}	6.64 ± 0.26^{b}	60.44 ± 0.00^{b}

Different lowercase letters in the same column indicate that there is significant difference by the Tukey test at 5% of significance. DFCs – dietary fiber concentrates, CO – control, without aqueous extraction, WB - horizontal agitation in water bath, HO – mechanical agitation in homogenizer, SH – orbital agitation in shaker, US – ultrasound extraction, MW – microwave extraction.

The moisture and fat contents did not differ among the methods used to obtain DFCs ($p>0.05$), being these values similar to those found by Martínez et al. (2012) for guava and pineapple DFCs (~9 g.100 g^{-1}). The moisture contents obtained in the present work are in agreement with Brazilian legislation (RDC nº 263, of September 22, 2005), which establishes a maximum value of 15 g.100 g^{-1} for flours, which is an important factor to the conservation of the product.

The highest levels of ashes and proteins were found in CO, US and MW treatments, indicating that these methods did not cause solubilization of these components as probably occurred in the other extraction methods (WB, HO, SH). The values of proteins observed in this work were higher than those detected in DFC obtained from guava (4.80 g.100 g^{-1}) (Martínez et al., 2012), and in guava peel flour (4.66 g.100 g^{-1}) (Arslan et al., 2017). The ashes values detected in this study were similar to those reported by Sena et al. (2010) for guava fiber concentrate (2.40 g.100 g^{-1}) and higher than that found in guava peel flour (0.72 g.100 g^{-1}) (Arslan et al., 2017).

The contents of total reducing sugars were similar ($p>0.05$) in the DFCs obtained after the application of extraction methods and lower ($p<0.05$) than the value found in the control. This effect is important to reduce the energetic value of the product. Campuzano et al. (2018) and Uchoa et al. (2008) reported 6.33 g.100 g^{-1} and 5.31 g.100 g^{-1} of sugars in banana flour and guava bagasse residue, respectively.

The DFCs obtained by the US method showed the highest dietary fiber content (65.63 g.100 g^{-1}), followed by the one produced by MW (60.44 g.100 g^{-1}). These values were similar to those determined by Martínez et al. (2012) in guava DFC (57.70 g.100 g^{-1}) and by Calvache et al. (2016) in papaya pulp and peel concentrate by ethanol extraction (60 and 54 g.100 g^{-1}). In the methods WB, OH and SH the dietary fiber contents (44.42 - 48.31 g.100 g^{-1}) were higher than the one found in the control (28.6 g.100 g^{-1}). These results indicated that all methods applied in this work have the potential to be used in DFCs production.

The DFCs produced from guava by-product could be used to enrich the nutritional value of food products or as dietary fiber supplements (Martens; Nilsen; Provan, 2017). Adequate intake of dietary fibers can promote health benefits such as reducing obesity, gastrointestinal problems, hypertension, diabetes and cardiovascular diseases (Lattimer; Haub, 2010). Dietary fiber incorporated into food products can improve the sensory characteristics, texture and shelf life due to gel forming ability, water binding capacity, fat mimetic, thickening and texturizing functions (Elleuch et al., 2011; Arslan et al., 2017).

The results for the technological properties of DFCs obtained after the extraction of the antioxidant compounds are shown in Table 3. The lower values of WSI found in WB, HO, SH, US and MW in relation to the control were expected, because the aqueous extractions lead to the solubilization of soluble sugars. The water absorption index is related to the physical state of the dietary fiber and proteins in the samples, and the values obtained in this work (6.32 – 9.82 g.g^{-1}) were higher than the one found by Campuzano et al. (2018) for banana flour at different maturation stages (3.52 to 2.44 g g^{-1}). In the present study, all the treatments promoted an increase in WAI in relation to the control. The results are important because higher WAI values can promote the use of DFCs in the development of food products such as jams, jellies, creams, ketchup, and bakery products, which demand water capture and retention, stabilizing the structure of food, with better texture attributes (Vergara-Valencia et al., 2007).

Table 3: Technological properties of dietary fiber concentrates (DFCs) obtained by different methods from guava by-product.

DFCs	WSI (g.g^{-1})	WAI (g.g^{-1})	OAI (g.g^{-1})
CO	0.45 ± 0.07^{a}	6.32 ± 0.06^{c}	2.46 ± 0.13^{a}
WB	0.16 ± 0.02^{b}	9.82 ± 0.17^{a}	2.62 ± 0.13^{a}
HO	0.20 ± 0.02^{b}	6.83 ± 0.23^{bc}	2.31 ± 0.30^{a}
SH	0.23 ± 0.02^{b}	7.01 ± 0.03^{b}	2.47 ± 0.02^{a}
US	0.21 ± 0.42^{b}	6.74 ± 0.41^{a}	3.94 ± 0.22^{b}
MW	0.13 ± 0.05^{b}	7.95 ± 0.33^{a}	4.32 ± 0.70^{b}

Different lowercase letters in the same column indicate that there is significant difference by the Tukey test at 5% of significance. DFCs – dietary fiber concentrates, CO – control, without aqueous extraction, WB - water bath with horizontal agitation, HO – mechanical agitation in homogenizer, SH – orbital agitation in shaker, US – ultrasound extraction, MW – microwave extraction, WAI - water absorption index, OAI - oil absorption index, WSI - solubility index.

In relation to the OAI, the values ranged from 2.31 to 4.32 g g^{-1}, and only the US and MW treatments promoted an increase in relation to the control. These values were higher than those reported by Leão et al. (2017) - 1.23 to 1.35 g g^{-1}- in pequi by-product. The OAI is an important parameter when the DFCs were applied in emulsions, meat products, and cake doughs, promoting higher viscosity (Barbosa-Martín et al., 2016).

3. CONCLUSIONS

This work contributes to the valorization of the productive chain of guava fruit, due to the alternatives studied for processing the by-products (peels) into antioxidant extracts and dietary fiber concentrates. To obtain extracts rich in TPC and with high antioxidant activity the microwave and ultrasound methods stand out in relation to HO, SH and WB. There was an increase in WAI values and a reduction in the contents of total reducing sugars of DFCs when compared to the control. The highest contents of dietary fibers and proteins and the highest values of OAI were found after extractions by US and MW. Thus, US and MW were the most effective methods for DFCs and antioxidant extracts production, being considered green technologies, which are associated with the use of water as solvent, can be considered sustainable processes to obtain new products from guava waste.

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